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Bureau of Mines

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MINERALS YEARBOOK

1960

Volume 1 of Three Volumes

METALS AND MINERALS
(Except Fuels)

Prepared by the staff of the

BUREAU OF MINES

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FOREWORD

MINERALS YEARBOOK, 1960, published in three volumes, provides a record of performance of the Nation's mineral industries during the year, with enough background information to interpret the year's developments.

The three-volume issues of the Yearbook follow this pattern:

Volume I includes chapters on metal and nonmetal mineral commodities except mineral fuels. In addition, it includes a chapter reviewing these mineral industries, a statistical summary, and chapters on mining and metallurgical technology, employment and injuries, and technologic trends. One new chapter, High-Purity Silicon, has been added to the list of commodity chapters. The chapter on Nonferrous Secondary Metals has been discontinued and the statistical material in it distributed to the appropriate nonferrous metals commodity chapters.

Volume II includes chapters on each mineral fuel, an employment and injuries presentation, and a mineral-fuels review chapter that summarizes developments in the fuel industries.

Volume III contains chapters covering each of the 50 States, plus chapters on island possessions in the Pacific Ocean and the Commonwealth of Puerto Rico and island possessions in the Caribbean Sea, including the Canal Zone. Volume III also has a statistical summary chapter, identical with that in Volume I, and a chapter on employment and injuries.

Figures in the Minerals Yearbook are based largely upon information supplied by mineral producers, processors, and users, and acknowledgment is made of this indispensable cooperation given by industry. Information obtained from individuals through confidential surveys has been grouped to provide statistical aggregates. Data on individual producers are presented only if available from published or other nonconfidential sources, or when permission of the individuals concerned has been granted.

MARLING J. ANKENY, *Director*.

ACKNOWLEDGMENTS

The Bureau of Mines has been assisted in collecting mine-production data and the supporting information appearing in this volume of the MINERALS YEARBOOK by the following cooperating organizations:

Alabama: Geological Survey of Alabama.
Alaska: Department of Natural Resources.
Arizona: Arizona Bureau of Mines.
Arkansas: Geological and Conservation Commission; Arkansas Oil and Gas Commission; Department of Revenue.
California: Division of Mines.
Delaware: Delaware Geological Survey.
Florida: Florida Geological Survey.
Georgia: Geological Survey of Georgia.
Idaho: Bureau of Mines and Geology.
Illinois: State Geological Survey Division.
Indiana: Geological Survey, Department of Conservation.
Iowa: Iowa Geological Survey.
Kansas: Conservation Division, State Corporation Commission and State Geological Survey of Kansas.
Kentucky: Kentucky Geological Survey.
Louisiana: Louisiana Geological Survey and Louisiana Department of Conservation.
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Maryland: Department of Geology, Mines, and Water Resources.
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Minnesota: Minnesota Geological Survey.
Mississippi: Mississippi Geological Survey, Mississippi State Oil and Gas Board, and Oil and Gas Severance Tax Division, Mississippi State Tax Commission.
Missouri: Division of Geological Survey and Water Resources, Department of Business Administration.
Montana: Montana Bureau of Mines and Geology.
Nevada: Nevada Bureau of Mines.
New Hampshire: New Hampshire State Planning and Development Commission.
New Jersey: Bureau of Geology and Topography.
New York: New York State Science Service.
North Carolina: Geological Survey of North Carolina.
North Dakota: North Dakota Geological Survey.
Oklahoma: Oklahoma Geological Survey and Oil and Gas Conservation Department; Oklahoma Corporation Commission, Gross Production Division; Oklahoma Tax Commission.
Oregon: State Department of Geology and Mineral Industries.
Pennsylvania: Bureau of Topographic and Geological Survey.
Puerto Rico: Mineralogy and Geology Section, Economic Development Administration, Commonwealth of Puerto Rico.
South Carolina: Geological Survey of South Carolina.
South Dakota: State Geological Survey.
Tennessee: Department of Conservation and Commerce.
Texas: Bureau of Economic Geology, The University of Texas; Oil and Gas Division, Railroad Commission of Texas; Oil and Gas Division, State Comptroller of Public Accounts.
Utah: Utah Geological and Mineralogical Survey.
Virginia: Division of Mineral Resources.
Washington: Division of Mines and Geology, Department of Conservation and Development.
West Virginia: West Virginia Geological and Economic Survey.
Wisconsin: Wisconsin Geological Survey.
Wyoming: The Geological Survey of Wyoming.

Except for the four review chapters, this volume was prepared by the staff of the Division of Minerals. The following persons supervised preparation of the various chapters: Charles T. Baroch, chief, Branch of Nonmetallic Minerals; Frank J. Cservenyak, chief, Branch of Ferrous Metals; and Paul F. Yopes, chief, Branch of Nonferrous Metals. Preparation of this volume was supervised and the chapters were coordinated with those in volume III by Donald R. Irving, assistant to the chief, Division of Minerals.

The manuscripts upon which this volume is based have been reviewed to insure statistical consistency among the tables, figures, and text, between this volume and volume III and between this volume and those for former years, by a staff supervised by Kathleen J. D'Amico, who was assisted by Julia Muscal, Helen L. Gealy, Helen E. Tice, Dorothy Allen, Mary E. Daugherty, and Joseph Spann.

The assembly and preparation of data for world production tables were supervised by Berenice B. Mitchell, Division of Foreign Activities.

Minerals Yearbook compilations are based largely on facts provided by the mineral industries. Acknowledgment is made of the willing contribution both by companies and individuals of these essential data.

CHARLES W. MERRILL,
Chief, Division of Minerals.

CONTENTS

Review of the Mineral Industries[1]

(Metals and Nonmetals Except Fuels)

By Kung-Lee Wang[2]

Contents

RAPID recovery of the nonfuel mineral industries and general industrial activity as a result of settlement of long labor-management disputes in the steel and copper industries opened 1960 on a high wave of buoyant optimism. Industrial activity tapered off after May, and the economy started on a mild downward trend. The recovery, however, had provided substantial strength to carry the nonfuel mineral industries to a good year.

Consumption of nonfuel minerals declined slightly in 1960; stocks increased sharply to a record high; imports declined slightly, and exports generally increased; domestic production increased; and prices were comparatively stable. These diverse movements characterized the domestic nonfuel mineral industries in 1960.

Value of production of the nonfuel mineral industries achieved a record high in 1960, as the metal-mining industries increased sharply over 1959. Domestic production of metals recovered rapidly from long strikes and increased 27 percent over 1959. Value of nonmetal production increased slightly.

The most outstanding development during 1960 was the accumulation of record high physical stocks at yearend. Increases in production were achieved in the face of declining consumption, primarily by accumulation of stocks and secondarily by increased exports. As the year closed, these large stocks were a disturbing factor in the mineral market.

Employment increased 7 percent over 1959 in the nonfuel mineral industries, compared with a 3-percent increase in all industries.

[1] Some fuels are covered in this chapter but only where specifically indicated and in general where mining-industry data were not available for both nonfuels and fuels components.
[2] Economist—minerals.

Productivity generally gained in the metal-mining industry, and the average price of nonfuel minerals increased slightly.

Income generated by the nonfuel mineral industries increased 15 percent over 1960, compared with a 4-percent increase in all industries. Metal mining made the greatest stride—a 31-percent increase—compared with a 3-percent increase in nonmetallic mining and quarrying. The annual profit rates of primary metals and of stone and clay and related products industries declined 10 to 12 percent over 1959, compared with 11.5 percent for all manufacturing. Expenditures on new plants and equipment in the mining industries (including fuels) were at the same level as 1959, compared with a 20-percent increase for all manufacturing.

Activity under the Defense Mobilization Program was again at a low level. The U.S. Tariff Commission rejected applications by the zinc sheet, iron ore, and cement industries for relief under the national security clause of the Trade Agreements Act and under the Antidumping Act.

World mineral markets did not follow the U.S. pattern. World production increased 14 percent, compared with a 2-percent rise in the United States. World consumption of minerals was generally higher than in 1959, contrary to the U.S. pattern. World volume of physical stocks rose, but not as much as stocks in the United States. The relative stability of world mineral prices matched that for the United States. Ocean freight rates rose again in 1960.

DOMESTIC PRODUCTION

Value of Mineral Production.—The production value of metals, nonmetals, and mineral fuels was 4 percent higher than in 1959 and second only to the record high of 1957. The increase in total value was nearly two-thirds of a billion dollars. Nonfuel minerals value achieved a record high and represented 32 percent of the total value of mineral production, compared with 31 percent in 1959 and 29 percent in 1958 and 1957. Virtually all the changes in total value resulted from physical volume changes because unit prices were steady, compared with previous years.

The metal sector made a speedy recovery from the prolonged strikes in the steel and copper industries. The 40-percent and 37-percent increases in iron-ore and copper-ore production values, respectively, were the most significant factors in the metals sector. These increases caused a record high nonfuel minerals value.

The nonmetals sector was affected by slackening demand for construction materials—cement, clays, gypsum, sand and gravel, and stone—mainly in residential building and only partly offset by increased demand for chemical and fertilizer materials. The result was a less than 0.5 percent increase in total value of nonmetals other than fuels.

Volume of Mineral Production.—The Bureau of Mines index of physical volume of mineral production increased three points in 1960, a 2-percent rise. The index rose to a high point, exceeded only by 1956, the second highest, and 1957, the highest. The metal index rose

TABLE 1.—Value of mineral production in United States by mineral group [1]

(Million dollars)

Mineral groups	1951–55 (average)	1956	1957	1958	1959	1960	Change in 1960 from 1959 (percent)
Metals and nonmetals except fuels:							
Nonmetals	2,432	3,266	3,267	3,346	3,721	3,730	(3)
Metals	1,728	2,358	2,137	1,594	1,570	2,021	+29
Total	4,160	5,624	5,404	4,940	5,291	5,751	+9
Mineral fuels	10,066	11,741	12,709	11,589	[2] 11,950	12,141	+2
Grand total	14,226	17,365	18,113	16,529	[2] 17,241	17,892	+4

[1] Beginning with 1953 Alaska and Hawaii are included.
[2] Revised figure.
[3] Increase less than 0.5 percent.

22.4 points, a 27-percent rise, and caused the rise of the all-mineral index. Ferrous metals, primarily iron ore, contributed heavily with a rise of 31.6 points, a 43-percent increase. The base and other nonferrous metals also contributed with rises of 18.1 and 25.0 points, 21-percent and 18-percent increases, respectively. Nonmetals made a 1.5-point gain, a 1-percent rise, of which chemical materials with a gain of 9.0 points offset the 1.2-point loss in construction materials.

TABLE 2.—Indexes of the physical volume of mineral production in the United States, by groups and subgroups [1]

(1947–49=100)

Year	All minerals	Metals						Nonmetals				Fuels
		Total	Ferrous	Nonferrous				Total	Construction	Chemical	Other	
				Total	Base	Monetary	Other					
1951	112.6	117.2	126.6	110.6	110.0	100.8	149.7	127.3	128.3	123.9	130.0	110.1
1952	110.9	112.7	109.5	114.9	109.4	97.4	251.8	132.1	134.6	127.7	124.2	107.8
1953	112.6	119.1	133.3	109.2	103.0	98.3	236.7	135.2	137.5	133.6	118.5	108.8
1954	107.9	97.6	95.5	99.0	93.2	93.6	205.2	146.4	152.4	140.9	107.8	104.0
1955	119.0	115.0	122.8	109.5	106.8	95.3	194.0	161.0	170.1	146.2	127.5	113.8
1956	125.8	117.1	116.6	117.4	116.1	94.9	206.8	172.6	179.9	163.5	135.8	120.5
1957	126.1	118.8	122.2	116.4	113.7	93.0	229.9	175.7	189.3	153.5	124.4	120.3
1958	115.5	90.8	79.3	99.0	98.2	87.9	144.7	176.2	195.7	142.7	111.7	110.2
1959	[2] 119.6	82.2	72.8	88.9	87.0	80.7	142.6	190.7	211.5	153.7	125.5	[2] 114.5
1960	122.6	104.6	104.4	104.3	105.1	82.7	167.6	192.2	210.3	162.7	125.3	115.3

[1] For description of index see Minerals Yearbook 1956, vol. I, Review of the Mineral Industries, pp. 2–5.
[2] Revised figure.

The Federal Reserve Board (FRB) indexes (tables 3 and 4) showed a similar overall rise. Weight differences between this index and the Bureau of Mines index as well as some differences in coverage and base years can result in different movements between the indexes, but the revised FRB indexes followed those of the Bureau closely.

The major advantage of the Bureau index is that it is available on a comparable basis since 1880. However, FRB indexes are available

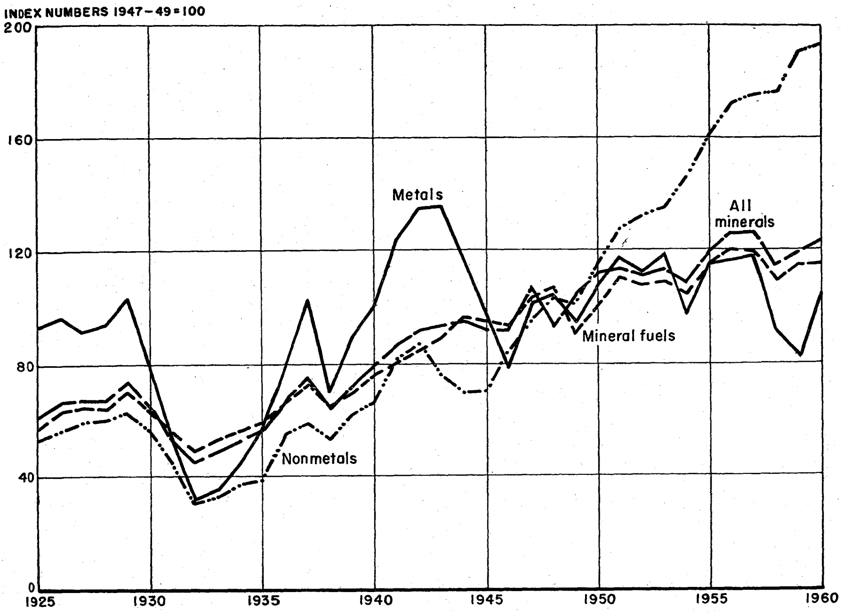

FIGURE 1—Indexes of physical volume of mineral production in the United States, 1925–60, by groups.

monthly and on a seasonally adjusted basis. The monthly indexes showed a rapid recovery from strikes in 1959 and then a leveling off in the metal mining industries. They reflected a continuously increasing production throughout the year in nonmetal mineral industries.

TABLE 3.—Indexes of production of metal and mineral mining, metals, nonmetallic products, and total industrial production, seasonally adjusted [1]

(1957=100)

Year	Metal, stone, and earth minerals mining	Iron and steel	Primary metals	Clay, glass, and stone products	Total industrial production
1953	82	102	100	88	91
1954	79	80	81	85	85
1955	91	106	106	97	96
1956	98	103	104	102	99
1957	100	100	100	100	100
1958	91	75	78	95	93
1959	94	86	90	110	105
1960	105	88	91	110	108

[1] Federal Reserve Bulletin, Industrial Production Indexes, March 1960, p. 316; March 1961, p. 350 and previous issues.

TABLE 4.—Monthly indexes of production, mining, metal mining and stone and earth minerals [1] seasonally adjusted

(1957=100)

Month	Mining [2]			Metal mining			Stone and earth minerals		
	1959	1960	Change from 1959 (percent)	1959	1960	Change from 1959 (percent)	1959	1960	Change from 1959 (percent)
January	97	98	+1.0	102	87	−14.3	101	108	+6.9
February	96	96		101	95	−5.9	101	106	+5.0
March	95	96	+1.1	101	104	+3.0	103	101	−1.9
April	98	98		99	106	+7.1	109	115	+5.5
May	99	97	−2.0	102	103	+1.0	109	114	+4.6
June	98	97	−1.0	94	97	+3.2	111	116	+4.5
July	94	98	+4.3	73	94	+28.8	111	118	+6.3
August	91	98	+7.7	48	96	+100.0	109	116	+6.4
September	90	96	+6.7	39	92	+135.9	108	114	+5.6
October	91	97	+6.6	42	88	+109.5	110	116	+5.5
November	96	98	+2.1	68	95	+39.7	113	113	
December	99	98	−1.0	80	107	+33.8	108	109	+1.0
Annual average	95	97	+2.1	77	96	+24.7	108	112	+3.7

[1] Federal Reserve Bulletin, Industrial Production Indexes, March 1960, p. 316; April 1960, p. 418; and March 1961, p. 350.
[2] Including fuels.

NET SUPPLY

Net Supply.—The net supply [3] of minerals and metals generally decreased in 1960. Iron, molybdenum, magnesium, and phosphate rock were the major exceptions. The declines can be attributed to the general increase of exports, the lead-zinc import-quota program, inventory reduction of the mineral-consuming industries through better inventory controls, the growth of productive capacity, and the waning of inflationary forces. Of the 34 commodities included in the net-supply tabulation, 23 decreased, and 11 increased. The net-supply analysis clearly showed that the recovery in 1958, which carried strongly through 1959, finally lost its steam and was reversed in 1960. The increase of exports prevented a poor year in the mineral industries.

Sources of Supply.—Imports continued as an important source of new supply. Of the commodities shown in table 5, the import contribution, 16 decreased, 5 increased, and 13 showed no change.

Sources of Imports.—Canada and Mexico expanded their share of the market in 7, lost 11, and maintained their position in 4 principal commodities. The other Western Hemisphere sources increased their share of the market in 8 principal commodities, declined in 6, and maintained their position in 1. Other free world markets increased in 11 and lost in 8 principal commodities. The largest shifts were in manganese, chromite, tungsten, copper, zinc, beryl, platinum, and fluorspar. The Soviet bloc was not a significant chromite supplier, but its markets for platinum and potash increased.

[3] Sum of primary shipments, secondary production, and imports, minus exports.

TABLE 5.—Net supply of principal minerals in the United States and components of gross supply [1]

(Thousand short tons unless otherwise stated)

Commodity	Net supply			Components as a percent of gross supply (gross supply=100)						Exports as a percent of gross supply	
	1959	1960	Change from 1959 (percent)	Primary shipments [2]		Secondary production [3]		Imports [4]			
				1959	1960	1959	1960	1959	1960	1959	1960
Ferrous ores, scrap, and metals:											
Iron (equivalent) [5]	92,977	103,222	+11	40	50	[6] 33	[6] 27	27	23	2	3
Manganese (content)	1,272	1,291	+1	11	7	-----	-----	[7] 89	[7] 93	1	1
Chromite (Cr_2O_3 content)	[8] 701	609	−13	6	7	-----	-----	94	93	[8] 1	(9)
Cobalt (content) thousand pounds	24,418	[10] 12,410	(11)	12	(12)	[13] 1	[13] 2	87	98	-----	-----
Molybdenum (content) do	32,656	39,170	+20	100	100	-----	-----	(9)	(9)	37	44
Nickel (content)	131	128	−2	11	11	4	4	85	85	-----	-----
Tungsten ore and concentrate (W content) short tons	4,810	4,999	+4	36	64	-----	-----	[7] 64	[7] 36	1	8
Other metallic ores, scrap, and metals:											
Copper (content)	1,718	1,585	−8	44	53	25	21	[7] 31	[7] 26	9	22
Lead (content)	1,107	1,074	−3	23	23	[14] 40	44	[7] 37	[7] 33	(9)	1
Zinc (recoverable content)	1,066	883	−17	39	48	7	8	[7] 54	[7] 44	1	3
Aluminum (equivalent) [15]	2,505	2,399	−4	[16] 14	[16] 17	3	2	[17] 83	[17] 81	[17] 6	[17] 12
Tin (content) long tons	66,827	65,186	−2	(9)	(9)	20	19	80	81	1	1
Antimony (recoverable content) [18] short tons	[8] 34,183	33,796	−1	[8] 5	3	[8] [13] 58	58	[7] 37	[7] 39	(9)	3
Beryl ore (BeO content) do	[8] 908	998	+10	4	4	-----	-----	96	96	(9)	1
Cadmium (content) [19] do	4,690	4,337	−8	33	41	-----	-----	[7] 67	[7] 59	9	22
Magnesium (content)	[8] 39,780	46,352	+17	[8] [20] 75	[20] 79	[8] 24	20	1	1	4	9
Mercury 76-pound flasks	65,273	58,088	−11	[20] 47	[20] 57	7	9	[7] 46	[7] 34	2	1
Platinum-group metals thousand troy ounces	1,130	716	−37	1	3	[21] 12	[21] 10	87	87	3	8
Titanium concentrate:											
Ilmenite and slag (TiO_2 content)	581	587	+1	59	71	-----	-----	41	29	-----	-----
Rutile (TiO_2 content)	26	35	+35	27	25	-----	-----	73	75	15	3
Uranium concentrate (U_3O_8 content) short tons	34,510	33,416	−3	47	53	-----	-----	53	47	-----	-----
Nonmetals:											
Asbestos	[8] 754	709	−6	6	6	-----	-----	94	94	[8] [22] 1	[22] 1
Barite, crude	1,542	1,355	−12	58	53	-----	-----	42	47	-----	-----
Boron minerals and compounds, finished products (gross weight)	366	340	−7	100	100	-----	-----	(9)	(9)	41	47
Bromine and bromine in compounds million pounds	186	166	−11	100	100	-----	-----	(9)	(9)	5	6
Clays	49,070	48,525	−1	100	100	-----	-----	(9)	-----	1	1
Flourspar, finished	[8] 725	767	+6	[8] 25	30	-----	-----	[7] 75	70	(9)	(9)
Gypsum, crude	[8] 16,732	14,231	−15	[23] 63	[23] 63	-----	-----	37	37	-----	-----
Mica (except scrap) thousand pounds	12,724	9,020	−29	5	6	-----	-----	95	94	8	7
Phosphate rock (P_2O_5 content) thousand long tons	3,999	4,213	+5	99	99	-----	-----	1	1	21	22
Potash (K_2O equivalent)	2,373	2,337	−2	91	92	-----	-----	9	8	12	17
Salt (common)	25,764	26,114	+1	96	96	-----	-----	4	4	2	2
Sulfur, all forms (content) [24] thousand long tons	5,917	5,722	−3	90	90	-----	-----	10	10	22	24
Talc and allied minerals	748	686	−8	97	97	-----	-----	3	3	7	8

[1] Net supply is sum of primary shipments, secondary production, and imports, minus exports. Gross supply is total before subtraction of exports.

[2] Primary shipments are mine shipments or mine sales (including consumption by producers) plus byproduct production. Shipments more nearly represent quantities marketed by domestic industry and as such are more comparable to imports. Use of shipments data rather than production data also permits uniform treatment among more commodities.

[3] From old scrap only.

[4] Imports for consumption except where otherwise indicated; scrap is excluded wherever possible both in imports and exports but all other sources of minerals through refined or roughly comparable stage are included except when commodity description indicates earlier stage. Exports of foreign merchandise (reexports), if any, are included when imports are general.

[5] Iron ore reduced to estimated pig-iron equivalent; reported weights used for all other items of supply.

[6] Receipts of purchased scrap.

[7] General imports; corresponding exports are of both domestic and foreign merchandise.

[8] Revised figure.

[9] Less than 0.5 percent.

[10] Sum of secondary production and imports only.

[11] Figure not comparable. 1960 figure did not include primary production to avoid disclosing individual company confidential data.

[12] Figure withheld to avoid disclosing individual company confidential data. Figure is not included in net and gross supply.

[13] Consumption of purchased scrap.

[14] Includes recovery from old scrap, dross, and residues, which are a part of so-called new scrap.

[15] Includes 87 percent of bauxite mine production (rather than shipments) and imports, and 92 percent of alumina imports, both converted to estimated aluminum equivalent (3.832 long tons bauxite and 1.913 short tons of alumina to 1 short ton aluminum) in 1959; 87 and 92 percent in 1960 (3.836 and 1.897 conversion factors). These percentages are based on estimated proportions used in producing the metal. To avoid a duplicate adjustment for nonmetallic use, export of bauxite to Canada were excluded from exports.

[16] Mine production of bauxite.

[17] Includes ingot equivalent (weight × 0.9) of imports of scrap, largely scrap pig. Some duplication occurs because of small quantity of loose scrap imported, which is also reflected in secondary production. See also footnote 15.

[18] Based on recovery from all forms as a byproduct from domestic and foreign sources.

[19] Primary shipments are estimated as a percentage of total primary production of metal, decreasing with increasing imports of lead and zinc; imports are represented by sum of remaining percentage of such production plus imports of metal. In 1960 the ratio was 45:55; in 1959, 39:61. Primary compounds not made from metal, data for which cannot be disclosed, are excluded for both years. Secondary includes recovery from both old and new scrap. Secondary data cannot be disclosed and are included with primary.

[20] Primary production of metal.

[21] Recovery from both old and new scrap.

[22] Exports of foreign merchandise (that is, reexports) are included.

[23] Estimated by adjusting production, excluding byproduct, for changes in producers' stocks.

[24] For pyrites, includes sulfur content (48 percent) of production.

TABLE 6.—Percentage distribution of imports of principal minerals consumed in the United States, by country group of origin [1]

Commodity	Canada and Mexico		East and South Pacific [2]		Other Western Hemisphere		Other free world		Soviet bloc [3]	
	1959	1960	1959	1960	1959	1960	1959	1960	1959	1960
Ferrous ores, scrap, and metals:										
Iron (equivalent)[4]	37	30	17	20	41	46	5	4	(5)	(5)
Manganese (content)	9	8	2	1	25	32	64	59	------	------
Chromite (Cr_2O_3 content)	------	------	------	------	3	2	92	97	5	1
Cobalt (content)	3	4	------	------	------	------	97	96	------	------
Nickel (content)	79	71	------	------	18	16	3	13	------	------
Tungsten ore and concentrate (W content)	1	3	32	13	21	18	46	66	------	------
Other metallic ores, scrap, and metals:										
Copper (content)	31	26	44	56	3	1	23	17	------	------
Lead (content)	39	38	38	38	1	2	23	22	------	------
Zinc (recoverable content)	65	70	21	19	(5)	1	14	10	(5)	------
Aluminum (equivalent)[6]	6	4	(5)	------	85	88	11	8	------	------
Tin (content)	1	(5)	1	2	(5)	(5)	98	98	------	------
Antimony (recoverable content)[7]	21	23	13	9	2	1	64	67	------	------
Beryl ore (BeO content)	------	------	------	------	66	59	34	41	------	------
Cadmium (content)[8]	78	91	3	1	------	------	19	2	------	------
Mercury	12	13	5	1	------	(5)	83	86	------	------
Platinum-group metals	25	29	(5)	(5)	3	5	59	50	13	16
Titanium concentrates: Rutile, ilmenite and slag (TiO_2 content)	43	39	17	20	------	------	40	41	------	------
Uranium (U_3O_8 content)[9]	75	72	(10)	(10)	------	------	25	28	------	------
Nonmetals:										
Asbestos	92	92	1	1	(5)	(5)	7	7	(5)	------
Barite, crude	57	44	18	18	(5)	4	25	35	------	------
Fluorspar, finished	61	55	------	------	------	------	39	45	------	------
Gypsum, crude	91	89	------	------	9	11	(5)	(5)	------	------
Mica (except scrap)	(5)	(5)	------	(5)	16	16	84	84	------	------
Potash (K_2O equivalent)	2	2	2	2	------	------	93	91	3	5
Sulfur (content)	100	100	------	------	------	------	(5)	(5)	------	------

[1] Data are based on imports for consumption and are classified like net new supply shown in table 5. U.S. Department of Commerce, Bureau of Census, United States Imports of Merchandise for Consumption—Commodity by Country of Origin 1960: Rept. FT 110, May 1961. Imports that are less than 5 percent of net new supply are omitted.
[2] West coast of South America (Salvador, Chile, Bolivia, Peru, and Ecuador), New Zealand, New Caledonia and Australia.
[3] U.S.S.R., Bulgaria, East Germany, Albania, Czechoslovakia, Hungary, Estonia, Latvia, Lithuania, Poland, Rumania, China, North Korea, and North Viet Nam.
[4] Includes iron ore, pig iron, and scrap.
[5] Less than 0.5 percent.
[6] See footnotes 15 and 17, table 5.
[7] Excludes antimony from foreign silver and lead ores.
[8] Metal and flue dust only.
[9] U.S. Atomic Energy Commission, Major Activities in Atomic Energy Program: January-December 1959, January 1960, p. 61; January-December 1960, January 1961, p. 120.
[10] Imports from Australia were included in other free world imports.

CONSUMPTION

Patterns.—Domestic consumption of minerals was generally lower than in 1959. Declines were marked (over 10 percent) in 10 of the commodities in tables 7 and 8. Altogether consumption of 23 commodities decreased and 11 increased. The largest decreases were in aluminum, barite, gypsum, mica, and platinum (all over 14 percent). Beryl, iron ore, manganese, and tungsten increased substantially (15 to 21 percent). Five other commodities made minor gains. The consumption analysis clearly indicated that 1960 was marked by a slackening of activities, covering the entire range of mineral commodities, except for steel-associated minerals.

TABLE 7.—Reported consumption of principal metals and minerals in the United States

Commodity	1959	1960	Change from 1959 (percent)
Antimony [1] ....thousand short tons..	13, 317	13, 267	(2)
Barite, crude ....do....	1, 396	1, 190	−15
Bauxite ....thousand long tons, dried equivalent..	[3] 8, 619	8, 883	+3
Beryl [4] ....short tons..	8, 173	9, 692	+19
Chromite ....thousand short tons, gross weight..	1, 337	1, 220	−9
Cobalt ....thousand pounds..	9, 899	8, 930	−10
Copper, refined ....thousand short tons..	1, 463	1, 350	−8
Fluorspar, finished ....do....	590	644	+9
Iron ore ....thousand long tons, gross weight..	93, 662	108, 050	+15
Lead ....thousand short tons..	1, 091	1, 021	−6
Magnesium, primary ....short tons..	[3] 41, 551	37, 100	−11
Manganese ore ....thousand short tons, gross weight..	[3] 1, 606	1, 946	+21
Mercury ....76-pound flasks..	54, 895	51, 167	−7
Mica splittings ....thousand pounds..	7, 223	6, 227	−14
Molybdenum, primary products [5] ....thousand pounds, Mo content..	32, 350	31, 837	−2
Nickel, exclusive of scrap ....short tons..	112, 661	108, 159	−4
Platinum-group metals (sales to consumers) ....thousand troy ounces..	896	775	−14
Tin ....long tons..	77, 373	80, 560	+4
Titanium concentrate:			
Ilmenite and slag ....thousand short tons, estimated TiO_2 content..	578	585	+1
Rutile ....do....	22	23	+5
Tungsten concentrate ....short tons, W content..	[3] 9, 835	11, 605	+18
Zinc, slab ....thousand short tons..	956	878	−8

1 Includes antimony content of antimonial lead produced at primary lead smelters and antimony content of alloys imported.
2 Less than 0.5 percent.
3 Revised figure.
4 Beryl ore of 10–12 percent BeO content.
5 Comprises ferromolybdenum, molybdic oxide, and molybdenum salts and metal.

TABLE 8.—Apparent consumption of metals and minerals in the United States [1]

Commodity	1959	1960	Change from 1959 (percent)
Aluminum [2] ....thousand short tons..	[3] 2, 488	2, 015	−19
Asbestos, all grades [4] ....do....	754	709	−6
Boron minerals and compounds [5] ....thousand short tons, gross weight..	366	340	−7
Bromine and bromine in compounds ....million pounds..	186	166	−11
Cadmium, primary ....thousand pounds, Cd content..	[3] 11, 471	10, 166	−11
Clays ....thousand short tons..	49, 070	48, 525	−11
Gypsum, crude ....do....	[3] 16, 732	14, 231	−15
Phosphate rock ....thousand long tons, P_2O_5 content [6]..	4, 079	4, 238	+4
Potash ....thousand short tons, K_2O equivalent..	2, 373	2, 337	−2
Salt, common ....thousand short tons..	25, 761	26, 114	+1
Sulfur (all forms) ....thousand long tons, S content..	5, 917	5, 860	−1
Talc and allied minerals ....thousand short tons..	782	722	−8

1 Covers commodities for which consumption is not reported.
2 Includes 1959 shipments to Government of 73,000 short tons and in 1960, 37,000 short tons.
3 Revised figure.
4 No adjustments for national stockpile acquisitions.
5 Reported as finished products.
6 Estimated at 31 percent of gross weight.

Sales and Orders.—Seasonally adjusted sales of primary metals declined throughout the year following the recovery peak in December 1959, resulting from the steel strike. For the year sales were down 3 percent from 1959, a decline of $777 million. Sales of the stone, clay, and glass-manufacturing industries were up 0.6 percent or $53 million. New orders in the primary-metal industry declined steadily from the first of the year. New orders were down 33 percent, a decrease of $6.5 billion.

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TABLE 9.—Sales, primary metal industry and stone, clay, and glass industry, and new orders, primary metal industry [1]

(Million dollars)

Year and month	Primary metal		Stone, clay and glass
	Sales	Net new orders	Sales
1956	28,339	29,028	8,982
1957	27,852	25,504	8,489
1958	22,949	22,504	7,658
1959	26,567	28,978	8,687
1960	25,790	22,420	8,740
1960: [2]			
January	2,730	2,230	750
February	2,690	2,200	770
March	2,540	1,720	700
April	2,310	1,810	750
May	2,240	1,960	750
June	2,010	1,780	760
July	2,110	1,890	750
August	1,980	1,840	730
September	1,920	1,850	730
October	1,790	1,640	700
November	1,790	1,750	700
December	1,750	1,770	700

[1] U.S. Department of Commerce, Office of Business Economics, Survey of Current Business: Vol. 41, No. 3, March 1961, pp. S-4 and S-5.
[2] Seasonally adjusted data; therefore will not add to 1960 total.

STOCKS

Indexes of Stocks.[4]—Bureau of Mines indexes of physical stocks held by mineral manufacturers, consumers, and dealers at yearend and stocks held by primary producers at yearend increased and reached record highs in 1960. Crude mineral stocks of primary producers gained substantially. The total minerals index increased 24 points, a gain of 19 percent. The increase was caused principally by a sharp rise in stocks of iron ore and other ferrous-metal ore; nonmetal stocks declined slightly. Mineral stocks of manufacturers, consumers,

TABLE 10.—Index of stocks of minerals of mineral manufacturers, consumers, and dealers at yearend

(1955=100)

Yearend	Total metals and nonmetals [1]	Metals					Nonmetals [1]
		Total	Iron	Other ferrous	Base nonferrous	Other nonferrous	
1951	[2] 75	[2] 75	79	68	72	[2] 69	102
1952	[2] 90	[2] 90	94	86	87	[2] 88	97
1953	[2] 105	[2] 105	105	108	106	[2] 103	112
1954	[2] 99	[2] 99	101	117	95	[2] 101	94
1955	[2] 100	[2] 100	100	100	100	[2] 100	100
1956	[2] 111	[2] 111	102	98	117	[2] 135	128
1957	[2] 130	[2] 129	126	122	122	[2] 180	161
1958	[2] 131	[2] 130	131	[2] 130	122	[2] 160	168
1959	[2] 128	[2] 127	127	[2] 147	116	[2] 157	173
1960	143	141	137	143	130	210	196

[1] Excluding fuels.
[2] Revised figure.

[4] The indexes were developed by William A. Vogely, chief economist, Bureau of Mines.

and dealers also increased but not as substantially as crude stocks. Unlike crude stock, the index of nonmetal stocks of these groups increased 13 percent over 1959.

TABLE 11.—Index of stocks of crude minerals at mines or in hands of primary producers at yearend

(1955=100)

Yearend	Total minerals [1]	Metals				Nonmetals
		Total	Iron ore	Other ferrous	Other	
1951	[2] 91	[2] 121	131	149	[2] 83	79
1952	[2] 99	[2] 121	129	197	[2] 72	90
1953	[2] 105	[2] 135	133	326	[2] 73	93
1954	[2] 114	[2] 146	165	163	[2] 87	100
1955	[2] 100	[2] 100	100	100	[2] 100	100
1956	[2] 123	[2] 122	128	152	[2] 97	124
1957	[2] 144	[2] 158	158	405	[2] 72	138
1958	[2] 140	[2] 155	164	[2] 340	[2] 63	135
1959	[2] 128	[2] 155	172	[2] 246	[2] 74	117
1960	152	241	290	213	112	116

[1] Excluding fuels.
[2] Revised figure.

The following commodities are included in the index of stocks of manufacturers, consumers, and dealers: Aluminum, arsenic, bauxite, bismuth, cadmium, cement, chromite, copper, ferrous scrap and pig iron, fluorspar, iron ore, lead, manganese ore and ferromanganese, mercury, molybdenum primary products, nickel, platinum-group metals, tin, titanium concentrates, tungsten concentrates, and zinc. The index of stocks of primary producers includes the following commodities: Antimony, bauxite, fluorspar, gypsum, iron ore, mercury, molybdenum, phosphate rock, potassium salts, sulfur, titanium concentrates, and tungsten. Primary market prices of each commodity were used as weights in the first index; average mine values were used in the second.

Value of Inventories.—The value of inventories held by firms in the primary-metal industry, seasonally adjusted, gained steadily until June. The inventory value declined each month thereafter, $370 million above the December 1959 value at yearend.

TABLE 12.—Seasonally adjusted book value of inventory, primary metal industry and stone, clay, and glass, December 1956–59 and monthly 1960 [1]

(Million dollars)

Year and month	Primary metal	Stone, clay, and glass	Year and month	Primary metal	Stone, clay, and glass
1956: December	3,975	1,711	1960: April	4,630	1,420
1957: December	4,269	1,270	May	4,700	1,430
1958: December	4,111	1,200	June	4,800	1,440
1959: December	4,120	[2] 1,360	July	4,750	1,440
1960: December	4,490	1,440	August	4,710	1,440
January	4,200	1,370	September	4,640	1,460
February	4,320	1,380	October	4,570	1,460
March	4,450	1,420	November	4,520	1,430

[1] U.S. Department of Commerce, Office of Business Economics, Survey of Current Business: Vol. 41, No. 2, February 1961, p. S-5.
[2] Revised figure.

The value of inventories held by firms in the stone, clay, and glass industry, seasonally adjusted, was steady throughout the year, slightly above the December 1959 value at yearend.

LABOR AND PRODUCTIVITY

Employment.—Total employment in the mineral industries recovered from the decline in 1959, reached a peak by June, and then tapered off during the last half of the year. The year average was 7 percent over 1959 and 1 percent above 1958. Iron mining followed the general pattern of the mineral industries. Employment in copper mining, which experienced the longest strike in its history in 1959, recovered steadily throughout the year whereas lead and zinc continued the downward trend. Nonmetal mining and quarrying employment increased after March but dropped off during the last quarter of the year, following the usual seasonal trend. The pattern in the mineral manufacturing industries was mixed; it declined slightly in the fertilizer and cement industries; however, employment in iron and steel mills made the strongest recovery since 1957. Employment in secondary smelting and refining of nonferrous metal industries showed no change, whereas employment in primary metals increased 10 percent.

The following tabulation shows major changes in average employment in 1960, compared with 1959:

	Percent
All industries	+3
Mining (including fuels)	−2
Metals and minerals (except fuels)	+7
Metal mining	+14
Nonmetal mining and quarrying	+2
Fuels	−5
Mineral manufacturing [1]	+8

[1] Based upon categories listed under mineral manufacturing in table 13.

For the first year since 1956, the mineral industries, except fuels, fared substantially better than all industries. The gain was attributed to metal mining and manufacturing industries, except lead and zinc that were recovering from long labor-management disputes.

Hours and Earnings.—Average weekly hours of production workers in the mining industry continued upward in 1960. Hourly earnings also increased, so that average weekly earnings were 5.6 percent above 1959.

All categories of mining except nonmetallic mining and quarrying, rose similarly in average hours and earnings; iron and copper mining increased the most in weekly earnings (8 percent). Nonmetallic-mineral-manufacturing industries showed some small increase in weekly earnings. Metal-manufacturing industries varied and indicated a slight decline in weekly earnings.

TABLE 13.—Total employment in the mineral industries (nonfuel) in the continental United States, by industry[1]

(In thousands)

Year and month	Mining					
	Total	Nonmetallic mining and quarrying	Metal			
			Total[2]	Iron	Copper	Lead and zinc
1957	224.5	113.3	111.2	38.9	32.6	16.7
1958	202.4	109.3	93.1	30.8	28.6	12.9
1959	[3] 190.8	110.7	[3] 80.1	27.2	22.3	12.3
1960:						
January	177.8	105.1	72.7	32.6	11.1	12.2
February	192.7	104.1	88.6	32.9	26.4	12.3
March	196.1	102.9	93.2	33.4	30.2	12.3
April	207.7	112.6	95.1	34.2	31.3	12.3
May	221.8	115.7	96.1	35.3	31.3	11.9
June	213.5	116.8	96.7	35.3	31.9	11.4
July	212.4	117.9	94.5	34.2	31.1	11.1
August	213.2	118.3	94.9	34.1	32.0	10.7
September	211.1	117.4	93.7	32.9	32.3	10.4
October	209.7	117.1	92.6	32.4	32.4	9.8
November	204.3	114.3	90.0	29.4	32.6	10.1
December	199.6	109.2	90.4	29.7	32.6	10.4
Year (average)	204.2	112.6	91.6	33.0	29.6	11.3

Year and month	Mineral manufacturing				
	Fertilizers	Cement, hydraulic	Blast furnaces, steel works, and rolling mills	Smelting and refining of nonferrous metals	
				Primary	Secondary
1957	35.8	42.0	642.7	68.1	13.2
1958	35.6	42.0	536.7	56.2	11.5
1959	36.9	41.7	522.0	52.2	12.2
1960:					
January	35.9	39.8	638.8	53.2	12.7
February	37.2	38.4	640.1	54.7	12.6
March	39.4	39.0	635.9	57.8	12.6
April	48.8	41.2	620.5	59.4	12.4
May	44.1	42.1	606.5	58.6	12.1
June	35.8	43.0	580.0	59.2	11.9
July	31.6	43.2	549.0	59.1	11.8
August	31.7	42.9	540.3	58.7	12.2
September	33.9	41.9	524.6	57.4	12.3
October	34.7	40.7	515.3	56.6	12.0
November	33.7	39.1	499.0	56.2	11.8
December	35.0	37.6	484.7	56.1	11.8
Year (average)	36.8	40.7	569.4	57.3	12.2

[1] U.S. Department of Labor, Bureau of Labor Statistics. Published in Monthly Labor Review, and Employment and Earnings. Data are based on reports from cooperating establishments and cover both full- and part-time employees who worked during or received pay for any part of pay period ending nearest 15th of month. Data are for "all employees;" those for "production and related workers" are also available in these publications.
[2] Includes other metal mining, not shown separately.
[3] Revised figure.

Labor Turnover Rates.—Accession rates declined and separation rates and layoff rates increased in the mineral industries during 1960. This trend followed closely the pattern of recovery and recession. Lead and zinc mining continued to be weak. Toward the second half of the year separation and layoff rates in iron mining increased sharply, indicating a drop in activity.

TABLE 14.—Average hours and gross earnings of production and related workers in the mineral industries (nonfuel) in continental United States, by industries [1]

Year	Mining								
	Total [2]			Metal					
				Total [3]			Iron		
	Weekly		Hourly earnings	Weekly		Hourly earnings	Weekly		Hourly earnings
	Earnings	Hours		Earnings	Hours		Earnings	Hours	
1956	$91.06	43.4	$2.10	$96.83	42.1	$2.30	$96.71	39.8	$2.43
1957	93.21	42.4	2.21	98.74	40.8	2.42	103.49	39.5	2.62
1958	92.62	41.3	2.26	96.22	38.8	2.48	100.27	36.2	2.77
1959	[4] 98.72	42.3	2.34	103.31	40.2	2.57	107.34	37.4	2.87
1960	104.22	42.5	2.45	111.49	41.6	2.68	115.20	40.0	2.88
	Metal—Continued						Nonmetallic mining and quarrying		
	Copper			Lead and zinc					
1956	$100.28	43.6	$2.30	$89.24	41.7	$2.14	$85.63	44.6	$1.92
1957	97.75	40.9	2.39	88.97	41.0	2.17	87.80	43.9	2.00
1958	94.62	39.1	2.42	85.93	39.6	2.17	89.63	43.3	2.07
1959	106.17	42.3	2.51	90.63	40.1	2.26	95.48	43.8	2.18
1960	114.75	43.3	2.65	92.29	40.3	2.29	98.29	43.3	2.27
	Mineral manufacturing								
	Fertilizer			Cement, hydraulic			Blast furnaces, steel works, and rolling mills		
1956	$67.68	42.3	$1.60	$83.84	41.3	$2.03	$102.06	40.5	$2.52
1957	71.83	42.5	1.69	87.91	40.7	2.16	104.79	39.1	2.68
1958	74.03	42.3	1.75	92.92	40.4	2.30	108.00	37.5	2.88
1959	78.12	43.4	1.80	98.98	40.9	2.42	122.28	39.7	3.08
1960	80.41	43.0	1.87	102.87	40.5	2.54	116.66	38.0	3.07
	Electrometallurgical products [5]			Other [5]			Primary smelting and refining of nonferrous metals		
1956	$88.22	40.1	$2.20	$102.47	40.5	$2.53	$91.46	41.2	$2.22
1957	93.26	40.2	2.32	105.18	39.1	2.69	95.82	40.6	2.36
1958	99.79	40.4	2.47	108.09	37.4	2.89	99.05	40.1	2.47
1959	104.64	40.4	2.59	122.67	39.7	3.09	105.93	40.9	2.59
1960	110.30	40.7	2.71	116.73	37.9	3.08	109.33	41.1	2.66
	Primary smelting and refining of copper, lead, and zinc [6]			Primary refining of aluminum [6]			Secondary smelting and refining of nonferrous metals		
1956	$88.81	41.5	$2.14	$95.34	40.4	$2.36	$85.04	42.1	$2.02
1957	89.91	40.5	2.22	103.68	40.5	2.56	87.53	40.9	2.14
1958	90.12	39.7	2.27	111.91	40.4	2.77	88.84	40.2	2.21
1959	95.94	41.0	2.34	117.68	40.3	2.92	94.16	41.3	2.28
1960	100.86	41.0	2.46	122.40	40.8	3.00	94.24	40.1	2.35

[1] U.S. Department of Labor, Bureau of Labor Statistics, Employment and Earnings: Ann. Supp. Issue, vol. 6, No. 11, May 1960, pp. 112–113. Employment and Earnings, vol. 7, No. 8, February 1961, pp. 32–33, 37.
[2] Weighted average of data for metal mining and nonmetallic mining and quarrying, computed by author of chapter, using figures for production workers as in Monthly Labor Review Table A–3 as weights.
[3] Includes other metal mining, not shown separately.
[4] Revised figure.
[5] Component of blast furnaces, steel works, and rolling mills.
[6] Component of primary smelting and refining of nonferrous metals.

TABLE 15.—Wages and salaries in the mineral industries in the United States [1]

(Million dollars)

Industry	1959	Change from 1958 (percent)	1960	Change from 1959 (percent)
All industries	[2] 258,474	[2] +7.8	271,319	+5.0
All mining	3,834	+1.6	3,832	−.1
Nonfuel mining	1,067	+2.3	1,165	+9.2
Metal mining	479	−2.8	568	+18.6
Nonmetallic mining and quarrying	588	+6.9	597	+1.5
Fuel mining	2,767	+1.3	2,667	−3.6
Manufacturing	[2] 84,720	+10.5	87,411	+3.2
Primary metal industries	7,237	+11.1	7,470	+3.2
Stone, clay and glass products	2,947	+13.0	3,042	+3.2

[1] U.S. Department of Commerce, Office of Business Economics, Survey of Current Business: Vol. 41, No. 7, July 1961, p. 26, table 49.
[2] Revised figure.

TABLE 16.—Average annual earnings in the mineral industries in the United States [1]

Industry	1959		1960	
	Average	Change from 1958 (percent)	Average	Change from 1959 (percent)
All industries	[2] $4,557	[2] +4.8	$4,705	+3.2
All mining	5,540	+6.1	5,685	+2.6
Nonfuel mining	5,444	+6.0	5,462	+.3
Metal mining	5,841	+7.8	6,108	+4.6
Nonmetallic mining and quarrying	5,158	+5.0	5,330	+3.3
Fuel mining	5,578	+6.2	5,686	+1.9
Manufacturing	5,215	+5.6	5,342	+2.4
Primary metal industries	6,332	+8.0	6,341	+.1
Stone, clay and glass products	5,207	+6.0	5,337	+2.5

[1] U.S. Department of Commerce, Office of Business Economics, Survey of Current Business: Vol. 41, July 1961, p. 27, tables 52 and 53.
[2] Revised figure.

TABLE 17.—Monthly labor-turnover rates in the mineral industries, 1959 average, and 1960 by months [1]

(Per 100 employees)

Turnover rate	All manufacturing	Hydraulic cement products	Blast furnaces, steel works, and rolling mills	Primary smelting and refining of nonferrous metals: copper, lead, zinc	Metal mining			
					Total metal mining	Iron mining	Copper mining	Lead and zinc mining
Total accession rate:								
1959 average	3.6	2.2	[3] 3.4	[3] 2.0	2.7	[2] 3.6	[2] 2.8	2.8
1960:								
January	3.6	1.1	2.3	1.9	3.6	4.0	(4)	2.8
February	2.9	3.0	1.8	2.1	2.4	2.1	(4)	2.4
March	2.7	3.0	1.2	1.9	3.9	1.9	6.0	2.8
April	2.8	5.5	1.2	2.7	6.0	6.1	6.3	4.4
May	3.2	3.4	1.3	1.8	3.6	1.8	2.6	2.7
June	3.9	3.9	1.9	2.7	4.0	2.2	4.6	4.0
July	2.9	1.6	2.3	2.2	2.8	1.0	3.5	2.5
August	3.8	2.2	2.5	3.4	2.7	.6	4.4	2.3
September	3.8	4.1	2.9	2.2	3.4	2.0	4.4	1.4
October	2.8	.9	2.0	2.1	2.1	.6	2.1	1.3
November	2.3	1.0	2.1	1.4	1.5	.4	1.6	1.1
December	1.9	1.1	2.3	1.6	1.7	2.1	.9	2.4
Average	3.1	2.6	2.0	2.2	3.1	2.0	[5] 3.6	2.5
Total separation rate:								
1959 average	3.4	2.1	[2] 1.4	1.8	2.6	[2] 2.0	[2] 2.5	2.9
1960:								
January	2.9	3.4	1.3	1.6	2.2	1.3	(4)	1.7
February	3.0	3.4	1.8	1.7	1.7	1.1	(4)	2.2
March	3.7	3.9	3.1	1.4	3.1	.6	2.7	4.0
April	3.6	1.6	3.1	2.2	2.6	1.0	1.9	4.3
May	3.3	1.2	5.3	2.3	2.7	1.3	2.5	3.9
June	3.3	1.3	5.6	1.4	3.2	1.5	2.6	2.9
July	3.6	2.9	5.7	3.2	3.3	2.7	2.3	3.5
August	4.3	5.1	5.2	2.4	3.7	2.8	3.2	3.6
September	4.4	4.0	4.8	3.9	4.3	5.3	3.5	2.2
October	3.8	3.7	6.0	2.5	3.6	6.1	2.2	1.1
November	3.9	4.9	6.0	2.3	4.3	8.1	2.1	1.4
December	4.1	7.2	5.4	2.6	6.2	13.7	2.3	4.1
Average	3.7	3.6	4.4	2.3	3.4	3.8	[5] 2.5	2.9
Layoff rate:								
1959 average	1.6	1.0	[2] .4	.3	.6	[2] .6	[2] .3	.7
1960:								
January	1.3	2.6	.4	.4	.7	.6	(4)	.1
February	1.5	2.6	.8	.1	.3	.4	(4)	.1
March	2.2	3.1	2.1	.1	.5	(6)	.5	.5
April	2.0	.7	2.1	.2	.2	.2	.2	.3
May	1.6	.4	4.4	.2	.2	.5	.1	.2
June	1.7	.5	4.7	.1	.3	.3	.2	.2
July	2.0	1.9	4.8	1.6	1.1	2.1	.3	(6)
August	2.2	3.4	4.4	.4	1.0	1.8	.6	.1
September	2.0	1.9	3.8	1.1	1.6	4.0	.5	(6)
October	2.2	2.7	5.2	.7	2.0	5.3	.3	.1
November	2.7	4.4	5.3	.8	2.8	7.6	.5	.3
December	3.0	6.7	4.9	1.2	3.9	11.4	.6	.7
Average	2.0	2.6	3.6	.6	1.2	2.9	[5] .4	.2

[1] Department of Labor, Bureau of Labor Statistics: Employment and Earnings, Monthly and Annual Supplement, table D-1. Rates are based upon labor turnover data for each entire month.
[2] 7-month averages.
[3] Revised figure.
[4] Not available, because of work stoppage.
[5] 10-month average.
[6] Less than 0.05.

Productivity.—Productivity generally increased in metal mining, except that copper mining declined. Indexes for lead-zinc and iron reached record highs.

In 1956 an index of lead-zinc production per man-hour (1949 base) was derived by the Bureau of Mines to fill a void left when the

Bureau of Labor Statistics (BLS) ceased publication of its index. BLS published the index through 1957 on the 1947 base.[5] To make the Bureau of Mines index comparable with the BLS labor productivity indexes for copper- and iron-ore mining (table 18), the lead-zinc productivity index was revised and computed on a production worker basis instead of an all employee basis. Comparison between the Bureau of Mines index and that of BLS converted to a 1949 base

TABLE 18.—Labor-productivity indexes for copper- and iron-ore mining[1]

(1947-49=100)

Year	Copper		Iron	
	Crude ore mined per—		Crude ore mined per—	
	Production worker	Man-hour	Production worker	Man-hour
1951-55 (average)	123.6	121.8	120.0	117.3
1956	135.4	137.2	133.1	135.3
1957	138.1	149.0	131.4	134.4
1958	142.7	161.2	116.6	[2] 130.3
1959	167.5	174.7	125.3	135.4
1960 [3]	163.6	166.7	151.7	153.2
	Recoverable metal [4] per—		Recoverable metal [4] per—	
	Production worker	Man-hour	Production worker	Man-hour
1951-55 (average)	115.7	114.0	110.5	107.8
1956	116.1	117.6	109.7	111.5
1957	118.0	127.3	107.0	109.5
1958	124.5	140.6	88.8	[2] 99.2
1959	136.0	141.9	[2] 90.3	[2] 97.6
1960 [3]	133.8	136.4	107.1	108.2

[1] U.S. Department of Labor, Bureau of Labor Statistics, Monthly Labor Review: Vol. 79, No. I, February 1956.
[2] Revised figure.
[3] Preliminary.
[4] Figures refer to usable ore rather than recoverable metal. For iron, usable ore is that product with the desired iron content (by selective mining, mixing of ores, washing, jigging, concentrating, sintering).

TABLE 19.—Labor-productivity indexes for lead-zinc-ore mining[1]

(1949=100)

Year	Recoverable lead and zinc from ore mined per— Production worker	Recoverable lead and zinc from ore mined per— Man-hour [2]	Year	Recoverable lead and zinc from ore mined per— Production worker	Recoverable lead and zinc from ore mined per— Man-hour [2]
1949	100.0	100.0	1955	106.6	107.6
1950	111.3	110.8	1956	106.6	105.6
1951	106.0	102.1	1957	109.5	109.3
1952	101.3	98.7	1958	114.8	120.0
1953	104.6	103.9	1959	120.8	124.7
1954	102.7	104.5	1960	134.5	138.2

[1] U.S. Department of Interior, Bureau of Mines, Minerals Yearbook; U.S. Department of Labor, Bureau of Labor Statistics, Employment and Earnings.
[2] Revised figure and based on production workers.

[5] U.S. Department of Labor, Bureau of Labor Statistics, Indexes of Output per Man-Hour for Selected Industries, 1939 and 1947–59; July 1960, p. 5.

shows little difference. The Bureau of Mines index, since it is timely, will continue to be used in this review.

PRICES AND COSTS

Index of Mine Value.—The index of average unit mine value, presented for the first time in the 1959 Review of the Mineral Industries chapter, for all minerals (including fuels), was down slightly in 1960; this was the fourth successive yearly decline. However, the decrease in the total mineral index was again due entirely to a decline in the fuel index. Both metal and nonmetal indexes indicated small gains. These gains were general in both groups; every subgroup increased except other nonferrous metals, which was unchanged. The decline in the average unit mine value of minerals brought it nearer to that for all wholesale prices. The average unit value of minerals was 122 in 1959 and 121 in 1960; the average unit value for wholesale prices was 119.5 in 1959 and 119.6 in 1960.

The difference between this and other published indexes is illustrated by the monetary-metal index. The Treasury price of gold and silver does not change from year to year, but the index does. The variations are caused by movements in the differential between smelter purchase price for ore and refined metal prices. The index of mine value is believed to reflect more accurately the actual per-unit mine return.

Prices.—Prices of mineral commodities were generally slightly higher, except for a large drop in the price of iron and steel scrap and a minor decline in that of iron and steel. The former showed the greatest decline not only in annual average price but also for January to December 1960. All commodities listed except bituminous binders showed greater variation in price than the average of all commodities, but again the variations were smaller than they had been in past years.

TABLE 20.—Index of average unit mine value of minerals produced in the United States, by group and subgroup

(1947–49=100) [1]

Year	All minerals	Metals						Nonmetals				Fuels
		Total	Ferrous	Nonferrous				Total	Construction	Chemical	Other	
				Total	Base	Monetary	Other					
1950	105	109	126	98	98	101	91	104	104	104	108	105
1951	109	128	140	120	124	100	121	109	107	111	122	107
1952	110	132	155	117	119	103	114	111	108	113	127	107
1953	115	137	171	113	114	104	122	116	111	125	124	112
1954	115	140	175	116	117	106	132	117	110	130	126	111
1955	116	156	180	138	144	104	144	119	111	135	131	111
1956	120	171	195	154	163	104	148	122	114	136	142	114
1957	127	157	207	121	121	109	161	124	115	138	148	123
1958	123	150	213	105	102	111	147	124	115	137	146	120
1959	122	158	216	117	116	111	152	126	119	135	147	118
1960	121	162	217	122	123	112	152	127	121	136	149	116

[1] For description of index see Review of Mineral Industries; Chap. in Minerals Yearbook: Vol. 1, 1959, pp. 22–24.
[2] Revised figure.

TABLE 21.—Price relatives for selected metals and mineral commodities, January and December 1960, and annual averages [1]

(1947-49=100)

Commodity	1960 January	1960 December	Change from January (percent)	Annual average 1959	Annual average 1960 [2]	Change from 1959 (percent)
Iron ore	168.4	172.9	+2.7	169.9	171.0	+0.6
Iron and steel scrap	105.3	71.2	−32.4	100.2	82.9	−17.3
Iron and steel	172.4	168.6	−2.2	172.0	170.0	−1.2
Nonferrous metals	142.2	133.9	−5.8	136.1	139.0	+2.1
Clay products	161.3	162.3	+.6	160.2	161.8	+1.0
Gypsum products	133.1	133.2	+.1	133.1	133.2	+.1
Concrete ingredients	142.0	142.0	----------	140.3	142.1	+1.3
Building lime	143.1	144.4	+.9	142.8	144.2	+1.0
Insulation material	102.9	98.9	−3.9	103.1	104.0	+.9
Asbestos-cement shingles	168.4	177.6	+5.5	166.0	173.6	+4.6
Bituminous binders (Jan. 1958=100)	100.0	100.0	----------	100.0	100.0	----------
Fertilizer materials	108.8	111.9	+2.8	106.9	109.6	+2.5
All commodities (minerals and all other)	119.3	119.5	+.2	119.5	119.6	+.1

[1] U.S. Department of Labor, Bureau of Labor Statistics, Wholesale Price Index: Annual and monthly releases; also published currently in Monthly Labor Review.
[2] Preliminary. Monthly Wholesale Price and Price Indexes, December 1960 and January 1961, pp. 5-7.

TABLE 22.—Price relatives for selected cost items in nonfuel mineral production, January and December 1960 and annual averages [1]

(1947-49=100)

Commodity	1960 January	1960 December	Change from January (percent)	Annual average 1959	Annual average 1960 [2]	Change from 1959 (percent)
Coal	124.1	123.1	−0.8	122.6	121.8	−0.7
Coke	170.4	170.4	----------	169.8	170.4	+0.4
Gas fuels (Jan. 1958=100)	116.6	120.0	+2.9	110.9	116.6	+5.1
Petroleum and products	114.4	120.8	+5.6	116.6	117.5	+0.8
Industrial chemicals	124.1	123.5	−0.5	123.8	124.2	+0.3
Lumber	126.1	115.0	−8.8	127.1	121.4	−4.5
Explosives	145.2	151.9	+4.6	143.6	147.9	+3.0
Construction machinery and equipment	173.6	177.0	+2.0	171.9	175.6	+2.2

[1] U.S. Department of Labor, Bureau of Labor Statistics, Wholesale Price Index: Annual and monthly releases; also published in Monthly Labor Review.
[2] Preliminary. Wholesale Price and Price Indexes, December 1960 and January 1961, pp. 5-7 (Monthly).

Costs.—Most cost items increased in price, compared with 1959. Gas fuel showed the greatest increase. Notable exceptions were lumber, which declined markedly, and coal, which declined slightly.

Relative Labor Costs.—The index of labor costs per pound of recoverable metal increased in copper-ore mining, but declined in lead-, zinc-, and iron-ore mining. A similar situation prevailed in labor costs per dollar of recoverable metals. The value of recoverable metal per man-hour remained unchanged for copper but increased for lead-, zinc-, and iron-ore mining.

Index of Metal Mining Expenses.—Since this index excludes capital costs and contract work, it does not represent changes in total unit cost of metal mining. It does, however, gage the impact of labor costs and productivity change as well as changes in prices of supplies and fuels that are used by the mining industry. Reflecting the decrease of costs of labor (adjusted for productivity), the index declined 5 points and marked the first reverse of the rising cost trend since 1955. The decline in the total index was attributed to the 8-point drop in labor expense.

TABLE 23.—Indexes of relative labor costs, copper-, lead-zinc-, and iron-ore mining

(1949=100)

Year	Labor costs per pound of recoverable metal [1]			Value of recoverable metal per man-hour [2]			Labor costs per dollar of recoverable metal [3]		
	Copper	Lead-zinc [4]	Iron ore	Copper	Lead-zinc [4]	Iron ore	Copper	Lead-zinc [4]	Iron ore
1949	100	100	100	100	100	100	100	100	100
1950	91	92	96	128	110	114	83	93	90
1951	97	111	100	146	131	132	77	86	88
1952	108	124	115	146	117	130	86	104	95
1953	122	117	129	160	92	150	82	133	97
1954	126	115	153	166	94	130	82	128	113
1955	119	119	128	233	107	168	62	120	93
1956	129	129	143	254	110	170	60	124	96
1957	124	126	158	194	101	176	81	137	101
1958	115	115	184	190	95	159	85	146	118
1959	117	116	[5] 199	226	105	[5] 157	73	138	[5] 124
1960 [6]	129	106	179	226	122	173	78	120	112

[1] Index computed from data in tables 14, 18, and 19.
[2] Index computed from data in tables 18 and 19, multiplied by price of electrolytic copper, average lead and zinc, and iron ore, and rebased.
[3] Index computed by author using above index of value and data in table 14.
[4] Revised index, computed by author, based on new labor productivity index for lead-zinc-ore mining.
[5] Revised figure.
[6] Preliminary.

TABLE 24.—Index of principal metal mining expenses [1]

(1947-49=100)

Year	Total	Labor [2]	Supplies	Fuels
1950	96	93	100	101
1951	106	101	116	102
1952	113	114	114	102
1953	[2] 119	124	114	104
1954	[2] 127	135	115	104
1955	[2] 119	123	117	102
1956	[2] 128	135	121	101
1957	133	139	127	105
1958	[2] 137	144	129	106
1959	[2] 143	154	130	106
1960	138	146	130	107

[1] Indexes constructed by author, using weights derived from the 1954 Census of Mineral Industries and using data from U.S. Department of Labor, Bureau of Labor Statistics, Wholesale Price Index: Annual and monthly releases and labor cost index from table 23.
[2] Revised figure.

INCOME

National Income Originated.—Income originated in metal mining gained by 31 percent in 1960, reversing the downward trend that started in 1957. Speedy recovery from the long steel and copper strikes was principally responsible for this gain. Stone, clay, and glass products was the only group listed in table 25 to show a decline.

TABLE 25.—National income originated in the mineral industries in the United States [1]

Industry	Income, million dollars			
	1958 [2]	1959 [2]	1960	Change from 1959 (percent)
All industries	367,384	399,551	417,054	+4.4
Metal mining	757	664	869	+30.9
Nonmetallic mining and quarrying	750	813	833	+2.5
Total mining except fuels	1,507	1,477	1,702	+15.2
Total mining including fuels	5,435	5,466	5,516	+.9
Manufacturing	103,817	119,569	121,544	+1.7
Primary metal industries	9,109	10,404	10,589	+1.8
Stone, clay and glass products	3,772	4,485	4,427	−1.3
	Percent			
All industries	100.00	100.00	100.00	
Metal mining	.21	.17	.21	
Nonmetallic mining and quarrying	.20	.20	.20	
Total mining except fuels	.41	.37	.41	
Total mining including fuels	1.48	1.37	1.32	
Manufacturing	28.26	29.93	29.14	
Primary metal industries	2.48	2.60	2.54	
Stone, clay and glass products	1.03	1.12	1.06	

[1] U.S. Department of Commerce, Office of Business Economics, Survey of Current Business: Vol. 41, No. 7, July 1961, p. 11, table 8. To arrive at national income, depletion charges are not deducted; this affects data for mining industries.
[2] Revised figures.

Profits and Dividends.—The annual rate of profit in 1960 on stockholders' equity (after corporate income taxes) was 10 percent lower than in 1959 for the mineral manufacturing corporations compared with 11.5 percent decrease for all manufacturing. However, cash dividends distributed by mineral manufacturing corporations increased but less than all manufacturing, in contrast to rate of profit.

Business Failures.—Mining failures continued to increase. Current liabilities of the firms reversed the 1959 decline and increased sharply. Both categories reached record highs.

TABLE 26.—Annual average profit rates on shareholder's equity, after taxes, and total dividends, mineral manufacturing corporations [1]

Corporations	Annual profit rate (percent)			Total dividends (million dollars)		
	1959	1960	Percent change 1960 from 1959	1959	1960	Percent change 1960 from 1959
All manufacturing	10.4	9.2	−11.5	7,908	8,280	+4.7
Primary metals	8.0	7.2	−10.0	941	955	+1.5
Primary iron and steel	8.0	7.2	−10.0	638	648	+1.6
Primary nonferrous metals	8.0	7.1	−11.2	302	307	+1.7
Stone, clay, and glass products	12.7	9.9	−22.0	297	301	+1.3

[1] Federal Trade Commission and Securities and Exchange Commission. Quarterly Financial Reports for Manufacturing Corporations, 1st Quarter and 4th Quarter 1960, tables 4 and 8.

TABLE 27.—Industrial and commercial failures and liabilities [1]

Industry	1958	1959	1960
Mining: [2]			
Number of failures	86	91	98
Current liabilities ... thousand dollars	17,619	8,363	19,650
Manufacturing:			
Number of failures	2,594	2,374	2,514
Current liabilities ... thousand dollars	227,979	199,373	269,985
All industrial and commercial industries:			
Number of failures	14,964	14,053	15,445
Current liabilities ... thousand dollars	728,258	692,808	938,630

[1] Dun & Bradstreet, Inc., Business Economics Department, Monthly Business Failures: New York, N.Y., January issues, 1959, 1960, 1961.
[2] Including fuels.

INVESTMENT

New Plant and Equipment.—Expenditures for new plant and equipment by fuel- and nonfuel-mining firms were the same as in 1959. The mining industry was lagging further behind all manufacturing, where expenditures for new plant and equipment increased 20 percent. Expenditures in the mining industry reflected the general trend of industry—speedy recovery from long labor-management disputes to a peak by midyear and then declined steadily through the last half of the year. While nonferrous metal manufacturing and stone, glass, and clay producing industries followed the pattern of the mining industry, the iron and steel industry increased its expenditures by 53 percent over 1959. The significantly large increase of the iron and steel industry made during a period of declining production reflected the intention of the industry to install new facilities and raise productivity to offset rising labor costs and to meet mounting foreign competition.

Issues of Mining Securities.—The mining industry (including fuels) was the source of 2.5 percent of all new corporate securities offered in 1960; this figure is above the 1.7 percent and 2.1 percent in 1959 and 1958, respectively. The percentage distribution between types of securities changed for mining, compared with 1957–59 as financing

TABLE 28.—Expenditures on new plant and equipment by firms in mining and selected mineral manufacturing industries [1]

(Billion dollars)

Industry	1958	1959	1960	1960 January-March	1960 April-June	1960 July-September	1960 October-December
Mining [2]	0.94	0.99	0.99	0.22	0.27	0.25	0.24
Manufacturing	11.43	12.07	14.48	3.09	3.76	3.62	4.01
Primary iron and steel	1.19	1.04	1.60	.33	.42	.42	.43
Primary nonferrous metals	.44	.31	.31	.07	.08	.07	.09
Stone, clay, and glass products	.40	.53	.62	.14	.17	.15	.16
Chemicals and allied products	1.32	1.23	1.60	.33	.40	.40	.46
Petroleum and coal products	2.43	2.49	2.64	.53	.69	.63	.78

[1] U.S. Department of Commerce, Office of Business Economics, Survey of Current Business: Vol. 40, No. 3, March 1960, p. 16; vol. 41, No. 3, March 1961, p. 14.
[2] Including fuels.

shifted more heavily toward bond financing. The total gross proceeds from corporate offerings were up $411 million, compared with 1959; mining proceeds gained $88 million. The 55-percent increase in proceeds in mining greatly exceeded the 4-percent gain in total corporate offerings and 6-percent increase in manufacturing.

Prices of Mining Securities.—The index of common-stock annual average prices of mining securities decreased in 1960, as did the composite and manufacturing indexes. The decline in the mining index was much more sharp than in other years. The indexes decreased 22 percent, 5 percent in manufacturing, and 2 percent in the composite.

TABLE 29.—Estimated gross proceeds of new corporate securities offered for cash in the United States in 1960 [1]

Type of security	Total corporate		Manufacturing		Mining [2]	
	Million dollars	Percent	Million dollars	Percent	Million dollars	Percent
Bonds	8,122	80	1,577	72	170	68
Preferred stock	393	4	41	2	1	[3] 1
Common stock	1,644	16	581	26	78	31
Total	10,159	100	2,199	100	249	100

[1] U.S. Securities and Exchange Commission, Statistical Bulletin: Vol. 20, No. 3, March 1961, p. 8. Substantially all new issues of securities offered for cash sale in the United States in amounts over $100,000 and with terms to maturity of more than 1 year are covered in these data.
[2] Including fuels.
[3] Less than ½ percent.

TABLE 30.—Indexes of common-stock annual average prices [1]

(1957–59=100)

Year	Composite [2]	Manufacturing	Mining [3]
1956	92.6	93.2	104.6
1957	89.8	90.7	107.2
1958	93.2	92.5	97.9
1959	116.7	116.5	95.0
1960	113.9	110.9	73.8

[1] Council of Economic Advisers, Economic Indicators (prepared for the Joint Economic Committee): April 1961, p. 30. Indexes are yearly averages of weekly closing-price indexes of common stock on New York Stock Exchange.
[2] In addition to mining and manufacturing, covers transportation, utilities, trade, finance, and service.
[3] Including fuels.

TRANSPORTATION

Data on rail and water transportation were not available for 1960, because they are not published until the late fall of the year after the year reported. Therefore the data in tables 31 and 32 cover 1958 and 1959.

The Maritime Administration, U.S. Department of Commerce, published a comprehensive tabulation of data on oceanborne and Great Lakes commerce of the United States in 1959.[6] This publication gives detailed shipping data by port of origin and port of destination by commodity. The United States is divided into 10 coastal areas: North

[6] U.S. Department of Commerce, Maritime Commission, Domestic Oceanborne and Great Lakes Commerce of the United States, 1959, With Summary for 1951–1959: May 1961, p. 18.

TABLE 31.—Indexes of average freight rates on carload traffic, 1958–59, and average revenue per ton, originated or terminated, 1957–59, in the United States

Item	Indexes [1] (1950=100)		Average revenue per ton [2] (dollars)		
	1958	1959	1957	1958	1959
Products of mines	115	117	3.11	3.16	3.13
Iron ore	125	138	2.19	2.39	2.46
Clay and bentonite	129	136	7.34	7.79	8.17
Sand, industrial	121	128	3.28	3.53	3.60
Gravel and sand, n.o.s.	116	116	1.40	1.35	1.36
Stone and rock, broken, ground and crushed	117	116	1.68	1.72	1.69
Fluxing stone and raw dolomite	129	139	1.73	1.89	1.96
Salt	112	115	6.76	6.96	6.84
Phosphate rock	111	100	2.47	2.34	2.15
Mineral manufacturers and miscellaneous [3]	123	118	11.52	11.85	11.54
Fertilizers, n.o.s.	119	115	8.11	8.37	8.12
Iron, pig	125	135	5.34	5.30	5.33
Cement: Natural and portland	105	95	4.31	4.03	3.74
Lime, n.o.s.	125	127	6.10	6.46	6.23
Scrap iron and scrap steel	122	129	4.13	4.39	4.43
Furnace slag	116	111	1.98	2.08	1.88
Nonmineral categories:					
Products of agriculture	117	114	8.71	8.66	8.39
Animals and products	123	118	23.73	24.21	23.92
Products of forests	124	125	8.04	8.35	8.33
Forwarder traffic	124	126	45.33	45.39	41.83
All commodities	118	118	6.63	6.96	6.94

[1] U.S. Interstate Commerce Commission, Bureau of Transport Economics and Statistics, Index of Average Freight Rates on Railroad Carload Traffic 1949–57: Statement RI-1, 1949–59, November 1961. Indexes are based on the Commission's 1-percent waybill sample. 1960 data are not available.
[2] U.S. Interstate Commerce Commission, Bureau of Transport Economics and Statistics, Freight Commodity Statistics, Class 1 Steam Railways in the United States: Statement 58100, 1957; 59100, 1958; and 60100, 1959, table 5.
[3] All manufacturers and miscellaneous.

Atlanta, South Atlantic, Gulf, California, Pacific Northwest, Great Lakes, Puerto Rico, Hawaii, Alaska, and Pacific Islands. For each area, data are given by dry cargo, tanker, commodity, and port.

The Great Lakes had almost 85 percent of the dry-cargo tonnage of domestic water commerce; coastwise traffic had 90 percent of the tanker tonnage. The following tabulation indicates the importance of minerals, including fuels, in Great Lakes shipping (in millions of short tons in dry cargo ships):

Commodity:	*1956*	*1957*	*1958*	*1959*
Iron ore	76.1	85.6	52.7	45.9
Bituminous coal and lignite	38.5	38.2	32.2	32.6
Crushed limestone	28.1	28.3	20.4	23.9
Building cement	1.7	2.1	1.9	2.3
Sand and gravel	1.8	1.6	1.0	1.6
All other commodities	8.3	8.0	5.9	10.4
Total	154.5	163.8	114.1	116.7

The mineral groups listed supplied 91 percent of the total traffic in 1959, compared with 95 percent during 1955–58. The change was attributed to increased shipments of agricultural commodities in 1959.

TABLE 32.—Rail and water transportation of mineral products in the United States, by products

(Thousand short tons)

Product	Rail [1] 1958	Rail [1] 1959	Rail Change from 1958 (percent)	Water [2] 1958	Water [2] 1959	Water Change from 1958 (percent)
Metals and minerals, except fuels:						
Iron ore	77,132	69,473	−10.0	54,114	47,454	−12.3
Iron and steel scrap	16,623	20,353	+22.4	1,631	1,744	+6.9
Metals and alloys	9,599	10,995	+14.5	} 2,339	} 3,933	} +68.1
Other ores and concentrates	17,831	16,497	−7.5			
Other scrap	1,852	1,977	+6.7			
Slag	5,636	6,193	+9.9	(3)	778	(3)
Sand and gravel	64,315	70,036	+8.9	} 55,512	} 64,988	} +17.1
Stone, crushed except limestone	53,774	54,613	+1.6			
Limestone, crushed	14,054	15,561	+10.7	24,134	27,188	+12.7
Cement	33,487	34,279	+2.4	5,141	5,683	+10.5
Phosphate rock	19,994	22,978	+14.9	3,122	2,589	−17.1
Clays	9,196	9,771	+6.3	2,174	2,197	+1.1
Sulfur	3,649	4,002	+9.7	3,927	4,680	+19.2
Other	24,539	26,193	+6.7	3,646	3,563	−2.3
Total	351,681	362,921	+3.2	155,740	164,797	+5.8
Mineral fuels and related products:						
Coal:						
Anthracite [4] [5]	23,770	20,358	−14.4	865	814	−5.9
Bituminous [4]	307,492	307,226	−.1	126,688	130,038	+2.6
Coke [4]	12,635	16,155	+27.9	279	285	+2.2
Crude petroleum	1,196	1,531	+28.0	67,888	72,356	+6.6
Gasoline	8,366	8,172	−2.3	92,226	93,011	+.9
Distillate fuel oil	} 8,475	} 8,066	} −4.8	72,541	73,192	+.9
Residual fuel oil				42,432	45,265	+6.7
Kerosine	} 18,134	} 18,761	} +3.5	9,346	9,325	−.2
Other				14,237	16,236	+14.0
Total	380,068	380,269	+0.1	426,502	440,522	+3.3
Total mineral products	731,749	743,190	+1.6	582,242	605,319	+4.0
Grand total, all products	1,181,457	1,223,397	+3.5	695,665	726,732	+4.5
Mineral products, percent of grand total:						
Metals and minerals, except fuels	30	30	----------	22	23	----------
Mineral fuels and related products	32	31	----------	61	61	----------
Total mineral products	62	61	----------	84	83	----------

[1] Revenue freight originated excluding forwarder and less-than-carlot shipments, for which data are not available. Source: Interstate Commerce Commission, Freight Commodity Statistics, Class I Steam Railways in the United States, for years ended Dec. 31, 1958 and 1959: Statements 59100 and 60100, Table 3.

[2] Domestic traffic—all commercial movements between any point in the 50 States or the United States territories and possessions and any other points. Traffic with Panama Canal Zone, Virgin Islands, and Defense Department vehicles carrying military cargoes excluded. Source: Department of the Army, Waterborne Commerce of the United States, calendar year 1958 and calendar year 1959, part 5, National Summaries.

[3] Not separately classified.

[4] Figures for rail shipments include briquets. For water shipment, briquets not reported by type of material; included with "Other."

[5] Includes anthracite to breakers and washeries (thousand short tons): 1958—10,587; 1959—8,601.

DEFENSE MOBILIZATION

Defense Production Act.[7]—The Defense Production Act (DPA) would expire on June 30, 1962 unless extended.[8] Of the $2.1 billion authorized borrowing authority, all had been committed by the delegated agencies at the end of 1960 except $116.4 million, which remained available for new programs. The probable ultimate net cost of the metals and

[7] Executive Office of the President, Office of Civil and Defense Mobilization, Report on Borrowing Authority: December 31, 1960, pp. 6–13.

[8] For further details see previous Minerals Yearbook chapters.

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TABLE 33.—Summary of Government inventories of raw materials, at acquisition cost and at market value

(Million dollars)

Type of acquisition	Inventory, December 31, 1959 [1]			Inventory, June 30, 1960 [2]		
	Total		Excess over stockpile objective	Total		Excess over stockpile objective
	Acquisition cost [3]	Market value [4]	Acquisition cost	Acquisition cost [3]	Market value	Acquisition cost
National stockpile (Public Law 520):						
Stockpile grade	5,897	6,127	1,925	5,834	6,081	1,886
Nonstockpile materials	313	151	313	319	155	320
Total	6,210	6,278	2,238	6,153	6,236	2,206
DPA inventory (Public Law 744):						
Stockpile grade	951	756	826	978	791	838
Nonstockpile materials	459	132	459	471	143	471
Total	1,410	888	1,285	1,449	934	1,309
Supplemental stockpile (Public Law 480):						
Stockpile grade	618	609	462	719	696	580
Nonstockpile materials	27	18	27	35	28	36
Total	645	627	489	754	724	616
Commodity Credit Corporation inventory (Public Law 608):						
Stockpile grade	125	131	63	113	108	65
Nonstockpile materials	10	4	10	6	8	6
Total	135	135	73	119	116	71
Federal Facilities Corporation (Public Law 608): Stockpile grade tin	10	9	10	10	9	10
Subtotals:						
Stockpile grade	7,601	7,632	3,286	7,654	7,685	3,379
Nonstockpile materials	809	304	809	831	334	833
Total	8,410	7,936	4,095	8,485	8,019	4,212

[1] GSA Summary of Raw Materials Inventories, December 31, 1959, DM-76-OC, Part A.
[2] Joint Committee on Defense Production, 10th Ann. Rept. S. Rept. 1, 87th Cong., 1st Sess., Jan. 9, 1961, p. 31. December 31, 1960 data not available.
[3] Acquisition cost of inventories includes open-market purchases at contract prices, intradepartmental transfers at market prices prevailing at time of transfer, transportation to first permanent storage location, beneficiating and processing costs, but does not cover cost of research, administrative and interest expenses, accessorial cost, storage, and handling.
[4] Because of mixed nature of individual commodities (types, quality, and grades) and lack of active trading in these materials, the market value of commodities not meeting stockpile specification and of inventory not having stockpile objectives was not calculated.

minerals program at the end of 1960 was $800 million, and if custodial, U.S. Treasury interest, and other administration expenses were included, it was $1,176 million.

National Strategic Stockpile Program.[9]—Deliveries to the strategic stockpile during 1960 were about $14 million, of which $10 million exceeded stockpile objectives. Commitments for future delivery of $44 million of strategic materials were canceled during the year. The disposal of surplus and obsolete materials from the strategic stockpile

[9] Executive Office of the President, Office of Civil and Defense Mobilization. Stockpile Rept. to Cong., January–June 1960, pp. vi–10; July–December, 1960, pp. vi–10.
The Joint Committee on Defense Production, 10th Annual Report, S. Rept. 1, 87th Cong., 1st sess., Jan. 9, 1961, pp. 19–40.

TABLE 34.—National stockpile objectives and inventory [1]

(Value in million dollars at market prices)

Objectives	Objectives: In effect Dec. 31, 1959	Objectives: In effect Dec. 31, 1960	Applicable inventory: On hand Dec. 31, 1959	Applicable inventory: On hand Dec. 31, 1960
Basic	2,400	2,150	2,300	2,090
Maximum	2,300	2,240	2,000	1,880
Total objectives	4,700	4,390	4,300	3,970
Excess over objectives	----------	----------	1,800	1,580
Outstanding commitments	----------	----------	15	10

[1] Executive Office of the President, OCDM, Stockpile Report to the Congress, July-December 1959, p. 2 and July-December 1960, p. VII.

and DPA inventories totaled $114 million, of which $96 million represented disposal from the strategic stockpile.

Office of Minerals Exploration (OME).[10]—Exploration for new sources of strategic and critical mineral commodities continued to be encouraged by government assistance under the program started in 1958, as the program under DPA was coming to a close. Of 41 applications received by OME under the program of matching government funds, 15 contracts were executed for beryllium, columbium, copper, lead, mercury, tantalum, and zinc projects in 9 States.

Eight Defense Minerals Exploration Administration (DMEA) projects were certified in 1960, covering copper, lead, nickel, tungsten, and zinc in 6 States. By the end of 1960, only 6 DMEA contracts remained in force. In 9 years of DMEA operation, discoveries or developments were certified on 392 of 1,159 contracts executed. The potential ore reserves discovered under the DMEA program were estimated to have a net recoverable value of nearly $1 billion at the prevailing market price. The cost of the program was approximately $31 million.

TABLE 35.—Commodities delivered under U.S. Government purchase regulations [1]

Commodity	Unit	Quantity delivered: 1959	Quantity delivered: 1960	Cumulation delivered as of Dec. 31, 1960	Total authorized purchases
Public Law 206, 83d Congress:					
Beryl ore	short dry tons	343	233	2,720	4,500
Mica [2]	short tons, hand-cobbed, mica or equivalent.	3,307	2,379	21,858	25,000

[1] GSA, Defense Materials Service, Report of Purchases under Purchase Regulations, as of December 31, 1959, and December 31, 1960. Only commodities listed for which purchases and/or deliveries made during 1960.

[2] The government terminated by June 30, 1960, all DPA contracts for the procurement of foreign mica.

[10] Department of the Interior, Office of Minerals Exploration, Fourth and Fifth Semiannual Reports and 1960 Quarterly Reports of OME.

Barter Program.[11]—During 1960, the Commodity Credit Corporation (CCC) negotiated $128.3 million worth of barter contracts of surplus agricultural commodities for strategic mineral materials, of which asbestos, bauxite, chemical grade chromite, industrial diamond, ferromanganese, fluorspar, manganese ores, and mica were the principal items.

Tungsten carbide powder, rare earths, and thorium were added to the list of strategic minerals eligible for barter in 1960.[12] As of December 31, 1960, strategic materials acquired through barter and held in CCC inventory pending transfer to the stockpile were valued at $85.9 million.

During 1960, CCC negotiated a number of transactions which converted existing dollar commitments of U.S. Government agencies to a barter basis. In some instances it was necessary to accept additional quantities of the mineral materials to effect these conversions and subsequently transfer them to the supplemental stockpile.

FOREIGN TRADE

Value.—Value of nonfuel mineral imports declined 1 percent. Value of exports increased sharply and achieved a record high, registering a 92-percent gain over 1959. The increase, $517 million, resulted from a large increase in the value of copper, iron and steel scrap, aluminum, iron ore and concentrate, molybdenum, nonferrous metal scrap, and phosphate rock exports. The first three commodities supplied 84 percent of the total increase of exports.

Tariffs.—On January 14, 1960, the U.S. Tariff Commission issued an "escape-clause" report on zinc sheet, and rejected an application instituted by a group of domestic producers for modification or withdrawal of trade-agreement concession applicable to the products under section 7 of the Trade Agreements Extention Act of 1951, as amended.

On February 29, 1960, the Commission released a report on its fluorspar investigation conducted under section 332 of the Tariff Act of 1930, made pursuant to Senate Resolution 162 of the 86th Congress, adopted August 21, 1959. The report described in detail the production, exports, imports, prices, and consumption of fluorspar in the United States. It also described channels of distribution, employment and wages, and financial experience and Government purchase and assistance program for the domestic industry; and the U.S. position in world production. In March, the Commission released a similar report of its investigation on lead-zinc conducted under the same Senate resolution.

On March 11, 1960, the Commission issued a statement of reasons for rejecting the claim that certain Canadian portland cement was dumped on the United States market within the meaning of the Antidumping Act of October 1921, as amended.

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[11] The Joint Committee on Defense Production, 10th Annual Report, S. Rep. 1, 87th Cong., 1st sess., Jan. 9, 1961, pp. 19–40.
Published and unpublished records of U.S. Dept. of Agriculture, Commodity Stabilization Service, Barter and Stockpiling Division.

[12] Details of the list, see USDA reports and announcements on barter contracts and exports.

On September 30, 1960, the Commission submitted to the President its first periodic report on the trade in nonmanufactured lead and zinc since the "escape-clause" action on October 1, 1958, which resulted in the imposition of import quotas on nonmanufactured lead and zinc. The Commission advised the President that the development in the trade in nonmanufactured lead and zinc did not warrant a change of lead and zinc import quotas. The President concurred with the Commission's recommendation.

TABLE 36.—Value of minerals and mineral products imported and exported by the United States, 1958–60 by commodity groups and commodities [1]

(Thousand dollars)

SITC No.	Group and commodity	Imports for consumption [2]			Exports of domestic merchandise [3]		
		1958	1959	1960	1958	1959	1960
	Metals (crude): [4]						
281-01	Iron ore and concentrates	231,563	312,415	321,713	34,426	33,824	57,575
282-01	Iron and steel scrap	10,095	11,639	6,386	97,447	167,239	244,579
	Ores of nonferrous base metals and concentrates:						
283-07	Manganese	76,364	74,810	82,262	700	819	719
283-11	Tungsten	11,960	4,235	3,478	17	5	1,251
283-06	Tin	11,244	23,282	31,104	-------	-------	-------
283-01	Copper	74,561	98,437	229,264	5,865	1,808	6,832
283-08	Chromium	28,206	31,853	24,239	49	3,084	320
283-05	Zinc	51,902	39,292	43,666	-------	1	3
283-03	Bauxite (aluminum ore) and concentrates	70,142	73,203	78,065	968	2,672	2,588
283-04	Lead	51,856	27,019	27,911	252	54	168
[5] 283-19	Columbium	2,346	2,652	3,687	37	13	150
283-02	Nickel	1,855	1,770	2,275	1	-------	-------
[5] 283-19	Titanium:						
	Ilmenite	6,766	7,991	5,066	} 172	290	167
	Rutile	4,513	2,943	3,611	}		
[5] 283-19	Cobalt	-------	-------	-------	-------	543	1,313
[5] 283-19	Molybdenum	5,530	-------	-------	15,045	24,778	39,843
[5] 283-19	Other	7,472	9,302	6,512	9,223	1,900	3,097
	Nonferrous metal scrap:						
284-01	Aluminum	2,969	3,299	1,598	5,595	10,485	26,905
	Old and scrap copper	2,676	1,654	3,524	9,429	5,292	31,384
	Old brass and bronze and clippings	1,852	698	184	[6] 10,456	[6] 12,497	[6] 52,220
	Other, not elsewhere included	3,663	3,277	3,804	3,285	3,494	6,081
285-02	Platinum-group metals	8,735	9,618	12,949	-------	-------	-------
	Total metals (crude)	666,270	739,389	891,298	192,967	268,798	475,195
	Metals (unwrought): [4 7]						
681-01	Pig iron and sponge iron	12,750	36,621	18,992	6,928	773	5,354
681-02	Ferroalloys:						
	Ferromanganese	11,046	14,067	19,008	464	388	203
	Ferrochromium	7,818	29,750	14,313	1,012	2,096	5,249
	Other	1,276	2,390	1,876	2,730	4,024	4,977
682-01	Copper	133,234	146,805	117,763	191,932	93,142	273,757
687-01	Tin	90,381	103,298	87,854	1,336	1,890	1,294
684-01	Aluminum	117,297	111,259	75,808	24,220	53,518	128,199
683-01	Nickel (including scrap)	87,565	111,485	116,679	-------	-------	-------
686-01	Zinc	35,625	34,002	29,646	797	2,841	18,389
685-01	Lead	76,217	71,506	70,335	661	943	865
{	Cobalt	28,664	35,926	17,093	(8)	(8)	(8)
689-01 {	Mercury	3,914	5,992	3,510	95	92	83
{	Other nonferrous base metals	21,795	62,521	17,592	8,123	12,787	29,695
671-02	Platinum-group metals, including unworked and partly worked	16,237	27,295	21,185	2,812	2,563	4,840
	Total metals (unwrought)	643,819	792,917	611,654	241,110	175,057	472,905
	Total metals (crude and unwrought)	1,310,089	1,532,306	1,502,952	434,077	443,855	948,100

See footnotes at end of table.

TABLE 36.—Value of minerals and mineral products imported and exported by the United States, 1958-60 by commodity groups and commodities [1]—Con.

(Thousand dollars)

SITC No.	Group and commodity	Imports for consumption [2]			Exports of domestic merchandise [3]		
		1958	1959	1960	1958	1959	1960
	Nonmetals (crude):						
	Diamonds:						
[5]672-01	Gems, rough or uncut	72,430	94,299	88,060	478	607	830
[5]272-07	Industrial	23,680	62,530	51,727	537	844	1,297
	Total	96,110	156,829	139,787	1,015	1,451	2,127
272-12	Asbestos, crude, washed or ground	58,314	65,007	63,345	407	763	845
271-02	Sodium nitrate	13,431	13,322	11,459			
272-13	Mica, unmanufactured (including scrap)	13,477	14,089	7,547	91	126	113
[5]272-14	Fluorspar	9,777	13,368	14,393	191	69	38
272-11	Stone for industrial uses, except dimension	7,890	12,927	9,443	921	641	687
272-06	Sulfur	13,551	13,901	15,457	41,367	42,000	42,262
271-03	Phosphates, natural, ground or unground	2,944	3,421	2,754	25,234	28,602	37,543
272-04	Clays	2,900	3,288	641	12,129	13,474	13,708
(9)	Other nonmetals (except fuels)	44,248	35,039	72,356	26,375	30,686	33,058
	Total nonmetals (crude)	262,642	331,191	337,182	107,730	117,812	130,381
	Grand total	1,572,731	1,863,497	1,840,134	541,807	561,667	1,078,481

[1] Grouping of commodities is based upon Standard International Trade Classification (SITC) of the United Nations. Basic data were compiled by Office of the Chief Economist, Bureau of Mines, from copies of unpublished tabulations prepared by Bureau of the Census for the United Nations; tabulations represent a tentative conversion of U.S. import and export classification to SITC categories. Some revisions in these data have been made by Office of the Chief Economist insofar as possible to (1) include for various classifications latest revisions compiled by Mae B. Price and Elsie D. Page of Bureau of Mines, from records of U.S. Department of Commerce; (2) incorporate in all years shown changes in assignments of classifications to SITC categories made by Bureau of the Census; and (3) in a few instances make other changes in such assignments that would make the data more comparable or more in line with SITC.

As could be expected, individual commodities and groupings shown or omitted will not in all instances be in accord with usual Bureau of Mines practice as followed in individual commodity chapters in this Minerals Yearbook. In a few instances, values will differ from those for the same commodity in corresponding chapter because of reclassifications, exclusions, or other reasons usually explained by footnotes in chapter.

[2] Includes items entered for immediate consumption, items withdrawn from bonded storage warehouse for consumption, and ores, etc., smelted and refined under bond—included at time smelted or refined product is withdrawn for consumption or for export.

[3] Includes both mineral products of domestic origin and foreign mineral products that have been smelted, refined, manufactured, or otherwise processed in United States.

[4] Excludes gold and silver.

[5] Part of SITC category indicated is covered; remainder of category is covered elsewhere in major grouping.

[6] Copper-base alloy scrap (new and old) including brass and bronze.

[7] Includes alloys.

[8] Exports, if any, are negligible and included with "Nonferrous metal scrap, other" 284-01; (see "Crude metallic minerals").

[9] Includes all SITC numbers 271-04; 272-01, 272-02, 272-03, 272-05, 272-08, 272-15, 272-16, and 272-19; and those parts of numbers 672-01, 272-07 and 272-14 not shown separately above.

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

On December 30, 1960, the Commission issued an "escape-clause" report on the duty-free status of iron ore, conducted under section 7 of the Trade Agreements Extension Act of 1951, as amended. The Commission found that iron ore was not being imported into the United States in such increased quantities as to cause or threaten serious injury to the competitive domestic industry and made no recommendation to the President for the modification or withdrawal of the concession.

During the year the Office of Civil and Defense Mobilization had no applications under consideration from any mineral industry under section 8 of the Trade Agreements Act, the so-called national defense clause.

WORLD REVIEW

World Production.—The United Nations index of world mining production (including fuels) increased to 138, compared with 121 in 1959 (1953=100). The 14-percent increase was much higher than the 2-percent rise for the United States.

World Consumption.—World consumption of minerals was generally higher than in 1959 in contrast to U.S. consumption. For the first 9 months of 1960, imports for consumption of iron ore in West Germany, United Kingdom, and Japan were 50 percent more than in the same period in 1959.[13] Consumption of copper outside the United States rose sharply enough to counterbalance falling demand in the United States. Free-world consumption of lead and zinc declined moderately—less than the drop in the United States. Free-world consumption of tin rose slightly but was behind the U.S. increase.

World Stocks.—Free-world stocks generally increased but not as much as the U.S. stocks. Iron ore, copper, lead, and zinc stocks all increased moderately, and tin stocks declined slightly.

World Prices.—Prices of metal ores recovered from the dip in 1959 and were slightly higher than in 1958. They were stable for the first three quarters of the year, but declined slightly in the last quarter. Price indexes for both minerals and primary commodities were somewhat softer.

Ocean Freight Rates.—Indexes of ocean freight rates increased sharply during the first quarter and drifted downward during the last three quarters but maintained the yearly upward trend begun in 1958. However, these indexes were low, compared with those of the 5 years preceding 1958.

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[13] United Nations, Commodity Survey, 1960, p. 212.

TABLE 37.—Index of world metal-mining production [1]

(1953=100)

Year	Free World	North America [2]	Latin America [3]	Asia: East and Southeast [4]	Europe [5]
1956	117	113	117	[6] 114	120
1957	125	122	[6] 130	[6] 113	[6] 127
1958	116	[6] 107	[6] 120	[6] 101	[6] 124
1959	[6] 121	[6] 106	[6] 124	[6] 104	[6] 121
1960	138	124	195	120	133
First quarter	126	106	160	115	130
Second quarter	145	137	201	118	137
Third quarter	143	136	198	123	125
Fourth quarter [7]	136	116	222	124	139

[1] U.N. Monthly Bulletin of Statistics: Vol. 15, May 1961, pp. 8–15.
[2] Canada and United States.
[3] Central and South America and Caribbean Islands.
[4] Afghanistan, Brunei, Burma, Ceylon, Singapore and the Federation of Malaya, Hong Kong, India, Indonesia, Iran, Japan, Republic of Korea, Pakistan, Philippines, Sarawak, China (Taiwan), Thailand, and the Republic of Viet Nam.
[5] Excluding Albania, Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, Rumania, and U.S.S.R.
[6] Revised figure.
[7] Provisional.

TABLE 38.—Index numbers of production in mining and quarrying, and production in basic metal industries in selected OEEC countries [1]

(1953=100)

Year	All member countries	Austria	Belgium-Luxembourg	France	Germany, West	Greece	Italy	Netherlands	Norway	Sweden	Turkey	United Kingdom
	Mining and quarrying											
1953	100	100	100	100	100	100	100	100	100	100	100	100
1954	101	109	[2] 97	103	104	123	110	100	101	91	88	101
1955	105	116	100	110	110	132	123	101	111	104	97	100
1956	108	120	100	113	115	150	139	102	123	115	107	100
1957	112	127	98	120	119	195	156	105	124	120	110	100
1958	110	124	92	128	119	205	159	110	123	112	(3)	95
1959	111	120	79	147	115	214	171	[2] 114	118	110	(3)	93
1960	116	128	79	168	119	(3)	180	124	129	128	(3)	90
	Basic metal industries											
1953	100	100	100	100	100	100	100	100	100	100	------	100
1954	[2] 112	119	[2] 109	114	116	103	119	117	103	110	------	108
1955	131	140	[2] 127	133	141	98	148	133	127	125	------	117
1956	139	151	[2] 137	140	150	102	162	131	154	137	------	119
1957	145	167	131	153	154	120	182	135	167	140	------	120
1958	139	165	126	158	146	132	171	134	[2] 171	[2] 134	------	109
1959	148	175	136	158	[2] 160	126	184	156	192	[2] 153	------	114
1960	(3)	204	149	(3)	186	(3)	228	(3)	218	160	------	(3)

[1] Organization for European Economic Cooperation (OEEC), General Statistics, No. 2, March 1961, pp. 6, 10.
[2] Revised figure.
7 Data not available

TABLE 39.—Apparent consumption of primary nonferrous metals—copper, lead, zinc and tin—in selected countries [1]

Country	Copper			Lead		
	Thousands of metric tons	Index (corresponding period of preceding year=100)		Thousands of metric tons	Index (corresponding period of preceding year=100)	
	1958	1959	1960, first half	1958	1959	1960, first half
World [2]	2,815.0	105	109	1,592.0	108	102
United States	950.6	114	86	572.1	109	91
United Kingdom	451.7	89	89	169.5	105	111
France	216.8	87	124	105.0	98	(3)
Germany, West	396.7	109	116	155.8	122	121
Japan	126.4	143	158	41.7	152	113
Belgium	72.6	95	(3)	45.4	114	111
Italy	112.3	109	167	60.5	101	102
Canada	111.5	106	99	43.9	103	98
Australia	59.8	100	113	33.8	98	126
India	57.6	94	116	21.5	123	97

Country	Zinc			Tin		
	Thousands of metric tons	Index (corresponding period of preceding year=100)		Thousands of metric tons	Index (corresponding period of preceding year=100)	
	1958	1959	1960, first half	1958	1959	1960, first half
World [2]	2,146.0	106	103	140.0	110	111
United States	787.5	108	92	48.8	95	107
United Kingdom	227.0	111	118	20.7	105	111
France	178.5	94	100	11.2	99	91
Germany, West	224.4	119	124	10.0	172	179
Japan	136.3	114	(3)	9.8	121	129
Belgium	87.6	116	102	[4] 2.1	[4] 113	[4] 134
Italy	62.4	101	124	3.5	118	108
Canada	54.3	110	90	3.3	129	100
Australia	74.6	108	115	3.2	111	112
India	62.6	76	118	4.2	105	100

[1] United Nations, Commodity Survey, 1960, April 1961, pp. 218–233.
[2] Excluding the central planning countries
[3] Not available.
[4] Belgium and Luxembourg.

TABLE 40.—World trade price and freight-rate indexes [1]

(1953=100)

Year	Price indexes			Trip charter freight rate indexes [2]		
	Primary commodities	Total minerals	Metal ores	General cargo	Ore	Fertilizers
1956	100	109	110	203	174	159
1957	102	114	107	145	138	131
1958	96	108	100	87	90	83
1959	94	103	99	93	90	75
1960	94	101	101	96	92	80
First quarter	95	102	101	100	102	90
Second quarter	94	101	101	95	91	(3)
Third quarter	94	101	101	93	89	69
Fourth quarter	93	100	100	95	87	73

[1] U.N. Monthly Bulletin of Statistics, March 1961, special tables A and C.
[2] United Kingdom indexes based upon weighted average of quotations by all nations on routes important to United Kingdom tramp fleet in 1951.
[3] Data not available.

Review of Metallurgical Technology

By Rollien R. Wells [1] and Earl T. Hayes [2]

THIS REPORT summarizes several technological advancements selected by the Bureau of Mines as being illustrative of the trend in metallurgy during 1960. It is not an all-inclusive list of metallurgical achievements. The authors have drawn freely from personal communications, interviews, papers delivered at technical meetings, and articles from the scientific press.

Metallurgists have contended that the significant advances in extractive metallurgy during the last decade have resulted from the availability, at a reasonable price, of large quantities of natural gas and oxygen. This stand has been strengthened by the activities of the metal-producing industries during 1960.

Steel was the word of the year. The headlines reporting reduced steel production tended to obscure the technological revolution that has been fomenting in the industry. Physical and process metallurgy have been changed and improved.

The announcement by United States Steel Corp. and General Electric Co. of a joint program to determine the feasibility of using low-cost steels in atomic reactors indicated the end of an era. Reactor materials have long been the unquestioned province of exotic metals such as zirconium, beryllium, and columbium. It has become painfully evident, however, that major material revisions must be made if atomic power is to be competitive with power produced by fossil fuel or falling water. Special steels possibly will play the key role in such a revision.

Twenty years ago, a steel with a tensile strength of a quarter million pounds per square inch was almost a rarity, and the few such steels produced were used almost entirely for piano wire and wire rope. More recently, amid the growing realization that dollars spent for steel can buy strength that more than compensates for weight, there has been a reexamination of high-strength steel for use in spacecraft, rockets, turbines, and chemical equipment. Research has shown that yield strengths exceeding 300,000 p.s.i. can be attained by selective additives or by the treatment known as ausforming. One low-alloy steel (a modified 4340) was heat-treated to an ultimate strength of 300,000 p.s.i. and still retained a fair ductility even at liquid air temperatures. This ductility would be of particular value in the structural components of missiles to withstand the stresses imposed by the very low temperatures of outer space. Cleanliness is imperative for the production of steels with strengths above 225,000 p.s.i. Under these circumstances, the dollar-a-pound added cost of

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vacuum-melting can be tolerated. In this connection, the world's largest vacuum-melting furnace, capable of making 5,000-pound heats, was put into full-scale operation by Kelsey-Hayes Co. at Utica, N.Y.

Basic-oxygen steelmaking, imported to the United States from Austria in 1954, has been making giant strides toward general acceptance. The principle is simple. Jets of high-purity oxygen are directed onto the surface of molten pig iron and scrap in a pear-shaped refining vessel. Limestone and fluidizers are added to form a slag which removes phosphorus, sulfur, manganese, and silicon. The result is a high-quality, low-carbon steel made in one-half to one-third the time taken by other methods.

The idea is not new; Sir Henry Bessemer suggested the possibility of using oxygen-enriched air when he applied for the patent on his pneumatic steelmaking process in 1856. Economic utilization of the idea, however, required the realization of tonnage production of oxygen at a reasonable price. Now, with more than 400 plants producing 100 billion cubic feet annually at less than 50 cents per thousand cubic feet, the oxygen converter process for steelmaking is here to stay. The oxygen converter doubles or triples capacity by reducing treatment time and decreases investment costs materially. One report is that this process cuts capital costs from $40 to only $15 per annual ingot ton. At Kaiser's Fontana plant, output has been doubled by three new basic furnaces that cost only one-third as much as the old open-hearth furnaces.

This does not mean that all of the open hearths will be torn down in favor of the new equipment. However, some experts predict that by 1965 at least 20 percent of all steel made in the United States will be made by the oxygen-converter process. On the other hand, at least 100 open hearths have been equipped for introducing oxygen to the bath by roof lances. Advocates claim that the results are as good as with the oxygen converter and that the slightly greater operating cost is offset by the utilization of existing equipment, hence eliminating new plant construction. In addition, the Ford Motor Co. recently announced the development of a process that may help remove the threat of obsolescence from the open-hearth furnaces. Burned lime is substituted for limestone, and a mixture of natural gas and oxygen is introduced into the bath through lances. The thermochemical reactions during the initial scrap-melting stage are so increased that production rates can be doubled or tripled, Ford reports. Many producers are dubious about the economics of this technique.

One disadvantage of the basic-oxygen process is that the converters normally cannot handle more than 20 percent scrap in the charge, since they are dependent on hot metal as a source of heat. Occasionally, scrap steel prices plummet as much as $10 per ton, making it advantageous to use as much scrap as possible. It appears likely, then, that even though the use of basic-oxygen converters is increasing, the industry will keep a substantial number of open hearths to maintain scrap-melting capacity.

During the year introduction of fuel into the bosh of a blast furnace graduated from a laboratory technique to a plant practice. Normally, all of the heat and reducing action in the blast furnace is supplied by relatively expensive (about $15 per ton) metallurgical coke. Injection of natural gas or fuel oil into the hot air blast supplies some of the heat more cheaply and accomplishes a portion of the reduction. The chief advantages, however, stem from the resulting higher blast temperature which effects greater furnace efficiency, higher productivity, and coke savings.

Encouraged by the successful investigations made by the Federal Bureau of Mines in an experimental blast furnace, U.S. Steel introduced natural gas into one of its big blast furnaces at the Fairless works. Although the company has not released detailed records on the full-scale test, it has reported that coke consumption was reduced from 1,400 to 1,160 pounds per ton of molten iron, while iron production was raised more than 10 percent.

The Colorado Fuel and Iron Corp. (C.F. & I.) also ran a successful series of natural-gas-injection tests in one of its blast furnaces at Pueblo, Colo. As a result, the company will convert all four of its furnaces to natural gas. C.F. & I. uses as gas-injection rate of about 5 percent of the normal air flow rate and achieves blast temperatures of 1,250° F.

Pittsburgh Coke and Chemical Co. tried using a 4-percent addition of waste coke-oven gas to the air stream at its Neville Island plant. A 12-percent boost in pig iron production and a 12-percent coke saving were reported.

Esso Research and Engineering Co. announced that it is working with Dominion Foundries and Oil Co. to perfect an oil-injection system for Dominion's new $10 million blast-furnace installation at Hamilton, Ontario. The Federal Bureau of Mines has conducted limited experiments with injection of solid fuels. Proponents of natural gas say that oil or coal can introduce unwanted sulfur into the iron product and point out that in small furnace tests natural gas injection results in efficiencies superior to those obtained by additions of oil, coke-oven gas, or solid fuel. It is conceded, however, that in some locations natural gas might be at an economic disadvantage. However, injection of some type of fuel into the bosh of blast furnaces probably will become a standard operating practice within the next few years.

Linde Co., Division of Union Carbide Corp., an oxygen producer, developed a generalized computer model of the blast furnace to help predict the results of operation variables without costly full-scale tests. Results of tests agree within 4 percent of the predicted data. On the basis of its investigation, Linde claims that an easy way to raise blast temperatures is to add oxygen to the air stream along with natural gas or oil. C.F. & I. reports that it will try this oxygen-fuel method during 1961.

The drive during recent years to achieve greater and greater blast-furnace throughput has led to the use of crushed and sized burden with pelletized fines and to the use of completely pelletized burden. This trend has given impetus to the continued research to develop methods of utilizing the low-grade portions of the country's dwindling iron-ore reserves. Current attention is focused chiefly on the silicious hematitic material known as jasper or semitaconite. This material although easier to crush than the magnetic taconites, is more difficult to concentrate because it does not respond to magnetic separation. Yet the mineral association is too intimate for the application of conventional gravity methods of upgrading.

M. A. Hanna Co. constructed a 10-ton-per-hour test plant near Cooley, Minn., to investigate the feasibility of treating semitaconites by roasting and magnetic separation. The Oliver Iron Mining Division of United States Steel Corp. also is looking into the possibilities of this treatment in a 5-ton-per-hour pilot installation completed in November at Trout Lake, Minn. The principle of magnetizing roasting has been known for at least 50 years, and the method was investigated on a pilot plant scale on the Mesabi Range in the early 1930's. Technically, the process was successful, but economically it was disappointing. Hanna and Oliver feel, however, that the process deserves a new look because of technological and economic changes.

The Allis-Chalmers Manufacturing Co.'s grate-kiln pelletizing process for agglomerating iron concentrates made its commercial debut at the new Humboldt Mining Co. plant near Ishpeming, Mich. The Humboldt plant, operated by Cleveland-Cliffs Iron Co., treats a hematite-bearing ore by grinding, desliming, and flotation to produce a plus 60-percent iron concentrate. This product is mixed with bentonite and formed into pellets in a balling drum. The green balls are dried and preheated on a traveling grate and fed into a rotary kiln for final heat treatment at 2,450° F. Less than a month after the Humboldt plant started operating, Cleveland-Cliffs (also operator of the Republic Mine) announced that the grate-kiln system would be included as part of the 900,000-ton-per-year expansion of the concentrating and pelletizing facilities at Republic, Mich.

Improvement of blast-furnace efficiency has reduced effort expended on investigations of the "direct reduction" processes, but interest in them continues. During the last 10 years, spurred on by rising costs and diminishing reserves, industry has spent millions of dollars on research to develop possible substitutes for the blast furnace. The result has been a steady parade of processes but a minimum of commercial applications.

One of the more successful processes has been operated on a 200-ton-per-day scale since March 1958 by Hojalata y Lamina, S.A. (HyL), Mexico's leading steel producer. The company began operating a second 500-ton-per-day unit in late 1960. M. W. Kellogg Co., designer and builder of the two plants, is reported to be negotiating with a Canadian firm to build an HyL plant at Fort William, Ontario. The process, a modification of the Maderas Process tested in a pilot plant by the Federal Bureau of Mines during World War II, involves a fixed-bed batch operation using reformed natural gas as a reductant.

The classic Wiberg-Söderfors process has been used commercially in Sweden since 1938 but has not found acceptance in the United States. By this process lump ore is reduced to sponge iron in a vertical-shaft furnace by a gas composed mainly of carbon monoxide. Another treatment that has found commercial favor in Europe but that has not received much attention in the United States is the 30-year-old Krupp-Renn process. Essentially, this is a semismelting operation, uniting ore and solid reductant in a rotary kiln.

The latest installation, a six-kiln plant at Essen-Borbeck, West Germany, has an annual capacity of 500,000 tons of "luppen" nodules containing about 92 percent metallic iron.

Several subfusion reduction processes, using variations of the rotary kiln, have been studied, but that method developed by Republic Steel Corp. and National Lead Co. has received the most notice in this country. The R–N process uses a countercurrent-fired rotary kiln and an excess of solid reductant. Even distribution of heat and controlled reduction are attained by admitting air at intervals along the ore bed. Now in the semicommercial stage, the R–N process has been used successfully since 1954 to treat 3,000-ton lots of a variety of ores.

The Höganäs process is a batch-type, subfusion method that has found limited use in producing special high-purity iron. Reduction is effected by packing ore, coke, and flux in a ceramic sagger and holding the temperature in a tunnel kiln at 2,100° F. for 12 to 36 hours. Originally a Swedish process, it was studied on a pilot-plant scale by the Federal Bureau of Mines in the middle 1940's. Since then a plant of the Hoeganaes Sponge Iron Co. has operated at Riverton, N.J. to produce iron powder.

Of the fluidized-bed reduction processes studied, only the H-iron process, developed by Bethlehem Steel and Hydrocarbon Research, Inc., has reached commercial operation. The method requires a high-grade feed, free of sulfur and phosphorus, a high reactor pressure (500 p.s.i.) and a relatively low temperature (1,000° F.). Reduction is effected by hydrogen produced by partial oxidation of natural gas. To prevent pyrophoricity of the fine product, it is treated in nitrogen at 1,500° to 1,600° F. before exposure to air. Since early 1959, Alan Wood Steel Co. has operated a 50-ton-per-day H-iron plant at Conshohocken, Pa., to produce a special low-carbon iron powder for the powder-metallurgy market. A second H-iron plant of 110-ton-per-day capacity, was placed in operation to supply melting stock to electric furnaces at the Vernon, Calif., plant of Bethlehem Pacific Coast Steel Corp.

The Nu-Iron process, developed and piloted on 2-ton-per-day scale by U.S. Steel, is a fluidized-bed method using hydrogen as a reductant. Operating conditions call for 1,300° F. and about 20 p.s.i. pressure. The pilot plant was technically successful, but owing to the present cost of hydrogen believed to be uneconomic in the United States. A similar process, that of Esso Research and Arthur D. Little, Inc., employs a three-stage, fluidized-bed reactor with a mixture of hydrogen and carbon monoxide as a reductant. The process operates at 1,450° to 1,650° F. and at 1 to 4 atmospheres pressure.

Two new processes involving pelletizing, prereduction, and electric furnace smelting were announced by industry. The Orecarb process, developed by the Swindel-Dressler Corp., includes preheating of ore and flux, mixing with coal fines, and pelletizing in a rotating retort. The pellets are prereduced to 25 percent metallic iron content in a rotary kiln at about 1,800° F. Final reduction and smelting are achieved in a conventional electric furnace. The Dwight-Lloyd-McWane method includes preparation of ore-coal-flux nodules in a "flying-saucer" pelletizer. These are treated on a downdraft sintering machine to obtain 50- to 70-percent reduction. Smelting to pig iron is effected in a submerged-arc electric furnace.

The Strategic-Udy process continues to attract attention. Essentially, the system comprises kiln prereduction with a solid reductant, followed by open-top electric smelting. Several projects incorporating the S–U system have been announced by industry but two are receiving more attention than the rest. Zechendorf Steel Co., a division of Webb and Knapp, Inc., has arranged for the installation of an S–U plant to treat copper smelter stag at Anaconda, Mont., for the production of semisteel with copper and zinc byproducts. The company has contracted for powder at an attractive price and reported that it negotiated contracts to supply steel to customers in the Northwest beginning in 1963. In Canada, New Mylamaque Explorations, Ltd., has contracted for Koppers of Canada, Ltd., to build an S–U plant at Kingston, Ontario, to treat a titanium-bearing iron ore; construction is scheduled for 1961.

In the United States, none of the direct-reduction processes is likely to supplant the efficient and reliable blast furnace, in spite of the high capital cost and inflexibility of operation that has earned it the name of "metallurgical monster." Yet under certan conditions, such as low-cost power and fuel, high-cost metallurgical coke, and a local but limited market, direct-reduction processes appear economically attractive. It is not improbable that future blast-furnace production will be supplemented by substantial production from direct-reduction units.

The biggest contender with iron and steel for headlines during 1960 came from aluminum. The first news story of significance appeared in late 1959 when a chemical journal reported that the Federal Bureau of Mines "with eternal optimism" was investigating a two-stage leaching process for recovery of aluminum oxide from ferruginous bauxites.

About midyear it was reported that a plant would be erected near Powhatan, Ohio, to recover 40,000 tons of aluminum sulfate annually from coal-mine waste by a newly developed North American Coal-Strategic Minerals leach process. The ultimate aim would be to produce alumina and, eventually, finished metal. However, the perennial problem conversion of sulfate to oxide, has not been solved. Researchers of the Commonwealth Scientific and Industrial Research Organization at Melbourne, Australia, also developed an acid route to producing alumina from clays and aluminous laterites.

Industrywide interest was sparked greatly in August when word leaked out that Canada's Aluminium Company of Canada, Ltd. (Alcan) was developing a method to eliminate the alumina-from-bauxite stage in the production of aluminum. Almost simultaneously it was announced that France's (and Europe's) major aluminum producers, Compagnie de Produits Chimiques et Electro-Metallurgiques (Pechiney) and Soc. d'Electro-Chimie, d'Electro-Metallurgie et des Acieries Electriques d'Ugine (Ugine) had joined forces to investigate similar processes to produce aluminum directly from bauxite. Past research to accomplish direct production always had bogged down in mechanical failures, but the dream still has persisted. Such a process possibly could lower appreciably the capital outlay for plant construction and permit significant reduction in operation costs. The mineral industry recognized the significance of the news that Alcan and Pechiney were reinvestigating the direct-reduction routes.

Aluminium, Ltd., announced plans to construct an 8,000-ton-per-year experiment plant at Arvida, Quebec, to use its "radically new" process. The plant, due to be completed in 2 years would cost only half as much as a conventional Hall plant of the same size. Pechiney and Ugine countered by revealing that they already have started construction of a semicommercial facility that is expected to be operating on a 3,000- to 5,000-metric-ton-per-year basis by early 1961.

Neither company released any details about its methods, so interested parties have had to read the recent patents and assemble educated guesses about who was doing what. Alcan probably will use a variation of the Gross sub-halide method, sometimes referred to as the disproportionation process. In brief, instead of purification in an alumina-extraction step, the metal is reduced directly from impure bauxite and distilled away from the impurities. The company has not revealed the method for reducing bauxite, but it is generally assumed that it is a carbothermic technique. The reduced mass is contacted with aluminum trichloride, ($AlCl_3$) at 1,000° to 1,200° C. and 1 atmosphere pressure. The volatile monochloride ($AlCl$) is formed, leaving the impurities behind. The $AlCl$ is cooled in a condenser by a shower of molten metal at about 700° C., and the reverse reaction occurs—metallic aluminum and aluminum trichloride are formed. The latter is recycled. An interesting engineering feature is Alcan's method of maintaining the 700° C. temperature of the molten metal bath in the condenser. A connecting compartment contains a floating bath of molten salt—sodium and aluminum chlorides—that absorbs heat from the metal and, in turn, is cooled by water coils.

Pechiney's only statement about its process is that the method to be tried involves "two-stage carbothermic reduction of bauxite." The company patents indicate that bauxite will be reacted with carbon and nitrogen to form aluminum nitride (AlN), followed by thermal decomposition of the nitride to yield aluminum and nitrogen. The second step is difficult because the nitride always is contaminated with unreacted carbon and alumina. These impurities, when present in the thermal-dissociation step, form aluminum cyanide ($AlCN$) and aluminum suboxide (Al_2O), both of which may react with metal vapor to form several undesirable side products. The Pechiney process meets the problem by the reaction of the nitride product in a vacuum at 3,100° F., followed by a multistep condenser system. The vapors pass through a heated graphite trap where the aluminum cyanide is removed as carbide and nitride sinter. The aluminum metal condenses in the center of a differential-temperature condenser; the suboxide decomposes to form metal powder and trioxide on the condenser walls.

However, not everyone is convinced that the Utopian route to aluminum will avoid the time-honored Bayer process for producing aluminum oxide from bauxite. Several alumina producers are spending their research and development dollars on plant and equipment improvement in an effort to increase efficiency and minimize costs.

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Recent examples of these efforts are embodied in the Kaiser Aluminum & Chemical Corp.'s new alumina plant at Gramercy, La.

The aluminum industry always has been highly successful in finding new and expanded uses for its product. Recently 5 firms announced that they have adopted all-aluminum, standard 6-ounce containers for frozen juice concentrates to be packed during 1961 under their 12 house brands. This is estimated to be 110 million cans or one-fifth of the concentrate industry's requirements for cans of this size. Additional concentrates will be packed in cans with aluminum bodies and tin-plate ends. Aluminum has entered the can business solely because its light weight results in substantial savings in freight. The tinplate suppliers profess unconcern about the drop-in-the-bucket loss of business; however, there is some worry about how far the aluminum-container trend may extend.

Copper producers, like steelmakers are investigating the advantages of oxygen. For example, the use of oxygen-enriched air shows promise in roasting sulfide ore; the operation is speeded, fuel cost is reduced slightly, and an exhaust gas is produced that is high in sulfur dioxide and that is suitable for processing to sulfuric acid. The International Nickel Company of Canada, Ltd. (Inco), adopted oxygen roasting at its Sudbury, Ontario, plant in 1957. Kennecott Copper Co. is making small-scale studies of oxygen-enriched air in the reverberatory furnace to reduce the volume of waste gases and, hence, heat losses. In Japan, the Nippon Mining Co. Ltd., is reported to be enthusiastic about an oxygen-converter smelting operation installed at the Hitachi mine in 1958. Sulfide concentrate is pelletized and dried. A small fraction of the concentrate is melted in a blast furnace to form a matte which is charged with the remaining dry pellets into a converter. Oxygen-enriched air reacts with the sulfide with sufficient heat to enable a direct conversion of the copper concentrate to blister copper and slag.

Removal of oxygen from molten blister copper prior to casting into anodes has traditionally been accomplished by inserting a green log into the refining furnace—a processing step known as poling. Recently, the Phelps Dodge Corp. eliminated poling at its Douglas, Ariz., plant by substituting an injection of reformed natural gas. Kennecott is conducting research on a similar scheme that combines natural gas and steam in a lance injection, and hopes to eliminate the cost of a gas-reforming plant.

In 1958 and 1959 the segregation process for the recovery of copper was studied on a small continuous basis at the Federal Bureau of Mines' Tucson, Ariz., Metallurgy Research Laboratory. In this process ore mixed with carbon (coke or coal) and salt is heated in a gas-fired kiln at 700° C. Copper, gold, and silver are reduced to the metallic state and deposited on the carbon; they are subsequently recovered by flotation. During 1960, the process was applied commercially to a mixed oxide-sulfied ore. Transarizona Resources, Inc., treating 1.6-percent copper ore from the Lake Shore claims near Casa Grande, Ariz., used the method successfully to produce 58- to 60-percent copper concentrate with recoveries averaging about 88 percent. As a result, the company is installing two new furnaces to raise plant capacity to 500 tons per day. A segregation process pilot plant operated at Sana Roselia, Mexico, until midyear with similar results. Ninety-percent recoveries were obtained on straight oxide ores. The Lampa Mining Co., Ltd., of Peru has successfully operated a 1-ton-per-hour segregation pilot plant to recover copper and silver from a manganiferous ore containing 1 to 2 percent copper and 5 to 20 ounces of silver per metric ton. Average recoveries of 80 to 85 percent of the copper and 70 to 75 percent of the silver were reported; the concentrate grade varied from 40 to 60 percent copper and 200 to 500 ounces of silver per ton.

Beryllium continued to command the greatest interest of metals in the space-age category. Pechiney of France announced that it was prepared to supply commercial quantities of beryllium as electrolytic flake. The purity of this material was such as to command a premium price over the normal magnesium-reduced material produced by two United States companies.

The lack of transverse or biaxial ductility seriously restricts the forming of beryllium by normal methods. Hogging or machining of parts from a beryllium block is one of the most commonly employed methods, but the high-circulating scrap-load adds to the high cost of finished beryllium products. So far, neither casting nor any of the usual methods for producing semifinished or finished shapes has been very successful.

The problem of purity versus ductility of beryllium has been a moot question for many years, but this year the hopes of metallurgists that purity was the answer were raised again. Small amounts of zone-refined beryllium exhibited reasonable ductility at room temperatures.

Nationwide research was started or accentuated on such problems as the production of beryllium by the iodide process, the evaluation of beryllium metal made by various reduction methods (including the electrolytic flake produced by the Federal Bureau of Mines at Boulder City, Nev.), and the development of analytical methods for determining trace impurities in the metal. This latter point is not to be minimized because the low atomic weight of beryllium imposes several restrictions on conventional analytical tools, that is, a normal spectrographic analysis.

Demand for this metal, other than for the traditional beryllium-copper uses, came from both nuclear energy and missiles or space-flight operations. One B–70 bomber requires 900 pounds of finished beryllium parts. The Brush Beryllium Co. produced the biggest hunk of beryllium ever made in response to request for a piece approximately 6 feet in diameter and 3 feet thick and with a weight of about 9,000 pounds. There is no doubt that the reawakened interest in this light, stiff metal will lead to extensive examination of the extractive metallurgy processes and to a critical appraisal of the beryllium resources of the world.

In the field of high-temperature-strength materials, two columbium-base alloys were developed that are regarded as having outstanding characteristics. Armour Research Foundation announced one containing 20 parts vanadium, 5 parts titanium, balance columbium; Union Carbide Metals Co., Division of Union Carbide Corp. made one which was essentially 50 weight-percent each of vanadium and columbium. Both showed strengths of the order of 35,000 p.s.i. for

100 hours at 2,200° F. Although such alloys exhibit excellent chemical corrosion resistance properties, they still deteriorate rapidly at high temperatures. Most of the applications at the extremely high temperatures encountered in rocket propulsion belong to the realm of tungsten and its alloys, so the best possibility for use of these vanadium-columbium alloys is in aircraft turbines. However, they are up against fierce competition by the nickel- and cobalt-base "superalloys" that have been developed in the last few years.

The nickel-base alloys are essentially a nickel-chromium solid solution with addition of high-temperature strengtheners such as tungsten, molybdenum, and vanadium or columbium. The cobalt-base series contains 20 to 25 percent chromium, about 1 percent carbon, and a carbide precipitant. Over a dozen super alloys are available commercially that are capable of operating for 100 hours at a 15,000-p.s.i. stress level. Five of these can tolerate similar conditions at 1,800° F. or above.

Titanium the original glamour metal of the era, saw a little of the tarnish removed from its record this year.

The revival of the B–70 bomber program and the continued missile development combined to bring about a mild recovery in the ailing titanium industry. New and better alloys based on higher additions of vanadium and chromium extended the usefulness of the metal to higher temperatures and new uses. There were no radical changes in the production or fabrication of titanium, and the price of sponge seems to have reached a low of $1.60 per pound.

Most researchers realize that the lead time between discovery and production is decreasing rapidly; this is well illustrated by the case history of synthetic diamonds. Research, started in the early 1950's culminated in an announcement by General Electric Co. (G.E.) in 1955 that synthetic industrial sand-size diamonds were available for sale. During the past year the wraps of technical secrecy were removed to disclose that a metal catalyst is the key to producing synthetic diamonds in available equipment. Without the catalyst, pressures of 3 million p.s.i. and temperatures above 3,500° C. (7,000° F.) would be required; with the catalyst, diamonds are grown at pressures of the order of 1 to 2 million p.s.i. and at tempertures of 1,200° to 2,500° C. (2,200°–4,400° F.). In practice, pressure from hydraulic jacks is transmitted to a pressure cell of pyrophyllite by tungsten carbide-faced dies. The high temperatures are attained by passing high-amperage current through a carbon or metallic resistance.

Only 5 years after the original G.E. release, De Beers Consolidated Mines, Ltd., the world's largest producer of natural diamonds, announced that it had its own diamond-making process. A Dutch firm of diamond cutters was reported to have perfected still another process. In effect, what required a century to realize initially took only 5 years to parallel.

Diamonds were not the only material studied in these new high-pressure, high-temperature machines. Battelle announced that it had produced a new form of uranium oxide (a gamma U308) in such a device. Dr. H. Tracy Hall, one of the inventors of the original G.E. process and now Director of Research at Brigham Young University, announced that the compressive strength of silicon carbide subjected to 200,000 p.s.i. and 10,000° C. improved 30-fold. He also reported having made chromium and manganese oxides and zirconium and titanium borides with similar high compressive strengths. The equipment could handle 10 cubic centimeters of material, and Dr. Hall believed this could be readily scaled up to 250 cubic centimeters.

The establishment of three Materials Research Centers by the Department of Defense was destined to widely affect U.S. metallurgy in 5 years or more. Centers were established at Cornell, Pennsylvania, and Northwestern Universities, and five more may be established in 1961. About $15 to $17 million went into the initial grants; operational funds are guaranteed for 4 years. In 1959 Congress authorized the Atomic Energy Commission to construct two similar centers, in addition to existing centers at California and Iowa State.

The establishment of such centers was dictated by the reasoning that this country desperately needs materials engineers and that these can be obtained only by training men in the combined fields of physical metallurgy, ceramics, plastic chemistry, and solid state physics. Only time can tell whether this fusion of disciplines will accelerate the solution of the materials problems of the space age.

Review of Mining Technology

By Paul T. Allsman [1] and James E. Hill [2]

A CYCLIC pattern of behavior is common in nature and to many human activities. Mining technology tends to exhibit this same behavior pattern. Unfortunately, cyclic development introduces imbalance into the technology of mine production. One phase of production operation often enters a period of intense interest and development; as a result some other phase lags behind, eventually forming a bottleneck in the total operational process. This, apparently, is true at the present time.

Immediately before and during World War II, mine transport was a subject of investigation and improvement. So-called trackless mining was introduced and improvements were made in truck, conveyor, and track haulage. Following World War II and continuing to the present time, drilling entered a period of rapid development with the introduction of tungsten carbide bits, more general use of jumbos, and new types of drills such as the air-leg and down-the-hole. Within the past 5 years blasting has been the subject of intense investigation, and new types of explosives and blasting techniques have been introduced. Today the technologics of ground control and mine transport, outdistanced by other phases of mine technology, are beginning to receive more attention because their relative backwardness tends to retard production.

EXPLORATION AND SAMPLING

Selection of targets for mineral exploration is being based more and more on indirect rather than direct evidence of ore bodies. The circumstances forcing this action will accentuate rather than deemphasize the trend. The 1960 Jackling lecture by Louis B. Slichter emphasized the need for a new philosophy of prospecting.[3] The lecturer postulated the importance of statistical analysis to bulwark experience and judgment in appraising expectations of finding ore. Such analysis, more definitive relationships of tectonic pattern and geologic structure to favorable ore deposition, and improved physical tools for exploration are needed to select target areas and conduct exploration.

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[1] Chief mining engineer.
[2] Assistant chief mining engineer.
[3] Slichter, Louis B., The Need of a New Philosophy of Prospecting: Min. Eng., vol. 12, June 1960, pp. 570–576.

Approaching a mining venture with initial proof of an ore body from indirect evidence is slow, expensive, and highly speculative. This is a serious obstacle to small mining companies trying to develop new ore bodies. Karl J. Springer described the method used by one group of small companies to overcome this problem.[4] His experience had been that an exploration program could not be very effective without a minimum expenditure of $75,000 a year, or, preferably a larger expenditure—up to $500,000 or more. A single small company could not afford the outlay that would give a fair probability for success. However, by forming a partnership of several companies, a successful exploration syndicate was formed. The program was to be carried forward in four steps, with decision to proceed or withdraw offered each partner at the completion of each step.

DEVELOPMENT

Development workings in underground mines are designed primarily to accommodate a transportation system. Once the workings are established, the transportation system becomes relatively inflexible. Moreover, as mining is extended the transportation system may become inadequate. Visits during the year to older metal-mining districts revealed that several mines have reached the point where development workings are either unsuitable or inadequate for modern transportation systems. Changes are being made to improve the transportation. These changes range from those that attempt to fit new systems to existing development workings to those that have virtually abandoned old developments and are establishing new and larger shafts and haulageways.

DRILLING AND BLASTING

The petroleum industry is continuing an intensive drilling research program from which the mining industry has already benefited. L. W. Ledgerwood, head of the drilling and development section, Jersey Production Research Co., stated that the industry has spent more than $25 million in efforts to develop systems more economical than rotary drilling, with as much as $1 million a year being spent on a single tool or development.[5] The greatest effort has been directed to developing better drill bits, but research work subjects range from the fundamentals of rock fragmentation to the relationship of drilling variables and individual items of drilling equipment. With a few exceptions past developments have been aimed at making equipment to implement preconceived ideas of drilling tools and systems, rather than just defining the most effective way to break rock and then building the needed system. Evolution of a satisfactory new drilling system, however, is a problem of research rather than development.

[4] Springer, Karl J., How a Small Mining Company can Pursue Mineral Exploration: Min. Cong. Jour., vol. 46, December 1960, pp. 48–50.

[5] Petroleum Week, Adversity Isn't Slowing Drillers' Push for Better Operating Methods: Vol. 11, No. 12, Sept. 23, 1960, pp. 48–84.

In an excellent résumé of efforts to develop new drilling systems, Ledgerwood lists and describes the major approaches to date.[6] The list includes mention of magnetostriction, solenoid, eccentric weight, and airhammer under hammer-action drills. Other drilling actions described are pellet impact, shock wave, explosives, turbodrill, electrodrill, flame, arc, abrasive jet, chemical, and rocket exhaust.

Interestingly, of all the possible methods of drilling holes in rock, the only new method applied to mining in recent years is flame or jet piercing. Ironically, the general principle is the same as the earliest known method of rock breaking in mining—fire setting. Meanwhile, the petroleum industry has been improving its drilling tools and adapting other such tools to its use. One is the air-gas hammer drill, similar to a down-the-hole drill, designed for drilling the harder formations met in oil well drilling.[7] Starting with tests using a 4-inch-diameter machine to drill 7⅞- to 9-inch holes, a 9-inch machine was designed that has drilled 13¾-inch holes and is being tested on a 17½-inch hole. Cone-type bits are used, although cross bits have been tested. For special conditions in hard rock the drill will give faster penetration with longer bit life.

Coupled to tool developments have been the invention and use of various testing devices and recorders. Jersey Production Research Co. is using a high-pressure chisel-impact chamber for measuring impact strength of rocks under simulated bottomhole pressure and a downhole recorder for measuring various factors influencing bit performance.[8] A California service company has tested a device for logging rock rigidity, using strain gages to identify various rocks during drilling.[9]

Inclined and horizontal drill holes for quarrying have been used more commonly in Europe than in the United States. The practice is usually tailored to special conditions of rock structure or quarry face and has shown distinct advantages under such conditions.[10] Dr. B. J. Kochanowsky discussed research conducted on inclined drilling for surface mining at the 10th Annual Drilling and Blasting Symposium, Colorado School of Mines.[11] Theoretical and model studies indicate operational and technological advantages for inclined rather than vertical drill holes, including better fragmentation, toe breakage, less back break, and safer working face. One of the new quarry drills is designed for both vertical and inclined drilling.

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[6] Ledgerwood, L. W., Jr., Efforts to Develop Improved Oilwell Drilling Methods: AIME Petrol. Trans. 8108, vol. 219, 1960, pp. 61–74.

[7] Howard, G. C., Vincent, R. P., and Wilder, L. B., Development and Field Use of a High-Frequency Gas-Operated Rotary-Percussion Drilling Tool: Jour. Petrol. Technol., vol. 12, May 1960, pp. 20–26. Drilling, Big New Air Hammer May Cut Your Costs: Vol. 22, No. 2, December 1960, pp. 64–66.

[8] Petroleum Week, Drill Collar is Anchored to Wellbore: Vol. 11, No. 10, Sept. 9, 1960, pp. 21–23.

[9] Petroleum Week, Device Logs Rocks During Drilling: Vol. 11, No. 15, Oct. 14, 1960, p. 22.

[10] Herdrich, A., The Use of Large Diameter Holes in Quarrying, Pts. I, II, III: Mine and Quarry Eng., vol. 24, January 1958, pp. 23–29; vol. 24, February 1958, pp. 70–75; vol. 24, March 1958, pp. 120–123.

[11] Kochanowsky, B. J., Theory and Practice of Inclined Drilling for Surface Mining: Pennsylvania State Univ. Mineral Industries, Exp. Sta. Bull., vol. 30, No. 3, December 1960, pp. 1–5.

A variation of the burn cut called the Coromant cut was developed at the Bodas mine in Sweden.[12] The cut is based on the principal of two or more holes being drilled immediately adjacent to form a slot. The procedure is to drill the first hole and insert a template guide to direct drilling of the second hole. A recent innovation for shaft sinking in the Ruhr coal fields is a folding drill jumbo on which heavy percussive-rotary drills can be mounted.[13] The combination provides high-penetration rate in medium-hard formations with minimum inconvenience in rig handling.

A study at the Mining Research Laboratory of the Colorado School of Mines on impact crater formation in rock provided significant data in the theoretical analysis of rock drilling.[14] Essentially, the tests consisted of a projectile striking a target material and forming a crater. Sandstone and granite were the target materials. A close correlation was found between the shear strengths of rocks and their material constants. The material constant appeared to be inversely proportional to the specific acoustic resistance of the target material, the proportionality factor being dependent on the shape of the projectile.

A contract for test drilling in connection with project Mohole was awarded, and a test site was selected near Guadalupe Island off the western coast of Mexico.[15] Drilling was to be attempted with an unmoored ship holding its position by means of four large outboard motors in water about 12,000 feet deep. Drilling was to employ standard rotary methods.

The development of modern blasting agents and current research problems in this field were outlined.[16] With increased use of these agents and intensive research during the past few years on their composition and action, many of the parameters for optimum performance had been established. However, the relatively recent introduction of these agents for blasting and the rapidly increased use had not provided the background of experience normally essential for developing safe practices in using explosives. Field experiments were being made on blasting agents with various mixtures of ingredients, particularly the so-called slurry blasting agents. It appeared that the development and use of fertilizer-grade ammonium nitrate blasting agents had reached a plateau where most of the original advantages in cost and handling had been realized. Much of the current work on these agents was directed to improving performance, reliability, and safety. In pursuing this end, there was a tendency to introduce increased costs, standards of preparation, and detonating requirements, tending to bring the blasting agents into range of competition from other explosives. These factors indicated that future progress in use of blasting agents in mining probably would be at a slower but more stable rate.

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[12] Mining Journal, The Coromant Cut: Vol. 253, No. 6485, Dec. 4, 1959, pp. 570–571.

[13] South African Mining and Engineering Journal, Drill-Rig Combine Speeds Sinking: Vol. 71, pt. 2, No. 3526, Sept. 2, 1960, pp. 563–565.

[14] Maurer, W. C., and Rinehart, John S., Impact Crater Formation in Rock: Jour. Appl. Phys., vol. 31, No. 7, July 1960, pp. 1247–1252.

[15] National Science Foundation Press Release, Experimental Drilling will Test Techniques for Project Mohole: No. 60–168, Dec. 30, 1960.

[16] Cook, M. A., Modern Blasting Agents: Science, vol. 132, Oct. 21, 1960, pp. 1105–1114.

Several investigations were in progress on vibrational and air-blast damage from blasting. Existing data on vibrations from mine and construction blasting was updated.[17] Field investigations were being conducted by the Federal Bureau of Mines on fundamental aspects of blast vibrations and to improve knowledge related damage criteria. To avoid economic loss and overcome some of the problems resulting from blasting in densely settled areas, the New York Trap Rock Corp. devised several field-tested techniques to reduce noise and air-blast propagation.[18] The company had been operating seismic recording apparatus since 1931, keeping records and planning blasts to stay well below the damage level, but complaints of damage continued. Investigation indicated that the complaints were attributable to noise and air blast. Noise was reduced by using low-energy detonating cord (LEDC) and giving close attention to loading factors. More significantly, air blast was reduced by avoiding unfavorable weather conditions when blasting, principally temperature inversion in the altitude range of 2,000 to 3,000 feet above the quarry.

MATERIALS HANDLING: LOADING, TRANSPORTATION, HOISTING

Anticipating the new frontier in mining provided by ocean bottoms, the Navy had developed a vehicle for underwater prospecting.[19] Dubbed RUM (remote underwater manipulator) the vehicle was essentially a remote-controlled tank with a long, jointed, manipulator arm and hand, together with an underwater television camera serving as eyes. RUM was developed for oceanographic research to make observations of the sea floor, collect samples and specimens, and install ocean-bottom-mounted instrumentation.

While the Navy was developing unique vehicles for unusual uses, the mining industry faced the more mundane problem of traffic—how to move an increasing volume of material while transport conditions become continually more difficult, because of deeper hoisting, longer hauls, steeper grades, and increased costs of equipment and maintenance. In its simplest form, materials handling in a mine consists of loading, hauling, and dumping rock, usually, however, a more sophisticated complex is required for the process. This may include methods of gathering material to load, intermediate transfers, dumping and reloading, horizontal and vertical transport, and stockpiling. Thus, materials handling is a system rather than a specific operation and must be so regarded to obtain efficiency. The system can be affected by other phases of mining and in turn may affect them. Because it is a complex system with many variables and has an important effect on the entire mining process, materials handling deserves most careful advance planning with balancing of all the possible variables inherent to a system.

[17] Leet, L. D., Vibrations From Blasting Rock: Harvard Univ. Press, Cambridge, Mass., 1960, 134 pp.

[18] Kringel, J. R., Control of Air Blast Effect Resulting from Blasting Operations: Min. Cong. Jour., vol. 46, April 1960, pp. 51–56.

[19] Naval Research Reviews, A New Vehicle for Exploring the Ocean's Floor: June 1960, pp. 12–13.

Research and development of components of transport systems were reported during the year. The Hydraulic Institute was making a survey of basic data available on pumping fluid-solid mixtures.[20] There was promise of expanded use of hydraulic transportation in materials handling systems at mines. The Central Institute for Mining in Poland experimented on installation of prototype equipment for horizontal and vertical hydrotransport of coal.[21] The most favorable conditions for a hydrotransport system are offered by those mines with a large supply of underground water. The practice of hydraulic stowing introduced a large reserve of water in the Polish mines.

Various types of conveyors are important in transport systems for bulk material and have not been given the consideration they deserve in metal mining. One drawback has been the limit of inclination (about 20 degrees maximum for most materials). A new development, the sandwich conveyor, is one solution for steep-angle belt transport.[22] Essentially, the sandwich conveyor is a double-belt device; one belt conveys the material, and the other runs on top of the material to hold it in place. Installations inclined as much as 45 degrees are possible. Another design uses a traveling chain instead of a top belt to hold the material in place.

Iron ore was moved from underground to the surface at the Mine de Murville in France by a cable-belt rope-driven conveyor.[23] The shaft consisted of two inclined legs sloped in opposite directions. The bottom leg had a rise of 342 feet and the upper leg had a rise of 291 feet for a total hoist of 633 feet. Maximum inclination was about 15 degrees. The ore was hauled to the bottom of the slope by electric locomotives where it was crushed to minus 12-inch size and then conveyed at a rate of 800 tons per hour to storage bunkers.

Coal mines and nonmetal mines had used conveyors in their transport systems for many years and lead the industry in taking advantage of the many improvements made during the past 10 years. Among the significant developments were (1) rope-suspended intermediate structure, (2) changes in basic design of idlers, (3) introduction of improved belting material and solid woven belting, and (4) special application design.[24] The latter is illustrated by the Stubbe Faltenband folded or accordion-pleated design installed in the Universal Atlas Cement Plant at Clarence Center, N.Y. The design allows conveying at steep gradients and around corners.[25]

Skip haulage in open pits was finding increased use as a component of a transport system providing efficient vertical movement of material. The present concept of inclined-skip hoisting in open pits was

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[20] Engineering and Mining Journal, Wanted—More Basic Information on Pumping Fluid-Solid Mixtures: Vol. 161, July 1960, p. 71.

[21] Borecki, Marcin, Hydraulic Transport in Polish Hard Coal Mines: Min. Jour., vol. 254, No. 6504, Apr. 15, 1960, pp. 429–430.

[22] Rasper, Ludwig, and Rasper, Peter, The Sandwich Conveyor—A solution for Steep Belt Transportation: Eng. Min. Jour., vol. 161, November 1960, pp. 100–103.

[23] Mining Journal, The Use of Belt Conveyors in Metal Mines: Vol. 255, No. 6529, Oct. 7, 1960, pp. 386–388.

[24] Meador, Harry W. J., New Developments in Belt Haulage: Min. Cong. Jour., vol. 46, September 1960, pp. 86–89.

[25] Jordon, Robert B., Modernization of a Gypsum Operation: Min. Cong. Jour., vol. 46, May 1960, pp. 34–37.

introduced in 1949 at the South Agnew mine in Minnesota. Subsequently, other installations were made in the iron mines of Minnesota and Canada and were followed by more recent use in western copper pits.[26] The major advantages gained by inclined-skip haulage in open pits are the decrease in the length of haul and the stripping requirements associated with benching to a grade necessary for rail or truck haulage.

Attention was focused during the year on surface-mining equipment that combined the functions of excavating, loading, and transport. The equipment required specific favorable physical conditions of material and terrain for successful application but offered distinct advantages where these conditions prevailed. The bucket wheel excavator, patented in Germany in 1913, was first used in German lignite mines in 1920. Units have been developed with capacities ranging from 90 to 12,000 cubic yards per hour. Introduced into strip coal mines in the United States, the device was being considered for other mining conditions.[27] The combination of continuous-action equipment, such as wheel excavators and conveyors, produces exceptionally high capacity operation. It appeared that the use of such equipment might be greatly extended, owing to recent improvements in boring and use of low-cost explosives. One company in California investigated the possible economic use of a bucket wheel excavator to remove relatively hard overburden by boring blast holes and using fertilizer grade ammonium nitrate (AN) explosive to loosen ground before excavation. Where conditions were favorable, dredges were used for stripping open pits. A cutter-suction dredge was used on a bauxite deposit in Surinam.[28] Stripping costs averaged 19.6 cents per yard. A similar system was being used at the Jessie H. mine in Minnesota. Steep Rock ore bodies in Canada continued to be uncovered by this method.

The newest development in truck haulage was the application of individually driven electric wheels.[29] Stated advantages were greater maneuverability and rapid stopping. Originally developed for military use, the equipment had not been extensively field tested in the mines. The Anaconda Company currently was testing this type of equipment in its Berkeley Pit.

The World's largest mine hoist was recently delivered to the U.S.S.R. by a Swedish company.[30] The hoist drum weighed 49 tons and the two skips weighed 40 tons each. Intended for a double-hoist system with a loading capacity of 50 tons per skip, the driving speed was 33 feet per second at a depth of 3,000 feet.

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[26] Engineering and Mining Journal, Skip Hoisting Solves Deep Pit Problem: Vol. 159, March 1958, pp. 98–99. Quilici, Frank, Skip Hoisting at the Liberty Pit: Min. Cong. Jour., vol. 46, March 1960, pp. 38–40.

[27] Kendall, R. E., Germany's Answer to Low Cost Dirt Moving : Min. Cong. Jour., vol. 46, January 1960, pp. 26–29.

[28] Cazort, John G., Jr., Stripping Overburden With a Dredge: Min. Eng., vol. 12, October 1960, pp. 1083–1089.

[29] Engineering and Mining Journal, New Electric Wheel Speeds Pit Haulage: Vol. 161, March 1960, p. 77. Borcherdt, Edward R., The Electric Wheel Drive in Mining: Min. Cong., Jour., vol. 46, September 1960, pp. 64–65.

[30] Mining and Engineering Journal, South Africa, World's Biggest Hoist: Vol. 71, pt. 1, No. 3509, May 6, 1960, p. 1093.

GROUND SUPPORT AND CONTROL

While the science of rock mechanics was being pursued vigorously by numerous investigators searching for answers to the many questions on rock pressures and their effect, the problems created in mining by such pressures were becoming more acute. The need for larger openings, imposed by increased mechanization and faster ore removal coupled with deeper mining, were among the factors generating problems from rock pressures. An excellent resume of the state of science of rock mechanics and a prognosis of its future application to mining engineering problems was presented.[31] Some of the fundamentals for design of openings in competent rock were published by the Bureau of Mines.[32] However, the extrapolation of these data to accepted design principles for mining and the fundamentals for design of openings in incompetent rocks remained to be accomplished.

In the meantime, control of ground for mining relied to a great extent on experience and trial and error methods to meet new or unknown conditions. Yieldable steel rings were used at the Silver Mountain exploration project in Idaho to hold heavy ground in a 400-foot shear zone.[33] The San Manuel mine in Arizona showed a cost advantage in using concrete support over timber or steel.[34] A major factor was a reduction in maintenance costs. An interesting development was the study of rock properties and load characteristics to design load potential of an experimental installation of prestressed, preloaded concrete pillars.[35]

DRAINAGE AND WATER CONTROL

Air and water pollution were subjects of national concern. All indications were that pollution problems, together with water conservation, would receive increased national attention. In many areas, the mining industry has a direct interest in the subject because disposal of mine drainage, particularly from coal mines, has presented a problem for many years. The general interrelation of water conservation and stream pollution was aptly presented by H. F. Hebley.[36] The fact that water is a valuable commodity to much of the western copper mining industry stimulated various schemes for reclaiming and re-using process water.[37]

The ratio of reclaimed to new water at properties for which information was available ranged from a low of 1:1 to a high of 4:1. The major steps controlling stream pollution from coal mine drainage were to: (1) Keep water out of mine, if possible, (2) eliminate it quickly once it entered the mine, (3) minimize exposure of water to

[31] Rinehart, John S., Rock Mechanics: Min. Cong. Jour., vol. 46, August 1960, pp. 50–52.
[32] Obert, Leonard, Duvall, Wilbur I., and Merrill, Robert H., Design of Underground Openings in Competent Rock: Bureau of Mines Bull. 587, 1960, 36 pp.
[33] Crandall, Wallace E., Use of Yieldable Steel-Ring Sets at Silver Mountain: Min. Cong. Jour., vol. 46, July 1960, pp. 38–41.
[34] Pillar, C. L., Placement and Use of Concrete Underground: Min. Cong. Jour., vol. 46, September 1960, pp. 66–72.
[35] Reed, John J., and Mann, C. D., Prestressed, Preloaded Concrete Pillars Give Better Roof Control: Eng. Min. Jour., vol. 161, November 1960, pp. 88–93.
[36] Hebley, H. F., Stream Pollution by Coal Mine Wastes: Min. Eng., vol. 5, April 1953, pp. 404–412.
[37] Michaelson, S. D., Ensign, B. H. Hubbard, S. J., and Lost, A. W., Water, A Controlling Factor of Copper Production: Min. Eng., vol. 12, July 1960, pp. 674–674D.

acid-forming material, (4) regulate discharge, and (5), sample regularly.[38] A summary of water laws related to mining brought out the probable impact on the mining industry from increased public concern regarding water pollution and conservation.[39]

Chemical grouting was being used successfully for localized control of water flow and loose water-saturated ground. Cement was first used to seal leaks in mine shafts nearly 100 years ago,[40] in Germany and France. Cement grout was found to work well in fissured or fractured ground but was inadequate in porous rock. The Francois process introduced chemicals to grouting, using a two-solution method which succeeded in reducing porosity. Recently two single-solution methods of chemical grouting were introduced, the chrome-lignin and the Am–9 processes. Used alone, or in combination with other grouting methods, the chemical grouting processes have extended the effectiveness of this method of sealing and stabilizing ground. Tests made by the St. Joseph Lead Co. at new shafts being sunk in Missouri illustrated the relative effectiveness of the different methods under varied ground conditions.[41]

HEALTH AND SAFETY

Mobile coolers were used in the South African gold mines for spot conditioning air at underground working sites. Track mounted units of 30-ton refrigeration capacity eliminated the need for extensive air conditioning systems during mine development.[42] Few mines in the United States have been faced with the necessity of cooling mine air, but in many foreign operations it has become a major problem. Heat flow in mines is fundamentally related to virgin rock temperature. Professor Boldizsar of Hungary presented a method for mathematically determining the heat load in deep mines, based on virgin rock temperature.[43]

Federal Bureau of Mines publications of general interest were issued on several aspects of health and safety in mines. The fundamentals of mine ventilation were summarized, providing a good review and reference document on the subject.[44] Information Circulars were issued on tentative safety recommendations for ammonium nitrate blasting agents,[45] recommended standards for alternating current in coal mines,[46] and American practice for rock dusting.[47]

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[38] Steinman, H. E., An Operator's Approach to Mine Water Drainage Problems and Stream Pollution: Min. Cong. Jour., vol. 46, July 1960, pp. 70–73.
[39] Hutchins, W. A., Water Laws Related to Mining: Min. Eng., vol. 12, February 1960, pp. 153–158.
[40] York, Lionel A., Cement Grouting: Precambrian Min. in Canada, vol. 33, August 1960, pp. 7–16.
[41] Reed, John J., and Bilheimer, Lee, How Research Advances Grouting Techniques at St. Joseph Lead: Min. World, vol. 22, November 1960, pp. 43–45.
[42] Engineering and Mining Journal, Mobile Cooler Conditions Africa's Hot Gold Mines: Vol. 161, March 1960, pp. 78–79.
[43] Boldizsar, T., Geothermal Investigations Concerning the Heating of Air in Deep and Hot Mines: Mine and Quarry Eng., vol. 26, June 1960, pp. 253–258.
[44] Kingery, D. S., Introduction to Mine Ventilation Principles and Practices: Bureau of Mines Bull. 589, 1960, 54 pp.
[45] Bureau of Mines Staff, Tentative Safety Recommendations for Field-Mixed Ammonium Nitrate Blasting Agents: Bureau of Mines Inf. Circ. 7988, 1960, 12 pp.
[46] Bureau of Mines Staff, Recommended Standards for Alternating Current in Coal Mines: Bureau of Mines Inf. Circ. 7962, 1960, 25 pp.
[47] Bureau of Mines Staff, American Standard Practice for Rock-Dusting Underground Bituminous Coal and Lignite Mines to Prevent Coal-Dust Explosions (ASA Standard M13.1–1960, UDC 622.81): Bureau of Mines, Inf., Cir. 8001, 1960, 5 pp.

Reports of Investigations were released on the safe use of mobile diesel-powered equipment underground [48] and the control of mine fires by high-expansion foam.[49]

An apparatus was designed that, according to Russian claims, made it possible to forecast any sudden eruption of methane at least 6 hours in advance.[50] Essentially a geophone, the device is able to detect the radiation of microsonic waves that build up in the coal seam before eruptions occur, the Russians said. The geophones—only two of them so far—had been tested for several years in mines of the Donbas coal basin.

Another development of interest was that of a methane monitoring system to prevent mine explosions. Methane measuring stations in various parts of the mine fed information through the mine telephone network to a computer which programed the ventilation system. As methane builds up in an area, more air is automatically directed to the area, thereby diluting the methane. If the methane becomes dangerously concentrated, the mine power system automatically stops.

MINING PRACTICE AND PERFORMANCE

The mining industry is plagued with a problem common to the modern industrial complex, the need for systematic and speedy handling of data. Operating and management decisions must be made from analysis of voluminous data under conditions in which the allowable margin of error and time latitude is narrowing. Modern electronic computers and machine data processing can be used to advantage in some instances. Several companies used or experimented with these data processing techniques.[51] Engineering News Record issued a special report on computers for engineering office practices to meet the growing interest in these machines.[52]

The characteristics of major electronic computers have been listed and compared. Costs rise rapidly with a machine's capabilities, so careful analysis of requirements is necessary to avoid undue expense. As machine installations increase and programing for machines becomes more widely understood, the mining industry will find more use for computers and data processing. A further incentive to greater use of computers is the growing recognition of the potentials to mining of such techniques as industrial engineering, operations research, and statistical analysis, all of which use mathematical presentations of mass data amenable to programing to computer.[53]

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[48] Holtz, John C., Safety With Mobile Diesel-Powered Equipment Underground: Bureau of Mines Rept. of Investigations 5616, 1960, 87 pp.

[49] Nagy, John, Murphy, E. M., and Mitchell, O. W., Controlling Mine Fires With High Expansion Form: Bureau of Mines Rept. of Investigation 5632, 1960, 28 pp.

[50] South African Mining and Engineering Journal: Vol. 71, pt. 2, No. 3535, Nov. 4, 1960, p. 1117.

[51] Harvey, Grant J., Digital Computers Cut Survey Costs: Eng. Min. Jour., vol. 161, July 1960, pp. 77–81. Koch, Gus S., and Link, Richard F., Data Processing by Machine—Asset at the Mine Site: Min. Eng., vol. 12, September 1960, pp. 1005–1007. Nalle, Peter B., and Weeks, Leroy W., The Digital Computer—Applications in Mining and Process Control: Min. Eng., vol. 12, September 1960, pp. 1001–1004.

[52] Merritt, Frederick S., Computers: Eng. News-Record, vol. 164, No. 15, Apr. 14, 1960, pp. 39–63.

[53] Lewis, David G., Operations Research in Limestone Mining: Min. Cong., Jour., vol. 46, November 1960, pp. 86–92.

Technologic Trends in the Mineral Industries

(Metals and Nonmetals Except Fuels)

By Donald R. Irving[1] and Arthur Berger[2 3]

THE EARTH-MOVING job confronting the domestic mineral-producing industry, excluding fuels, and reported by the Bureau of Mines for all commodities for the first time, averaged 2.3 billion tons of ore and waste from 1958 through 1960. About four-fifths of the total was crude ore. These figures do not include material handled at nonproducing mines engaged in exploration and development, materials moved in constructing access and haulage roads; excavations for campsites, mine and mill-building foundations, power and tailing dams, or similar activities; and waste handled at surface stone and sand and gravel operations.

One fundamental difference between metal and nonmetal ores is that less than 15 percent of the material handled was marketable product for metals, compared with 90 percent marketable product for nonmetals. The difference would be even greater if the bulk commodities, bauxite, iron ore, and manganese ore—for which marketable product is measured in terms of ore instead of metal—were excluded from the metals category.

More than 90 percent of the crude ore and total material handled came from surface operations. All the titanium, magnesite, perlite, pumice, sand and gravel, and vermiculite ores came from surface mines; all the chromite, molybdenum, and potash ores were mined underground.

Seven States—Arizona, California, Florida, Michigan, Minnesota, Texas, and Utah—furnished more than 40 percent of the total material handled; all except Texas and Utah reported more than 100 million tons.

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[3] Assisted statistically by M. Katherine Harding, mathematician.

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Almost half the exploration and development footage in both 1958 and 1959 was for uranium, and all but one-tenth was for metals. Activity in 1959 was only 85 percent of that reported in 1958.

Rotary, diamond, and long-hole drilling, in that order, were the most used exploration methods and together supplied almost three-quarters of the exploration and development footage.

Six States—Arizona, Colorado, Missouri, New Mexico, Utah, and Wyoming—furnished about two-thirds of the exploration and development footage.

Total Material Handled.—The U.S. mineral-producing industry, excluding fuels, handled 2.2 billion short tons of crude ore and waste in 1958, 2.3 billion tons in 1959, and 2.7 billion short tons in 1960. Of the total, crude ore comprised 79 percent in 1958, 80 percent in 1959, and 76 percent in 1960. For metals in 1958, 83 million tons of marketable product (expressed as metal, ore, or concentrate) was obtained from 354 million tons of crude ore. An almost equal quantity of waste (358 million tons) was handled. Corresponding figures for nonmetals were 1.3 billion tons of marketable product, 1.4 billion tons of ore, and 96 million tons of waste.

In 1959, the marketable product for metals dropped 6 percent to 78 million tons, crude ore declined 7 percent to 329 million tons, and waste and overburden handled decreased 3 percent to 349 million tons. In contrast, the usable product for nonmetals increased 8 percent to 1.4 billion tons, crude ore output rose 8 percent to 1.5 billion, and waste and overburden handled was up 7 percent to 103 million tons.

In 1960, the marketable product for metals gained 37 percent over the 1959 output, reaching 107 million tons; crude ore increased 27 percent to 419 million tons and waste and overburden handled increased 48 percent to 515 million tons. Marketable product for nonmetals remained the same at 1.4 billion tons, crude ore production increased 7 percent to 1.6 billion tons, and waste and overburden increased 25 percent to 129 million tons. Waste and overburden at phosphate rock deposits accounted for most of the increase.

Data were not available for the quantity of waste handled at surface stone and sand and gravel operations and consequently the figures on total material handled are understated by the amount of such waste.

TABLE 1.—Material handled at underground and surface mines in the United States, by commodities in 1958

(Thousand short tons)

Commodity	Crude ore	Waste	Total
Metals:			
Bauxite	1,774	2,399	4,173
Chromite	364	100	464
Copper	114,824	167,069	281,893
Gold:			
Lode	2,415	1,328	3,743
Placer	70,178	------------	70,178
Iron ore	122,993	128,140	251,133
Lead	8,511	816	9,327
Manganese ore	2,226	3,217	5,443
Mercury	328	578	906
Molybdenum	7,012	6,367	13,379
Silver	742	445	1,187
Titanium	10,855	4,235	15,090
Tungsten	95	80	175
Uranium	5,178	39,295	44,473
Zinc	6,757	3,704	10,461
Total	354,252	357,773	712,025
Nonmetals:			
Abrasives	139	83	222
Asbestos	922	1,332	2,254
Barite	1,732	2,633	4,365
Boron minerals	1,678	------------	1,678
Clays	43,750	21	43,771
Feldspar	948	240	1,188
Fluorspar	883	179	1,062
Gypsum	9,600	4,913	14,513
Magnesite	535	781	1,316
Mica:			
Scrap	496	230	726
Sheet	827	48	875
Perlite	372	54	426
Phosphate rock	52,034	79,217	131,251
Potassium salts	12,758	------------	12,758
Pumice	1,781	193	1,974
Salt	22,329	2	22,331
Sand and gravel	684,498	------------	684,498
Sodium compounds	590	------------	590
Stone	535,923	241	536,164
Sulfur	5,963	1,346	7,309
Talc, soapstone, and pyrophyllite	751	285	1,036
Vermiculite	833	------------	833
Other [1]	1,356	4,637	5,993
Total	1,380,698	96,435	1,477,133
Grand total	1,734,950	454,208	2,189,158

[1] Aplite, calcium magnesium chloride, diatomite, graphite, greensand marl, kyanite, olivine, wollastonite.

TABLE 2.—Material handled at surface and underground mines in the United States, by commodities in 1959

(Thousand short tons)

Commodity	Surface			Underground			Total		
	Crude ore	Waste	Total	Crude ore	Waste	Total	Crude ore	Waste	Total
Metals:									
Bauxite	2,003	3,072	5,075	269		269	2,272	3,072	5,344
Chromite				219	21	240	219	21	240
Copper	84,512	150,091	234,603	19,204	816	20,020	103,716	150,907	254,623
Gold:									
Lode	280	20	300	2,013	1,241	3,254	2,293	1,261	3,554
Placer	59,748		59,748	62		62	59,810		59,810
Iron ore	95,915	117,891	213,806	18,979	1,811	20,790	114,894	119,702	234,596
Lead	37	28	65	7,216	667	7,883	7,253	695	7,948
Manganese ore	1,477	2,519	3,996	312	66	378	1,789	2,585	4,374
Mercury	122	421	543	154	65	219	276	486	762
Molybdenum				9,092	8,255	17,347	9,092	8,255	17,347
Silver	105	211	316	624	226	850	729	437	1,166
Titanium	12,269	4,787	17,056				12,269	4,787	17,056
Tungsten	3	89	92	186	72	258	189	161	350
Uranium	2,750	51,591	54,341	4,185	1,037	5,222	6,935	52,628	59,563
Zinc	253	3,210	3,463	7,132	838	7,970	7,385	4,048	11,433
Total	259,474	333,930	593,404	69,647	15,115	84,762	329,121	349,045	678,166
Nonmetals:									
Abrasives	99	70	169	31		31	130	70	200
Asbestos	925	1,395	2,320	40		40	965	1,395	2,360
Barite	2,275	3,922	6,197	306		306	2,581	3,922	6,503
Boron minerals	1,281		1,281	688		688	1,969		1,969
Clays	47,340		47,340	2,043	23	2,066	49,383	23	49,406
Feldspar	1,001	256	1,257	15	1	16	1,016	257	1,273
Fluorspar	62	57	119	377		377	439	57	496
Gypsum	8,033	5,518	13,551	2,867	60	2,927	10,900	5,578	16,478
Magnesite	643	939	1,582				643	939	1,582
Mica:									
Scrap	626	292	918	5	1	6	631	293	924
Sheet	225	49	274	665	4	669	890	53	943
Perlite	443	64	507				443	64	507
Phosphate rock	54,313	83,867	138,180	846	108	954	55,159	83,975	139,133
Potassium salts				13,933		13,933	13,933		13,938
Pumice	2,082	226	2,308				2,082	226	2,304
Salt	79		79	21,973	2	21,975	22,052	2	22,054

Sand and gravel	730,205	---	730,205	---	---	---	730,205	---	730,205
Sodium compounds	3	---	3	839	---	839	842	---	842
Stone	560,500	---	560,500	23,663	264	23,927	584,163	264	584,427
Sulfur	473	1,457	1,930	6,018	8	6,026	6,491	1,465	7,956
Talc, soapstone, and pyrophyllite	297	283	580	529	31	560	826	314	1,140
Vermiculite	947	---	947	---	---	---	947	---	947
Other [1]	1,160	3,863	5,023	15	5	20	1,175	3,868	5,043
Total	1,413,012	102,258	1,515,270	74,853	507	75,360	1,487,865	102,765	1,590,630
Grand total	1,672,486	436,188	2,108,674	144,500	15,622	160,122	1,816,986	451,810	2,268,796

[1] Includes aplite, calcium magnesium chloride, diatomite, graphite, greensand marl, kyanite, olivine, wollastonite.

TABLE 3.—Material handled at underground and surface mines in the United States, by commodities in 1960

(Thousand short tons)

Commodity	Surface			Underground			Total		
	Crude ore	Waste	Total	Crude ore	Waste	Total	Crude ore	Waste	Total
Metals:									
Bauxite	2,490	3,808	6,298	208	-----	208	2,698	3,808	6,506
Beryllium concentrate	44	20	64	6	7	13	50	27	77
Chromite	-----	-----	-----	214	12	226	214	12	226
Copper	110,560	236,353	346,913	24,434	1,035	25,469	134,994	237,388	372,382
Gold:									
Lode	321	77	398	1,955	1,150	3,105	2,276	1,227	3,503
Placer	52,242	-----	52,242	90	-----	90	52,332	-----	52,332
Iron ore	151,400	164,219	315,619	22,082	2,085	24,167	173,482	166,304	339,786
Lead	29	40	69	7,226	631	7,857	7,255	671	7,926
Manganese ore	368	436	804	54	28	82	422	464	886
Manganiferous ore	1,005	74	1,079	187	-----	187	1,192	74	1,266
Mercury	102	239	341	156	32	188	258	271	529
Molybdenum	-----	-----	-----	11,684	57	11,741	11,684	57	11,741
Nickel	1,103	323	1,426	-----	-----	-----	1,103	323	1,426
Rare earth and thorium concentrates	7	8	15	-----	-----	-----	7	8	15
Silver	181	4	185	799	155	954	980	159	1,139
Titanium concentrate:									
Ilmenite	8,887	13,181	22,068	-----	-----	-----	8,887	13,181	22,068
Rutile	1,075	1,130	2,205	-----	-----	-----	1,075	1,130	2,205
Tungsten	61	1	62	449	25	474	510	26	536
Uranium	2,630	84,514	87,144	5,340	2,042	7,382	7,970	86,556	94,526
Zinc	440	1,561	2,001	7,558	920	8,478	7,998	2,481	10,479
Other [1]	3,493	985	4,478	-----	-----	-----	3,493	985	4,478
Total metals	336,438	506,973	843,411	82,442	8,179	90,621	418,880	515,152	934,032
Nonmetals:									
Abrasive stone	6	11	17	-----	-----	-----	6	11	17
Asbestos	853	1,155	2,008	43	4	47	896	1,159	2,055
Barite	1,243	2,951	4,194	98	-----	98	1,341	2,951	4,292
Boron minerals	2,126	-----	2,126	11	-----	11	2,137	-----	2,137
Clays	47,141	-----	47,141	1,913	28	1,941	49,054	28	49,082
Emery	9	-----	9	-----	-----	-----	9	-----	9
Feldspar	1,386	100	1,486	24	-----	24	1,410	100	1,510
Fluorspar	60	44	104	333	13	346	393	57	450
Garnet (abrasive)	90	51	141	-----	-----	-----	90	51	141
Gypsum	7,339	7,440	14,779	2,486	34	2,520	9,825	7,474	17,299
Magnesite	550	1,226	1,776	-----	-----	-----	550	1,226	1,776
Magnesium compounds	42,700	-----	42,700	-----	-----	-----	42,700	-----	42,700

Mica:									
Scrap	1,273	381	1,654	8	1	9	1,281	382	1,663
Sheet	83	----	83	182	1	183	265	1	266
Perlite	384	2	386	3	----	3	387	2	389
Phosphate rock	59,824	108,746	168,570	1,035	----	1,035	60,859	108,746	169,605
Potassium salts	15,210	----	15,210	15,071	50	15,121	30,281	50	30,331
Pumice	2,258	161	2,419	----	----	----	2,258	161	2,419
Pyrites	93	1,027	1,120	177	----	177	270	1,027	1,297
Salt	45,375	2	45,377	6,770	----	6,770	52,145	2	52,147
Sand and gravel	709,495	----	709,495	----	----	----	709,495	----	709,495
Sodium carbonate (natural)	2,568	----	2,568	931	----	931	3,499	----	3,499
Sodium sulfate (natural)	3,545	----	3,545	----	----	----	3,545	----	3,545
Stone	587,789	----	587,789	29,000	365	29,365	616,789	365	617,154
Sulfur:									
Frasch-process mines	5,649	----	5,649	----	----	----	5,649	----	5,649
Other mines	321	313	634	----	----	----	321	313	634
Talc, soapstone, and pyrophyllite	342	117	459	484	50	534	826	167	993
Tripoli	24	----	24	33	----	33	57	----	57
Vermiculite	331	234	565	----	----	----	331	234	565
Other nonmetals [2]	3,706	4,740	8,446	50	6	56	3,756	4,746	8,502
Total nonmetals	1,541,773	128,701	1,670,474	58,652	552	59,204	1,600,425	129,253	1,729,678
Grand total	1,878,211	635,674	2,513,885	141,094	8,731	149,825	2,019,305	644,405	2,663,710

[1] Magnesium chloride for metal, platinum-group metals, and zirconium concentrate.
[2] Aplite, calcium magnesium chloride, diatomite, graphite, greensand marl, kyanite, olivine, wollastonite.

Minnesota, largely because of iron ore, led all States in total material handled in 1959 with almost 192 million tons. Four other States—California, Florida, Arizona, and Michigan—reported more than 100 million tons of ore and waste handled. These five States together with Utah and Texas supplied more than 40 percent of the total material handled. All 50 States and the District of Columbia contributed to the national total.

Copper, placer gold, iron ore, and uranium furnished 88 percent of the crude ore and 90 percent of the total material handled for metals in 1958; 87 and 90 percent, respectively, in 1959; and 88 and 92 percent, respectively, in 1960. Clays, phosphate rock, sand and gravel, and stone furnished 95 percent of the crude ore and 94 percent of the total material handled for nonmetals in 1958, compared with 95 percent of both crude ore and material handled in 1959, and 90 and 89 percent, respectively, in 1960.

TABLE 4.—Total material handled at underground and surface mines, by States, 1959

(Thousand short tons)

State	Quantity	State	Quantity
Alabama	35,122	New Jersey	23,738
Alaska	25,646	New Mexico	56,211
Arizona	139,661	New York	77,411
Arkansas	28,277	North Carolina	25,992
California	185,901	North Dakota	9,992
Colorado	55,773	Ohio	83,814
Connecticut	9,506	Oklahoma	20,189
Florida	164,958	Oregon	33,858
Georgia	22,122	Pennsylvania	63,809
Idaho	25,991	Rhode Island	2,081
Illinois	68,702	South Carolina	12,370
Indiana	41,267	South Dakota	23,944
Iowa	38,839	Tennessee	36,849
Kansas	28,135	Texas	96,558
Kentucky	22,920	Utah	98,504
Louisiana	30,297	Vermont	5,599
Maine	10,372	Virginia	30,724
Maryland	18,207	Washington	37,341
Massachusetts	18,413	West Virginia	12,184
Michigan	102,697	Wisconsin	57,444
Minnesota	191,898	Wyoming	34,911
Mississippi	8,955	Other:	
Missouri	49,579	Delaware, District of Columbia, and Hawaii	4,895
Montana	38,543		
Nebraska	14,571		
Nevada	38,510	Total	2,268,796
New Hampshire	5,516		

Surface Versus Underground Mining.—Titanium minerals, magnesite, perlite, pumice, sand and gravel, and vermiculite were mined entirely from surface operations; all chromite, molybdenum, and potassium salts, and virtually all lead, tungsten, zinc, salt, and sodium compounds were mined underground in 1959.

For almost all metals and nonmetals that were mined partly by surface and partly by underground methods, the percent of total material handled at the surface mines in 1959 exceeded the percent of total ore recovered in these mines. Exceptions were lode gold and clays, for which the percentage was slightly lower, and placer gold, salt, sodium compounds, and stone, for which no difference in percentage was reported. Surface mining supplied less than 2 percent of the tungsten crude ore but more than 26 percent of the total material handled, 3 percent of the zinc ore and 30 percent of the total material, 7 percent of the sulfur and 24 percent of the total material, and 40 percent of the uranium and more than 90 percent of the total material.

The quantity and percent of marketable product obtained from surface and underground operations (table 6) enables comparisons with crude ore mined and total material handled (table 5). For example, 77 percent of the copper, 81.5 percent of the crude ore, and 92 percent of total material came from surface operations. The corresponding figures for surface iron ore operations (76 percent of the marketable product, 83.5 percent of the crude ore, and 91 percent of the total material handled) are similar to those for copper. In contrast, 2 percent of the zinc, 3.4 percent of the crude ore mined, and 30 percent of the total material handled came from surface operations in 1959.

Tables 7, 8, and 9 provide additional details of the relationship between marketable product, crude ore, and total material handled by surface and underground methods. Table 9 gives the average grade of ore for each commodity in terms of percent of marketable product. Grade ranged from lows for sheet mica of 0.02 percent (surface) and 0.05 percent (underground) to essentially 100 percent for bulk commodities such as tripoli (underground), clays, gypsum, phosphate rock (underground), sand and gravel, and stone.

TABLE 5.—Crude ore and total material handled at surface and underground mines, by commodities in 1959

(Percent)

Commodity	Crude ore mined		Total material handled	
	Surface	Underground	Surface	Underground
Metals:				
Bauxite	88.2	11.8	95.0	5.0
Chromite	----------	100.0	----------	100.0
Copper	81.5	18.5	92.1	7.9
Gold:				
Lode	12.2	87.8	8.4	91.6
Placer	99.9	.1	99.9	.1
Iron ore	83.5	16.5	91.1	8.9
Lead	.5	99.5	.8	99.2
Manganese ore	82.6	17.4	91.4	8.6
Mercury	44.2	55.8	71.3	28.7
Molybdenum	----------	100.0	----------	100.0
Silver	14.4	85.6	27.1	72.9
Titanium	100.0	----------	100.0	----------
Tungsten	1.6	98.4	26.3	73.7
Uranium	39.7	60.3	91.2	8.8
Zinc	3.4	96.6	30.3	69.7
Nonmetals:				
Abrasives	76.2	23.8	84.5	15.5
Asbestos	95.9	4.1	98.3	1.7
Barite	88.1	11.9	95.3	4.7
Boron minerals	65.1	34.9	65.1	34.9
Clays	95.9	4.1	95.8	4.2
Feldspar	98.5	1.5	98.7	1.3
Fluorspar	14.1	85.9	24.0	76.0
Gypsum	73.7	26.3	82.2	17.8
Magnesite	100.0	----------	100.0	----------
Mica:				
Scrap	99.2	.8	99.4	.6
Sheet	25.3	74.7	29.1	70.9
Perlite	100.0	----------	100.0	----------
Phosphate rock	98.5	1.5	99.3	.7
Potassium salts	----------	100.0	----------	100.0
Pumice	100.0	----------	100.0	----------
Salt	.4	99.6	.4	99.6
Sand and gravel	100.0	----------	100.0	----------
Sodium compounds	.4	99.6	.4	99.6
Stone	95.9	4.1	95.9	4.1
Sulfur	7.3	92.7	24.3	75.7
Talc, soapstone, and pyrophyllite	36.0	64.0	50.9	49.1
Vermiculite	100.0	----------	100.0	----------
Other [1]	98.7	1.3	99.6	.4

[1] Aplite, calcium magnesium chloride, diatomite, graphite, greensand marl, kyanite, olivine, wollastonite.

TABLE 6.—Marketable product recovered from surface and underground mines, by commodities, in 1959

Commodity and unit	Marketable product	Surface		Underground		Total quantity
		Quantity	Percent	Quantity	Percent	
Metals:						
Bauxite ... thousand long tons	Ore	1,553	88	202	12	1,755
Chromite ... thousand short tons	do	------	------	110	100	110
Copper ... do	Metal	605	77	182	23	787
Gold:						
Lode ... thousand troy ounces	do	22	3	771	97	793
Placer ... do	do	359	99	3	1	362
Iron ore ... thousand long tons	Ore and concentrate	44,776	76	14,013	24	58,789
Lead ... thousand short tons	Metal	1	1	184	99	185
Manganese ore ... do	Ore and concentrate	513	90	60	10	573
Mercury ... thousand flasks	Metal	6	22	21	78	27
Molybdenum ... thousand pounds	Concentrate	------	------	37,026	100	37,026
Silver ... thousand troy ounces	Metal	88	1	12,627	99	12,715
Titanium ... thousand short tons	Concentrate	642	100	------	------	642
Tungsten ... do	Ore and concentrate	------	------	2	100	2
Uranium ... do	Ore	2,750	40	4,185	60	6,935
Zinc ... do	Metal	9	2	352	98	361
Nonmetals:						
Abrasives ... do	Ore	23	43	31	57	54
Barite ... do	Ore and concentrate	745	83	155	17	900
Clays ... do	do	47,340	96	2,043	4	49,383
Feldspar ... thousand long tons	do	492	99	5	1	497
Fluorspar ... thousand short tons	do	30	17	151	83	181
Gypsum ... do	Ore	8,033	74	2,867	26	10,900
Magnesite ... do	Ore and concentrate	594	100	------	------	594
Mica:						
Scrap ... do	Concentrate	68	97	2	3	70
Sheet ... thousand pounds	do	96	14	610	86	706
Perlite ... thousand short tons	Ore	326	100	------	------	326
Phosphate rock ... thousand long tons	Ore and concentrate	15,093	95	775	5	15,868
Potassium salts ... thousand short tons	Concentrate	------	------	2,206	100	2,206
Pumice ... do	Ore	1,996	100	------	------	1,996
Salt ... do	do	48	(1)	21,583	100	21,631
Sand and gravel ... do	do	730,205	100	------	------	730,205
Sodium compounds ... do	Ore and concentrate	2	(1)	478	100	480
Stone ... do	Ore	560,500	96	23,663	4	584,163
Sulfur ... thousand long tons	Ore and concentrate	243	4	5,316	96	5,559
Talc, soapstone, and pyrophyllite ... thousand short tons	do	265	34	522	66	787
Vermiculite ... do	do	207	100	------	------	207
Other [2] ... do	do	739	98	13	2	752

[1] Less than 0.5 percent.
[2] Aplite, calcium magnesium cloride, diatomite, graphite, greensand marl, kyanite, olivine, wollastonite.

TABLE 7.—Crude ore mined per unit of marketable product at surface and underground mines in the United States, by commodities in 1959

Commodity	Unit of marketable product	Surface			Underground			Total		
		Crude ore mined (thousand short tons)	Marketable product, units	Ratio of units of crude ore to units of marketable product	Crude ore mined (thousand short tons)	Marketable product, units	Ratio of units of crude ore to units of marketable product	Crude ore mined (thousand short tons)	Marketable product, units	Ratio of units of crude ore to units of marketable product
Metals:										
Bauxite	Thousand long tons	2,003	1,553	1.3:1	269	202	1.3:1	2,272	1,755	1.3:1
Chromite	Thousand short tons				219	110	2.0:1	219	110	2.0:1
Copper	do	84,512	605	139.7:1	19,204	182	105.5:1	103,716	787	131.8:1
Gold:										
Lode	Thousand troy ounces	280	22	12.7:1	2,013	771	2.6:1	2,293	793	2.9:1
Placer	do	59,748	359	166.4:1	62	3	20.7:1	59,810	362	165.2:1
Iron ore	Thousand long tons	95,915	44,776	2.1:1	18,979	14,013	1.4:1	114,894	58,789	2.0:1
Lead	Thousand short tons	37	1	37.0:1	7,216	184	39.2:1	7,253	185	39.2:1
Manganese ore	do	1,477	513	2.9:1	312	60	5.2:1	1,789	573	3.1:1
Mercury	Thousand flasks	122	6	20.3:1	154	21	7.3:1	276	27	10.2:1
Molybdenum	Thousand pounds				9,092	37,026	.2:1	9,092	37,026	.2:1
Silver	Thousand troy ounces	105	88	1.2:1	624	12,627	5:1	729	12,715	.06:1
Titanium	Thousand short tons	12,269	642	19.1:1				12,269	642	19.1:1
Tungsten	do	3	(1)		186	2	93.0:1	189	2	94.5:1
Uranium	do	2,750	2,750	1.0:1	4,185	4,185	1.0:1	6,935	6,935	1.0:1
Zinc	do	253	9	28.1:1	7,132	352	20.3:1	7,385	361	20.5:1
Total		259,474			69,647			329,121		

Nonmetals:										
Abrasives	Thousand short tons	99	23	4.3:1	31	31	1.0:1	130	54	2.4:1
Barite	do	2,275	745	3.1:1	306	155	2.0:1	2,581	900	2.9:1
Clays	do	47,340	47,340	1.0:1	2,043	2,043	1.0:1	49,383	49,383	1.0:1
Feldspar	Thousand long tons	1,001	492	2.0:1	15	5	3.0:1	1,016	497	2.0:1
Fluorspar	Thousand short tons	62	30	2.1:1	377	151	2.5:1	439	181	2.4:1
Gypsum	do	8,033	8,033	1.0:1	2,867	2,867	1.0:1	10,900	10,900	1.0:1
Magnesite	do	643	594	1.1:1				643	594	1.1:1
Mica:										
Scrap	do	626	68	9.2:1	5	2	2.5:1	631	70	9.0:1
Sheet	Thousand pounds	225	96	2.3:1	665	610	1.1:1	890	706	1.3:1
Perlite	Thousand short tons	443	326	1.4:1				443	326	1.4:1
Phosphate rock	Thousand long tons	54,313	15,113	3.6:1	846	755	1.1:1	55,159	15,868	3.5:1
Potassium salts	Thousand short tons				13,933	2,206	6.3:1	13,933	2,206	6.3:1
Pumice	do	2,082	1,996	1.0:1				2,082	1,996	1.0:1
Salt	do	79	48	1.6:1	21,973	21,583	1.0:1	22,052	21,631	1.0:1
Sand and gravel	do	730,205	730,205	1.0:1				730,205	730,205	1.0:1
Sodium compounds	do	3	2	1.5:1	839	478	1.8:1	842	480	1.8:1
Stone	do	560,500	560,500	1.0:1	23,663	23,663	1.0:1	584,163	584,163	1.0:1
Sulfur	Thousand long tons	473	243	1.9:1	6,018	5,316	1.1:1	6,491	5,559	1.2:1
Talc, soapstone, and pyrophyllite	Thousand short tons	297	265	1.1:1	529	522	1.0:1	826	787	1.0:1
Vermiculite	do	947	207	4.6:1				947	207	4.6:1
Other [2]	do	3,366	1,105	3.0:1	743	139	5.3:1	4,109	1,244	3.3:1
Total		1,413,012			74,853			1,487,865		
Grand total		1,672,486			144,500			1,816,986		

[1] Negligible.
[2] Aplite, asbestos, boron minerals, calcium magnesium chloride, diatomite, graphite, greensand marl, kyanite, olivine, wollastonite.

TABLE 8.—Material handled per unit of marketable product at surface and underground mines in the United States, by commodities in 1959

Commodity	Unit of marketable product	Surface			Underground			Total		
		Material handled (thousand short tons)	Marketable product, units	Ratio of units of material handled to units of marketable product	Material handled (thousand short tons)	Marketable product, units	Ratio of units of material handled to units of marketable product	Material handled (thousand short tons)	Marketable product, units	Ratio of units of material handled to units of marketable product
Metals:										
Bauxite	Thousand long tons	5,075	1,553	3.3:1	269	202	1.3:1	5,344	1,755	3.0:1
Chromite	Thousand short tons				240	110	2.2:1	240	110	2.2:1
Copper	do	234,603	605	387.8:1	20,020	182	110.0:1	254,623	787	323.5:1
Gold:										
Lode	Thousand troy ounces	300	22	13.6:1	3,254	771	4.2:1	3,554	793	4.5:1
Placer	do	59.748	359	166.4:1	62	3	20.7:1	59,810	362	165.2:1
Iron ore	Thousand long tons	213,806	44,776	4.8:1	20,790	14,013	1.5:1	234,596	58,789	4.0:1
Lead	Thousand short tons	65	1	65.0:1	7,883	184	42.8:1	7,948	185	43.0:1
Manganese ore	do	3,996	513	7.8:1	378	60	6.3:1	4,374	573	7.6:1
Mercury	Thousand flasks	543	6	90.5:1	219	21	10.4:1	762	27	28.2:1
Molybdenum	Thousand pounds				17,347	37,026	0.5:1	17,347	37,026	0.5:1
Silver	Thousand troy ounces	316	88	3 6:1	850	12,627	0.07:1	1,166	12,715	0.09:1
Titanium	Thousand short tons	17,056	642	26.6:1				17,056	642	26.6:1
Tungsten	do	92			258	2	129.0:1	350	2	175.0:1
Uranium	do	54,341	2,750	19.8:1	5,222	4,185	1.2:1	59,563	6,935	8.6:1
Zinc	do	3,463	9	384.8:1	7,970	352	22.6:1	11,433	361	31.7:1
Total		593,404			84,762			678,166		

Nonmetals:										
Abrasives	Thousand short tons	169	23	7.3:1	31	31	1.0:1	200	54	3.7:1
Barite	do	6,197	745	8.3:1	306	155	2.0:1	6,503	900	7.2:1
Clays	do	47,340	47,340	1.0:1	2,066	2,043	1.0:1	49,406	49,383	1.0:1
Feldspar	Thousand long tons	1,257	492	2.6:1	16	5	3.2:1	1,273	497	2.6:1
Fluorspar	Thousand short tons	119	30	4.0:1	377	151	2.5:1	496	181	2 7:1
Gypsum	do	13,551	8,033	1.7:1	2,927	2,867	1.0:1	16,478	10,900	1.5:1
Magnesite	do	1,582	594	2.7:1	—	—	—	1,582	594	2.7:1
Mica										
Scrap	do	918	68	13.5:1	6	2	3.0:1	924	70	13.2:1
Sheet	Thousand pounds	274	96	2.9:1	669	610	1.1:1	943	706	1.3:1
Perlite	Thousand short tons	507	326	1.6:1	—	—	—	507	326	1.6:1
Phosphate rock	Thousand long tons	138,180	15,113	9.1:1	954	755	1.3:1	139,134	15,868	8.8:1
Potassium salts	Thousand short tons	—	—	—	13,933	2,206	6.3:1	13,933	2,206	6.3:1
Pumice	do	2,308	1,996	1.2:1	—	—	—	2,308	1,996	1.2:1
Salt	do	79	48	1.6:1	21,975	21,583	1.0:1	22,054	21,631	1.0:1
Sand and gravel	do	730,205	730,205	1.0:1	—	—	—	730,205	730,205	1.0:1
Sodium compounds	do	3	2	1.5:1	839	478	1.8:1	842	480	1.8:1
Stone	do	560,500	560,500	1.0:1	23,927	23,663	1.0:1	584,427	584,163	1.0:1
Sulfur	Thousand long tons	1,930	243	7.9:1	6,026	5,316	1.1:1	7,956	5,559	1.4:1
Talc, soapstone, and pyrophyllite	Thousand short tons	580	265	2.2:1	560	522	1.1:1	1,140	787	1.4:1
Vermiculite	do	947	207	4.6:1	—	—	—	947	207	4.6:1
Other [1]	do	8,624	1,105	7.8:1	748	139	5.4:1	9,372	1,244	7.5:1
Total	—	1,515,270	—	—	75,360	—	—	1,590,630	—	—
Grand total	—	2,108,674	—	—	160,122	—	—	2,268,796	—	—

[1] Aplite, asbestos, boron minerals, calcium magnesium chloride, diatomite, graphite, greensand marl, kyanite, olivine, wollastonite.

TABLE 9.—Percent of marketable product obtained from crude ore mined by surface and underground methods in the United States in 1959

Commodity	Marketable product	Marketable product, percent	
		Surface	Underground
Metals:			
Bauxite	Ore and concentrate	86.9	89.2
Chromite	do	----------	50.2
Copper	Metal	0.72	0.95
Iron ore	Ore and concentrate	52.3	82.7
Lead	Metal	2.7	2.5
Manganese	Ore and concentrate	34.7	19.2
Mercury	Metal	0.19	0.52
Molybdenum	Concentrate	----------	0.20
Titanium	do	5.2	----------
Tungsten	do	----------	1.1
Uranium	Ore	100.0	100.0
Zinc	Metal	3.6	4.9
Nonmetals:			
Abrasives	Ore	23.2	[1] 100.0
Barite	Ore and concentrate	32.7	50.7
Clays	Ore	100.0	100.0
Feldspar	Ore and concentrate	55.0	38.5
Fluorspar	do	48.4	40.1
Gypsum	Ore	100.0	100.0
Magnesite	Ore and concentrate	92.4	----------
Mica:			
Scrap	Concentrate	10.9	40.0
Sheet	do	0.02	0.05
Perlite	Ore	73.6	----------
Phosphate rock	Ore and concentrate	31.2	100.0
Potassium salts	Concentrate	----------	15.8
Pumice	Ore	95.9	----------
Salt	do	60.8	98.2
Sand and gravel	do	100.0	----------
Sodium compounds	do	66.7	57.0
Stone	do	100.0	100.0
Sulfur	Ore and concentrate	57.6	98.9
Talc, soapstone, and pyrophyllite	do	89.2	98.7
Vermiculite	do	21.9	----------

[1] Tripoli only.

Mining Methods.—Surface mining methods were predominantly single or multiple bench open pits. However, most of the crude phosphate rock ore, more than half of the lode gold ore, almost half of the barite ore, and lesser proportions of the crude ores for iron, abrasives, fluorspar, scrap mica, pumice, and talc, soapstone, and pyrophyllite mined by surface methods were recovered by dragline excavation. Dredging furnished all the surface-mined ores for placer gold, 84 percent of the titanium ores, and more than 40 percent of the scrap mica ores.

About three-fifths of the ore mined underground in 1959 was by open-stoping, one-fifth was by caving, and the remaining one-fifth by other and unspecified methods. More than half of the ore came from naturally supported open stopes. More than one-third of the ore mined underground came from four States: New Mexico, Michigan, Missouri, and Colorado, in order of descending tonnage.

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TABLE 10.—Mining methods used in surface operations for selected commodities in 1959

Commodity	Crude ore by mining method										
	Single bench		Multiple bench		Dragline excavation		Dredging		Other and unspecified		Total
	Thousand short tons	Percent of total	Thousand short tons	Percent of total	Thousand short tons	Percent of total	Thousand short tons	Percent of total	Thousand short tons	Percent of total	Thousand short tons
Metals:											
Bauxite	1,855	92.6	146	7.3					2	0.1	2,003
Copper	(1)	(1)	81,208	100.0							81,208
Gold:											
Lode	24	8.7	93	34.2	153	56.7			1	.4	271
Placer							59,748	100.0			59,748
Iron ore	9,428	9.9	79,806	83.8	5,905	6.2			95	.1	95,234
Lead	32	100.0									32
Manganese ore	485	54.2	392	43.8	12	1.4	1	.1	5	.5	895
Mercury	95	86.4	14	12.7	(1)	(1)			1	.9	110
Silver			98	100.0							98
Titanium	1	(1)	2,017	16.4			10,249	83.6			12,267
Tungsten	(1)	(1)	3	100.0							3
Uranium	485	18.9	1,788	69.6					295	11.5	2,568
Zinc			87	53.5					76	46.5	163
Nonmetals:											
Abrasives	16	17.6	54	59.3	16	17.6			5	5.5	91
Barite	558	25.6	492	22.6	1,040	47.8			88	4.0	2,178
Feldspar	293	29.3	629	62.8					79	7.9	1,001
Fluorspar	25	42.4	30	50.0	2	3.8			2	3.8	59
Gypsum	5,912	73.6	1,816	22.6					305	3.8	8,033
Magnesite			643	100.0							643
Mica:											
Scrap	197	31.5	13	2.1	59	9.4	259	41.5	97	15.5	625
Sheet	216	96.0	5	2.2					4	1.8	225
Perlite	42	9.5	161	36.3					240	54.2	443
Phosphate rock	759	1.4	2,005	3.7	51,432	94.9					54,196
Pumice	690	33.5	64	3.1	329	15.9			980	47.5	2,063
Salt	9	18.0							41	82.0	50
Sodium compounds									3	100.0	3
Sulfur			463	98.7					6	1.3	469
Talc, soapstone, and pyrophylite	240	83.9	43	15.0	2	.7			1	.4	286
Vermiculite	942	99.5	5	.5							947

[1] Negligible.

TABLE 11.—Mining methods used in underground operations by commodities in 1959

Commodity	Crude ore by mining method								
	Open—Natural support		Stoping—Artificial support		Caving		Other and unspecified		Total
	Thousand short tons	Percent of total	Thousand short tons	Percent of total	Thousand short tons	Percent of total	Thousand short tons	Percent of total	Thousand short tons
Metals:									
Bauxite	269	100.0							269
Chromite			219	100.0					219
Copper	7,124	37.1	1,075	5.6	11,004	57.3			19,203
Gold:									
Lode	60	3.0	1,945	96.6			8	0.4	2,013
Placer							62	100.0	62
Iron ore	9,035	47.6	1,518	8.0	6,984	36.8	1,442	7.6	18,979
Lead	6,054	83.9	1,147	15.9			15	.2	7,216
Manganese ore	43	13.8	257	82.4			12	3.8	312
Mercury	10	6.5	143	92.9			1	.6	154
Molybdenum					9,092	100.0			9,092
Silver	57	9.1	567	90.9			(1)	(1)	624
Tungsten	1	.5					185	99.5	186
Uranium	3,389	81.0	301	7.2	121	2.9	372	8.9	4,183
Zinc	5,309	74.5	1,617	22.7			199	2.8	7,125
Total	31,351	45.0	8,789	12.6	27,201	39.1	2,296	3.3	69,637
Nonmetals:									
Abrasives	31	100.0							31
Barite	1	.3	302	98.6			3	1.1	306
Clays	16	.8	1,920	94.3	79	3.9	21	1.0	2,036
Feldspar	2	13.3	13	86.7					15
Fluorspar	179	47.5	185	49.1	11	2.9	2	.5	377
Gypsum	2,497	87.1	23	.8			347	12.1	2,867
Mica:									
Scrap	1	20.0	4	80.0					5
Sheet	224	33.7	427	64.2			14	2.1	665
Phosphate rock	523	61.9	184	21.7			139	16.4	846
Potassium salts	13,623	97.8					310	2.2	13,933
Salt	5,951	27.1					16,022	72.9	21,973
Sodium compounds	322	38.4					517	61.6	839
Stone	22,977	97.1			118	.5	568	2.4	23,663
Sulfur	175	2.9	36	.6			5,807	96.5	6,018
Talc, soapstone, and pyrophyllite	309	58.4	118	22.4			102	19.2	529
Other [2]	54	7.3			2	.2	687	92.5	743
Total	46,885	62.6	3,212	4.3	210	.3	24,539	32.8	74,846
Grand total	78,236	54.1	12,001	8.3	27,411	19.0	26,835	18.6	144,483

[1] Negligible.
[2] Aplite, asbestos, boron minerals, calcium magnesium chloride, graphite, greensand marl, kyanite, olivine, wollastonite.

TABLE 12.—Mining methods used in underground operations, by States in 1959

State	Crude ore by mining method								
	Open stoping				Caving		Other and unspecified		Total
	Natural support		Artificial support						
	Thousand short tons	Percent of total	Thousand short tons	Percent of total	Thousand short tons	Percent of total	Thousand short tons	Percent of total	Thousand short tons
Alabama	3,349	87.8			133	3.5	331	8.7	3,813
Arizona	304	3.1	1,095	11.1	8,496	85.8			9,895
Arkansas	725	70.2	308	29.8					1,033
California	81	3.2	155	6.2			2,284	90.6	2,520
Colorado	853	8.1	736	7.0	8,744	83.4	157	1.5	10,490
Georgia	474	90.6	49	9.4					523
Idaho	1	.1	1,202	99.9					1,203
Illinois	2,744	84.0	271	8.3	141	4.3	110	3.4	3,266
Indiana	499	57.2					374	42.8	873
Iowa	570	100.0							570
Kansas	2,512	80.2					622	19.8	3,134
Kentucky	4,428	94.2	275	5.8					4,703
Louisiana	1,682	23.7					5,429	76.3	7,111
Maine					10	100.0			10
Maryland	23	100.0							23
Michigan	9,773	66.0	1,144	7.7	3,028	20.5	854	5.8	14,799
Minnesota	4	.3	130	9.2	1,282	90.5			1,416
Missouri	13,355	100.0							13,355
Montana	654	15.8	1,173	28.3	2,304	55.6	12	.3	4,143
Nevada	71	49.3	66	45.8			7	4.9	144
New Hampshire	124	100.0							124
New Jersey	130	8.0	823	50.8			669	41.2	1,622
New Mexico	13,764	87.1	983	6.2	279	1.8	779	4.9	15,805
New York	4,163	60.5	223	3.2	94	1.4	2,403	34.9	6,883
North Carolina	152	20.2	583	77.7			16	2.1	751
Ohio	2,328	43.3					3,045	56.7	5,373
Oklahoma	231	98.3					4	1.7	235
Oregon	4	40.0	6	60.0					10
Pennsylvania	2,781	61.2	168	3.7	1,557	34.3	37	.8	4,543
South Dakota	51	2.8	1,740	97.2					1,791
Tennessee	5,231	100.0							5,231
Texas	244	3.3					7,247	96.7	7,491
Utah	875	49.8	524	29.8	126	7.2	232	13.2	1,757
Virginia	2,514	69.4	179	4.9			932	25.7	3,625
West Virginia	1,484	64.8					806	35.2	2,290
Wisconsin	668	48.0			723	52.0			1,391
Wyoming	536	34.4	50	3.2	494	31.6	481	30.8	1,561
Other [1]	854	87.5	118	12.1			4	.4	976
Total	78,236	54.1	12,001	8.3	27,411	19.0	26,835	18.6	144,483

[1] Rhode Island, Vermont, Washington.

Man-Hours.—Three-fourths of the man-hours worked in mining in 1959 were attributable to surface mines, if hours worked by employees of surface yards and shops at underground mines were excluded. If the man-hours worked by these employees were included, man-hours worked in surface mines would be about 70 percent of the total.

Metals supplied one-third (83 million) of the man-hours worked in mining. Of this quantity, three metal commodities—iron ore, copper, and uranium—reported 71 percent (59 million). More than 80 percent of the man-hours worked in nonmetals mines were in sand and gravel and stone operations. These last two commodities supplied 55 percent of the 258 million man-hours worked in mining.

TABLE 13.—Man-hours[1] worked at surface and underground mines, by commodities in 1959

(Thousands)

Commodity	Man-hours		
	Surface	Underground	Total
Metals:			
Bauxite	555	113	668
Chromite		164	164
Copper	12,572	9,737	22,309
Gold:			
Lode	84	3,146	3,230
Placer	2,114	18	2,132
Iron ore	13,948	12,068	26,016
Lead	32	5,539	5,571
Manganese	433	846	1,279
Mercury	164	605	769
Molybdenum		1,382	1,382
Silver	23	1,228	1,251
Titanium	341		341
Tungsten	18	208	226
Uranium	2,413	8,196	10,609
Zinc	98	7,204	7,302
Total	32,795	50,454	83,249
Nonmetals:			
Abrasives	94	9	103
Asbestos	195	58	253
Barite	472	355	827
Boron minerals	228	24	252
Clays	6,758	1,584	8,342
Feldspar	414	66	480
Fluorspar	25	644	669
Gypsum	1,458	1,188	2,646
Magnesite	200		200
Mica:			
Scrap	210	11	221
Sheet	663	825	1,488
Perlite	77		77
Phosphate rock	4,043	593	4,636
Potassium salts		2,889	2,889
Pumice	263		263
Salt	74	1,736	1,810
Sand and gravel	80,770		80,770
Sodium compounds	10	263	273
Stone	57,410	4,388	61,798
Sulfur	4,975	252	5,227
Talc, soapstone, and pyrophyllite	187	638	825
Vermiculite	20		20
Other[2]	557	34	591
Total	159,103	15,557	174,660
Grand total	191,898	66,011	257,909

[1] Excludes surface man-hours worked at shops and yards of underground mines.
[2] Aplite, bromine, calcium magnesium chloride, diatomite graphite, greensand marl, kyanite, olivine, and wollastonite.

Exploration and Development.—About half of the exploration and development footage in 1958 and 1959 was for uranium, and all but one-tenth was for metals. The coverage in 1959 excluded part of the gold, clay, and stone mines and to enable comparisons to be made, data on these mines have been excluded in table 14 for 1958. For selected metals (tables 15 and 17) 74 percent of the exploration footage in both 1958 and 1959 was by drilling—diamond, churn, rotary, and long-hole. Rotary drilling furnished 54 percent of the drilling footage in 1958 and 40 percent in 1959. For selected nonmetals, drilling supplied 76 and 85 percent of the exploration footage in 1958 and 1959, respectively. In both years 81 percent of the drilling was by rotary drill (tables 16 and 18).

Most of the exploration and development activity was confined to a few States. Arizona, Colorado, Missouri, New Mexico, Utah, and Wyoming contributed about two-thirds of the total activity in 1958. In Missouri, lead exploration predominated; in Arizona 64 percent of the footage was for copper and 32 percent for uranium; and in Colorado, New Mexico, Utah, and Wyoming uranium exploration predominated.

TABLE 14.—Exploration and development activity in the United States, by commodities

Commodity	1958		1959	
	Feet	Percent of total	Feet	Percent of total
Metals:				
Copper	1,113,283	9.6	692,902	7.2
Gold, lode	305,593	2.6	199,858	2.1
Iron ore	1,115,982	9.6	993,508	10.3
Lead	276,631	2.4	1,022,328	10.6
Manganese	242,964	2.1	42,612	.4
Tungsten	149,412	1.3	16,775	.2
Uranium and vanadium	5,350,944	45.9	4,619,410	48.1
Zinc and zinc-lead	1,599,793	13.8	579,078	6.0
Other [1]	304,121	2.6	597,725	6.2
Total	10,458,723	89.9	8,764,196	91.1
Nonmetals:				
Barite	83,827	.7	121,780	1.3
Fluorspar	116,180	1.0	91,745	1.0
Gypsum	289,169	2.5	124,970	1.3
Phosphate rock	93,841	.8	207,741	2.2
Sulfur	160,499	1.4	166,835	1.7
Other [2]	426,149	3.7	135,420	1.4
Total	1,169,665	10.1	848,491	8.9
Grand total	11,628 388	100.0	9,612,687	100.0

[1] Antimony (1958), bauxite, beryl (1959), chromite, columbium-tantalum, mercury, molybdenum, titanium, zirconium (1959).
[2] Asbestos, diatomite, feldspar, magnesite (1958), mica, olivine (1958), perlite, potash, pumice, salt, sodium compounds (1958), talc, soapstone, and pyrophyllite, and wollastonite (1959).

TABLE 15.—Exploration and development for selected metals, by methods in 1958

(Feet)

Method	Commodity						
	Bauxite	Chromite	Copper	Gold, lode	Iron ore	Lead	Manganese
Shaft sinking	-	83	2,250	5,453	3,006	861	3,710
Raising	-	235	81,637	21,867	85,710	2,919	6,930
Winzing	-	45	6,365	965	-	610	5,160
Tunneling	-	702	28,205	4,463	3,960	3,115	7,738
Drifting	-	220	126,739	40,755	88,173	9,845	8,748
Crosscutting	-	45	12,514	9,532	88,592	3,674	15,928
Diamond drilling	-	4,000	252,154	110,168	261,970	8,579	9,854
Churn drilling	17,912	80	43,791	10	104,315	-	11,965
Rotary drilling	69,550	16,400	451,529	535	170,884	1,200	151,720
Long-hole drilling	-	350	19,399	50,844	244,004	3,576	4,760
Trenching	-	13,100	1,855	58,674	41,400	1,330	8,251
Other	-	125	86,845	2,327	23,968	240,922	8,200
Total	87,462	35,385	1,113,283	305,593	1,115,982	276,631	242,964

Method	Mercury	Molybdenum	Titanium	Tungsten	Uranium and vanadium	Zinc and zinc-lead	Total
Shaft sinking	385	66	-	-	9,368	2,835	28,017
Raising	3,640	-	-	1,835	9,799	45,088	259,660
Winzing	612	-	-	-	1,820	3,293	18,870
Tunneling	2,541	-	-	140	14,658	8,303	73,825
Drifting	5,823	5,254	-	3,489	243,662	139,411	672,119
Crosscutting	1,914	-	-	1,157	17,296	27,729	178,381
Diamond drilling	6,977	14,472	-	13,615	535,357	869,063	2,086,209
Churn drilling	-	-	22,800	140	41,112	196,611	438,736
Rotary drilling	8,840	-	50	-	3,331,847	5,988	4,208,543
Long-hole drilling	10,098	-	-	127,996	310,473	236,328	1,007,828
Trenching	7,310	-	-	1,040	22,201	660	155,821
Other	4,265	-	13,249	-	813,351	64,484	1,257,736
Total	52,405	19,792	36,099	149,412	5,350,944	1,599,793	10,385,745

TABLE 16.—Exploration and development for selected nonmentals, by methods in 1958

(Feet)

Method	Commodity				
	Barite	Fluorspar	Gypsum	Magnesite	Phosphate rock
Shaft sinking		1,058	80		
Raising	591	4,704	2,000		9,878
Winzing		365			
Tunneling	663	1,200	300		
Drifting	3,028	11,222	12,000		13,518
Crosscutting		1,430	4,500		9,400
Diamond drilling		72,001	11,634	2,694	
Churn drilling		14,626			
Rotary drilling	74,945	5,000	231,625	46,700	54,203
Long-hole drilling	100	2,000		5,245	
Trenching	4,500	1,000	2,000		900
Other		1,574	25,030		5,942
Total	83,827	116,180	289,169	54,639	93,841

Method	Potash	Pumice	Sodium compounds	Sulfur	Talc, soapstone and pyrophyllite	Total
Shaft sinking					380	1,518
Raising					5,068	22,241
Winzing					75	440
Tunneling					920	3,083
Drifting			25,000		2,346	67,114
Crosscutting					910	16,240
Diamond drilling	16,986			10	5,963	109,288
Churn drilling					3,941	18,567
Rotary drilling	14,373	10,000	3,000	159,489		599,335
Long-hole drilling	8,000				850	16,195
Trenching				1,000	600	10,000
Other		1,014			82,850	116,410
Total	39,359	11,014	28,000	160,499	103,903	980,431

TABLE 17.—Exploration and development for selected metals, by methods in 1959

(Feet)

Method	Commodity						
	Chromite	Copper	Gold, lode	Iron ore	Lead	Manganese	Mercury
Shaft sinking		1,873	2,294	2,009	1,138	190	377
Raising	692	51,687	16,833	79,122	18,392	7,322	6,627
Winzing		5,953	1,204		706	185	353
Tunneling		1,150	36,292	13,242	3,892	2,700	250
Drifting		93,556	16,999	137,026	71,703	8,700	6,149
Crosscutting	504	16,194	5,840	21,611	16,395	470	1,570
Diamond drilling		329,311	83,694	265,315	625,789	3,205	320
Churn drilling		55,224		75,064	221,719		8,000
Rotary drilling		99,532		159,436	800	10,910	9,300
Long-hole drilling	26,693	29,550	29,345	212,158	16,496	4,270	8,578
Trenching		5,900	4,825	21,700	5,100	4,660	8,840
Other		2,972	2,532	6,825	40,198		25,364
Total	27,889	692,902	199,858	993,508	1,022,328	42,612	75,728

Method	Molybdenum	Titanium	Tungsten	Uranium	Zinc	Total
Shaft sinking	336		45	7,738	1,188	17,188
Raising	136		1,568	18,929	30,586	231,894
Winzing				1,322	196	9,919
Tunneling				27,725	2,041	87,292
Drifting	18,020	50	2,332	402,709	72,719	829,963
Crosscutting			376	24,919	11,816	99,695
Diamond drilling	35,044		11,769	521,742	119,606	1,995,795
Churn drilling		12,000		33,636	33,193	438,836
Rotary drilling		6,000		2,284,481	100	2,570,559
Long-hole drilling	274,162			695,285	167,788	1,464,325
Trenching		300	685	4,568	40,150	96,728
Other		109,836		596,356	94,185	878,268
Total	327,698	128,186	16,775	4,619,410	573,568	8,720,462

TABLE 18.—Exploration and development for selected nonmetals, by methods in 1959

(Feet)

Method	Commodity							
	Barite	Fluorspar	Gypsum	Phosphate rock	Potash	Sulfur	Talc, soapstone, and pyrophyllite	Total
Shaft sinking	213	967	400				95	1,675
Raising	300	1,016	2,300	7,193		1,783	3,796	16,388
Winzing		125				832	95	1,052
Tunneling	2,858	100		2,418	1,200		1,976	8,552
Drifting	4,322	3,808	10,000	8,326		1,490	3,353	31,299
Crosscutting	545	1,168		5,289		1,233	1,182	9,417
Diamond drilling	2,092	73,276	17,155	1,498		3,270	3,173	100,464
Churn drilling	1,000	6,940				178		8,118
Rotary drilling	107,000		79,961	173,534		158,049	1,100	519,644
Long-hole drilling	250	200	11,000		3,700		204	15,354
Trenching	150		3,500	900			1,400	5,950
Other	3,050	4,145	654	8,583	12,000		8,000	36,432
Total	121,780	91,745	124,970	207,741	16,900	166,835	24,374	754,345

TABLE 19.—Exploration and development for metals and nonmetals, by States

State	1958		1959	
	Feet	Percent of total	Feet	Percent of total
Alabama	65,648	0.6	6,750	0.1
Alaska	26,856	.2	39,837	.4
Arizona	776,191	6.7	695,197	7.2
Arkansas	47,255	.4	8,285	.1
California	539,437	4.6	206.738	2.2
Colorado	2,109,095	18.1	1,943,684	20.1
Florida	43,788	.4	20,235	.2
Georgia	17,912	.2	27,679	.3
Idaho	175,987	1.5	312,912	3.3
Illinois	97,175	.8	98,999	1.0
Kansas	10,175	.1	----------	----------
Kentucky	1,074	(1)	2,403	(1)
Louisiana	123,751	1.1	142,600	1.5
Maine	4,000	(1)	----------	----------
Michigan	497,528	4.3	246,494	2.6
Minnesota	274,869	2.4	188,613	2.0
Missouri	1,005,681	8.6	991,720	10.3
Montana	610,522	5.3	135,903	1.4
Nebraska	14	(1)	40	(1)
Nevada	627,642	5.4	181,100	1.9
New Hampshire	50	(1)	1,400	(1)
New Jersey	26,727	.2	22,456	.2
New Mexico	1,117,070	9.6	1,309,145	13.5
New York	159,723	1.4	450,610	4.7
North Carolina	55,184	.5	21,021	.2
Ohio	----------	----------	38	----------
Oklahoma	8,750	.1	----------	----------
Oregon	64,298	.6	35,899	.4
Pennsylvania	47,281	.4	93,331	1.0
South Carolina	100	(1)	----------	----------
South Dakota	132,093	1.1	124,354	1.3
Tennessee	209,998	1.8	283,830	3.0
Texas	38,588	.3	52,992	.6
Utah	1,214,967	10.5	488,350	5.1
Vermont	34,485	.3	27,322	.3
Virginia	236,528	2.0	67,409	.7
Washington	172,282	1.5	137,498	1.4
West Virginia	----------	----------	6,415	.1
Wisconsin	49,841	.4	36,763	.4
Wyoming	1,005,823	8.6	1,204,665	12.5
Total	11,628,388	100.0	9,612,687	100.0

[1] Less than 0.05 percent.

TABLE 20.—Exploration and development for metals, by States

State	1958		1959	
	Feet	Percent of total	Feet	Percent of total
Alabama	60,707	0.6	6,750	0.1
Alaska	26,856	.3	39,837	.5
Arizona	750,895	7.2	689,612	7.9
Arkansas	38,691	.4		
California	330,707	3.2	98,124	1.1
Colorado	2,094,395	20.0	1,936,547	22.0
Florida	33,049	.3	12,000	.1
Georgia	17,912	.2	23,979	.3
Idaho	127,681	1.2	169,912	1.9
Illinois	11,613	.1	10,292	.1
Kansas	5,035	(1)		
Michigan	490,528	4.7	241,494	2.8
Minnesota	274,869	2.6	188,613	2.2
Missouri	1,003,181	9.6	991,720	11.3
Montana	535,959	5.1	113,909	1.3
Nevada	590,523	5.6	172,711	2.0
New Jersey	26,727	.3	22,456	.3
New Mexico	1,077,711	10.3	1,289,945	14.7
New York	151,586	1.4	440,200	5.0
North Carolina	24,357	.2	22	(1)
Oklahoma	8,750	.1		
Oregon	53,798	.5	32,999	.4
Pennsylvania	47,281	.5	93,332	1.1
South Dakota	131,203	1.3	123,518	1.4
Tennessee	137,998	1.3	144,545	1.6
Texas			31,043	.4
Utah	1,211,661	11.6	480,378	5.5
Virginia	44,728	.4	35,403	.4
Washington	122,858	1.2	133,578	1.5
Wisconsin	49,841	.5	36,763	.4
Wyoming	977,623	9.3	1,204,514	13.7
Total	10,458,723	100.0	8,764,196	100.0

[1]Less than 0.05 percent.

TABLE 21.—Exploration and development for nonmetals, by States

State	1958		1959	
	Feet	Percent of total	Feet	Percent of total
Alabama	4,941	0.4	----------	----------
Arizona	25,296	2.2	5,585	0.7
Arkansas	8,564	.7	8,285	1.0
California	208,730	17.8	108,614	12.8
Colorado	14,700	1.3	7,137	.8
Florida	10,739	.9	8,235	1.0
Georgia	----------	----------	3,700	.4
Idaho	48,306	4.1	143,000	16.8
Illinois	85,562	7.3	88,707	10.4
Kansas	5,140	.4	----------	----------
Kentucky	1,074	.1	2,403	.3
Louisiana	123,751	10.6	142,600	16.8
Maine	4,000	.3	----------	----------
Michigan	7,000	.6	5,000	.6
Missouri	2,500	.2	----------	----------
Montana	74,563	6.4	21,994	2.6
Nebraska	14	(1)	40	(1)
Nevada	37,119	3.2	8,389	1.0
New Hampshire	50	(1)	1,400	.2
New Mexico	39,359	3.4	19,200	2.3
New York	8,137	.7	10,410	1.2
North Carolina	30,827	2.6	20,999	2.5
Ohio	----------	----------	38	(1)
Oregon	10,500	.9	2,900	.3
South Carolina	100	(1)	----------	----------
South Dakota	890	.1	836	.1
Tennessee	72,000	6.2	139,285	16.4
Texas	38,588	3.3	21,949	2.6
Utah	3,306	.3	7,972	.9
Vermont	34,485	3.0	27,322	3.2
Virginia	191,800	16.4	32,006	3.8
Washington	49,424	4.2	3,920	.5
West Virginia	----------	----------	6,415	.8
Wyoming	28,200	2.4	150	(1)
Total	1,169,665	100.0	848,491	100.0

[1] Less than 0.05 percent.

TABLE 22.—Exploration and development in Colorado in 1958

(Feet)

Method	Copper	Fluorspar	Gold, lode and placer	Lead-zinc	Uranium	Other [1]	Total
Shaft sinking	75	----------	145	264	1,467	326	2,277
Raising	----------	3,200	1,077	6,409	3,336	47	14,069
Winzing	10	----------	130	117	655	----------	912
Tunneling	820	----------	110	1,760	3,524	100	6,314
Drifting	240	4,500	5,066	15,044	68,838	5,772	99,460
Crosscutting	50	1,000	318	3,984	4,897	14,622	24,871
Diamond drilling	----------	----------	1,900	23,200	394,417	----------	419,517
Churn drilling	----------	----------	----------	----------	25,250	----------	25,250
Rotary drilling	----------	5,000	----------	----------	737,179	2,130	744,309
Long-hole drilling	----------	1,000	300	39,761	72,058	----------	113,119
Trenching	500	----------	150	30	4,066	800	5,546
Other	6,000	----------	----------	582	646,969	200	653,751
Total	7,695	14,700	9,196	91,151	1,962,656	23,997	2,109,395

[1] Columbium-tantalum, minor metals, and molybdenum.

TABLE 23.—Exploration and development in Missouri in 1958

(Feet)

Method	Barite	Iron ore	Lead	Total
Shaft sinking		1,210	804	2,014
Raising			2,691	2,691
Winzing				
Tunneling				
Drifting			46,541	46,541
Crosscutting				
Diamond drilling		13,900	681,841	695,741
Churn drilling		35,610	177,026	212,636
Rotary drilling		3,500		3,500
Long-hole drilling			140	140
Trenching	2,500	2,100		4,600
Other			37,818	37,818
Total	2,500	56,320	946,861	1,005,681

TABLE 24.—Exploration and development in New Mexico in 1958

(Feet)

Method	Copper	Lead-zinc	Potash	Uranium	Other [1]	Total
Shaft sinking	134	250		3,426	110	3,920
Raising		302		3,271		3,573
Winzing	137			257	65	459
Tunneling	100			212	250	562
Drifting	610	660		92,450	430	94,150
Crosscutting	50	100		7,167	150	7,467
Diamond drilling	40,709	3,165	16,986	11,696		72,556
Churn drilling	16,490			1,810		18,300
Rotary drilling			14,373	775,255	300	789,928
Long-hole drilling		1,242	8,000	102,090		111,332
Trenching					452	452
Other	7,000			7,646	200	14,846
Total	65,230	5,719	39,359	1,005,280	1,957	1,117,545

[1] Lode gold, manganese, silver, and stone.

TABLE 25.—Exploration and development in Utah in 1958

(Feet)

Method	Copper	Gold, lode and placer	Lead-zinc	Uranium	Other [1]	Total
Shaft sinking	10	84	84	1,324	150	1,652
Raising	50	484	11,706	2,711	578	15,529
Winzing	18	45	160	65		288
Tunneling	18,030	98	2,680	6,499		27,307
Drifting	100	1,401	27,817	70,442	1,418	101,178
Crosscutting	20	249	1,306	3,229		4,804
Diamond drilling	10,782		20,671	68,307	100,010	199,770
Churn drilling				10,500		10,500
Rotary drilling				543,838	2,150	545,988
Long-hole drilling			57,400	90,280		147,680
Trenching	50		50	440	1,000	1,540
Other	40		21,500	137,226		158,766
Total	29,100	2,361	143,374	934,861	105,306	1,215,002

[1] Fluorspar, iron ore, phosphate rock, and sulfur.

TABLE 26.—Exploration and development in Wyoming in 1958

(Feet)

Method	Iron ore	Uranium	Other [1]	Total
Shaft sinking		469		469
Raising	2,274	235	50	2,559
Winzing		250		250
Tunneling	1,478	925	50	2,453
Drifting	6,976	5,362	25,000	37,338
Crosscutting		340		340
Diamond drilling	4,685	2,971	200	7,856
Churn drilling				
Rotary drilling		938,123	3,000	941,123
Long-hole drilling		11,580	30	11,610
Trenching		1,725		1,725
Other		100		100
Total	15,413	962,080	28,330	1,005,823

[1] Columbium-tantalum, feldspar, minor metals, and sodium compounds.

Major exploration and development activity for selected commodities in 1959 and the percent of the total footage reported for the commodity were as follows: Barite, Tennessee, 90 percent; copper, Arizona, 64 percent; iron ore, New York, 23 percent, Michigan, 22 percent, and Minnesota, 19 percent; lead and zinc, Missouri, 56 percent; phosphate rock, Idaho, 69 percent; sulfur, Louisiana, 82 percent; and uranium, Colorado, 34 percent, and New Mexico and Wyoming, 26 percent each.

TABLE 27.—Exploration and development of barite, by States in 1959

State	Feet	Percent of total
Arkansas	8,285	6.8
New Mexico	2,300	1.9
Tennessee	109,285	89.7
Other [1]	1,910	1.6
Total	121,780	100.0

[1] California, Montana, and Nevada.

TABLE 28.—Exploration and development of copper, by States in 1959

State	Feet	Percent of total	State	Feet	Percent of total
Arizona	444,823	64.2	Tennessee	28,048	4.0
Colorado	10,456	1.5	Utah	10,071	1.5
Michigan	28,066	4.1	Other [1]	10,692	1.5
Montana	21,358	3.1			
Nevada	70,029	10.1	Total	692,902	100.0
New Mexico	69,359	10.0			

[1] California, Idaho, and North Carolina.

TABLE 29.—Exploration and development of iron ore, by States in 1959

State	Feet	Percent of total	State	Feet	Percent of total
Alaska	14,933	1.5	Pennsylvania	78,944	7.9
California	24,830	2.5	Texas	31,043	3.1
Michigan	213,428	21.6	Wisconsin	21,263	2.1
Minnesota	188,613	19.1	Wyoming	14,688	1.4
Missouri	95,675	9.6	Other [1]	18,275	1.9
Nevada	42,200	4.2			
New Jersey	22,456	2.2	Total	993,508	100.0
New York	227,160	22.9			

[1] Alabama, Arizona, New Mexico, Utah, and Washington.

TABLE 30.—Exploration and development of lead and zinc, by States in 1959

State	Feet	Percent of total	State	Feet	Percent of total
Arizona	20,246	1.3	Tennessee	113,497	7.1
Colorado	42,801	2.7	Utah	104,292	6.5
Idaho	121,875	7.6	Virginia	29,043	1.8
Illinois	10,292	.6	Washington	70,391	4.4
Kansas	33,501	2.1	Wisconsin	15,500	1.0
Missouri	896,045	56.0	Other [1]	11,577	.7
Nevada	14,754	.9			
New York	103,204	6.4	Total	1,601,406	100.0
Pennsylvania	14,388	.9			

[1] California, Montana, and New Mexico.

TABLE 31.—Exploration and development of phosphate rock, by States in 1959

State	Feet	Percent of total	State	Feet	Percent of total
Florida	8,235	4.0	Utah	7,962	3.8
Idaho	142,700	68.8			
Montana	18,844	9.0	Total	207,741	100.0
Tennessee	30,000	14.4			

TABLE 32.—Exploration and development of sulfur, by States in 1959

State	Feet	Percent of total	State	Feet	Percent of total
California	1,738	1.0	Virginia	4,032	2.4
Colorado	3,016	1.8			
Lousiana	136,100	81.6	Total	166,835	100.0
Texas	21,949	13.2			

TABLE 33.—Exploration and development of uranium, by States in 1959

State	Feet	Percent of total	State	Feet	Percent of total
Arizona	221,718	4.8	Utah	355,192	7.7
California	20,600	.4	Washington	26,378	.6
Colorado	1,563,836	33.9	Wyoming	1,189,826	25.7
New Mexico	1,189,617	25.8	Other [1]	13,691	.3
Oregon	19,364	.4			
South Dakota	19,188	.4	Total	4,619,410	100.0

[1] Idaho, Montana, and Nevada.

Statistical Summary of Mineral Production

By Kathleen J. D'Amico [1]

THIS SUMMARY is shown in Minerals Yearbook volumes I and III of this series on mineral production in the United States, its island possessions, the Canal Zone, and the Commonwealth of Puerto Rico, and on the principal minerals imported into and exported from the United States. The several commodity and area chapters contain further details on production. A summary table comparing world and U.S. mineral production also is included.

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

Because of inadequacies in the statistics available, some series deviate from the foregoing definition. The quantities of gold, silver, copper, lead, zinc, and tin are recorded on a mine basis (as the re-

TABLE 1.—Value of mineral production in the United States,[1] 1925–60, by mineral groups [2]

(Millions)

Year	Mineral fuels	Nonmetals (except fuels)	Metals	Total	Year	Mineral fuels	Nonmetals (except fuels)	Metals	Total
1925	$2,910	$1,187	$715	$4,812	1943	$4,028	$916	$987	$5,931
1926	3,371	1,219	721	5,311	1944	4,574	836	900	6,310
1927	2,875	1,201	622	4,698	1945	4,569	888	774	6,231
1928	2,666	1,163	655	4,484	1946	5,090	1,243	729	7,062
1929	2,940	1,166	802	4,908	1947	7,188	1,338	1,084	9,610
1930	2,500	973	507	3,980	1948	9,502	1,552	1,219	12,273
1931	1,620	671	287	2,578	1949	7,920	1,559	1,101	10,580
1932	1,460	412	128	2,000	1950	8,689	1,822	1,351	11,862
1933	1,413	432	205	2,050	1951	9,779	2,079	1,671	13,529
1934	1,947	520	277	2,744	1952	9,616	2,163	1,617	13,396
1935	2,013	564	365	2,942	1953	10,257	2,350	1,811	14,418
1936	2,405	685	516	3,606	1954	9,919	[3] 2,630	1,518	14,067
1937	2,798	711	756	4,265	1955	10,780	[3] 2,957	2,055	15,792
1938	2,436	622	460	3,518	1956	11,741	[3] 3,266	2,358	17,365
1939	2,423	754	631	3,808	1957	12,709	[3] 3,267	2,137	18,113
1940	2,662	784	752	4,198	1958	11,589	[3] 3,346	[4] 1,594	[4] 16,529
1941	3,228	989	890	5,107	1959	[4] 11,950	[3] 3,721	1,570	[4] 17,241
1942	3,568	1,056	999	5,623	1960	12,141	[3] 3,730	2,021	17,892

[1] Excludes Alaska and Hawaii, 1925–53.
[2] Data for 1925–46 are not strictly comparable with those for subsequent years, since for the earlier years the value of heavy clay products has not been replaced by the value of raw clays used for such products.
[3] Total adjusted to eliminate duplicating value of clays and stone.
[4] Revised figure.

[1] Publications editor.

coverable content of ore sold or treated). The values assigned to these quantities, however, are based on the average selling price of refined metal, not the mine value. Mercury is measured as recovered metal and valued at the average New York price for metal.

Data for clays and stone, 1954–60, included output used in making cement and lime. Mineral-production totals have been adjusted to eliminate duplicating these values.

The weight or volume units shown are those customary in the particular industries producing the respective commodities. No adjustment has been made in the dollar values for changes in the purchasing power of the dollar.

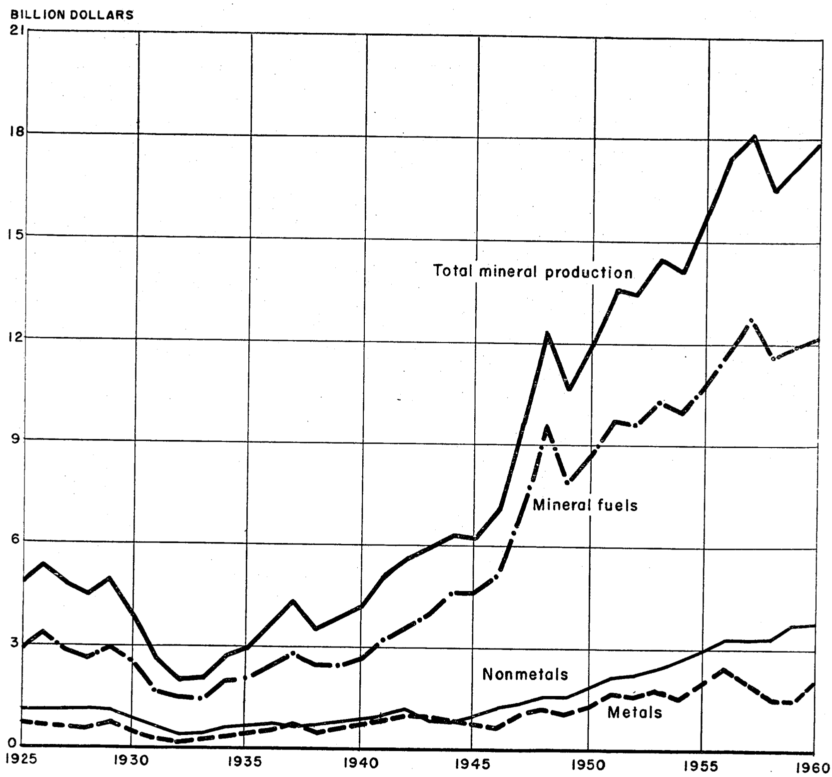

FIGURE 1.—Value of mineral production in the United States, 1925–60.

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

Mineral	1957 Quantity	1957 Value (thousands)	1958 Quantity	1958 Value (thousands)	1959 Quantity	1959 Value (thousands)	1960 Quantity	1960 Value (thousands)
Mineral fuels:								
Asphalt and related bitumens (native):								
Bituminous limestone and sandstone ... short tons	1,168,507	$3,221	1,326,493	$3,343	1,518,765	$3,868	1,242,874	$3,070
Gilsonite ... do	207,704	4,259	317,280	4,864	379,362	9,385	383,037	10,020
Carbon dioxide, natural (estimate) ... thousand cubic feet	704,276	139	722,615	102	485,179	71	521,169	99
Coal:								
Bituminous and lignite [2] ... thousand short tons	492,704	2,504,406	410,446	1,996,281	412,028	1,965,607	415,512	1,950,425
Pennsylvania anthracite ... do	25,338	227,754	21,171	187,898	20,649	172,320	18,817	147,116
Helium ... thousand cubic feet	310,365	5,112	352,134	5,741	375,408	6,144	475,179	7,768
Natural gas ... million cubic feet	10,680,258	1,201,759	11,030,298	1,317,492	12,046,115	1,556,800	12,771,038	1,789,970
Natural gas liquids:								
Natural gasoline and cycle products ... thousand gallons	5,734,307	415,791	5,596,458	393,139	5,597,102	408,694	5,842,507	416,819
LP gases ... do	6,655,282	263,665	6,783,000	296,571	7,874,706	349,802	8,444,074	391,566
Peat ... short tons	316,217	3,458	327,813	3,446	419,460	4,372	470,889	5,138
Petroleum (crude) ... thousand 42-gallon barrels	2,616,901	8,079,259	2,449,016	7,380,065	2,574,590	7,473,336	[3] 2,574,933	[3] 7,419,382
Total mineral fuels	------------	12,709,000	------------	11,589,000	------------	[6] 11,950,000	------------	12,141,000
Nonmetals (except fuels):								
Abrasive stone [4] ... short tons	(4)	331	(4)	[5] 182	3,672	315	2,539	240
Asbestos ... do	43,653	4,917	43,979	5,127	[6] 45,459	[6] 4,391	45,223	4,231
Barite ... do	1,145,791	12,897	605,402	[6] 7,508	901,815	10,301	713,926	8,563
Boron minerals ... do	541,124	38,041	528,209	38,310	619,946	46,150	640,591	47,550
Bromine ... thousand pounds	191,971	48,038	176,397	46,689	195,483	51,508	175,010	44,637
Cement ... thousand 376-pound barrels	299,189	961,499	317,263	1,038,672	346,675	1,144,867	321,646	1,089,134
Clays ... thousand short tons	45,620	155,805	43,750	143,487	49,383	159,659	49,054	162,372
Emery ... short tons	11,893	184	7,687	126	8,555	150	8,169	142
Feldspar ... long tons	498,057	4,935	469,738	4,278	548,390	[6] 5,372	502,380	4,779
Fluorspar ... short tons	328,872	15,777	319,513	15,071	185,091	8,680	229,782	10,391
Garnet (abrasive) ... do	9,776	1,080	12,303	869	14,568	1,211	10,522	986
Gem stones (estimate)	(7)	882	(7)	1,006	(7)	1,184	(7)	1,188
Gypsum ... thousand short tons	9,195	29,871	9,600	32,495	10,900	39,231	9,825	35,690
Lime ... do	10,266	135,143	9,203	120,921	12,498	163,890	12,963	173,050
Magnesite ... short tons	678,489	3,258	492,982	2,409	594,307	2,401	498,528	2,051
Magnesium compounds from sea water and brine (except for metals) ... short tons, MgO equivalent	184,236	15,997	207,053	16,419	276,309	21,636	293,454	21,903
Mica:								
Scrap ... short tons	92,438	2,109	93,347	2,065	[6] 101,541	[6] 2,665	119,929	2,962
Sheet ... pounds	690,052	2,492	661,344	2,845	706,395	3,419	578,985	2,830
Perlite ... short tons	301,605	2,562	291,994	2,463	324,669	2,737	312,153	2,665
Phosphate rock ... thousand long tons	13,976	87,689	14,879	93,693	15,869	98,758	17,516	117,041

See footnotes at end of table.

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

Mineral	1957		1958		1959		1960	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands
Nonmetals (except fuels)—Continued								
Potassium salts..........thousand short tons, K_2O equivalent..	2,266	$84,612	2,147	$75,000	2,383	$80,393	2,638	$87,054
Pumice..........thousand short tons..	1,827	4,628	1,973	5,287	2,276	5,863	2,212	5,569
Pyrites..........thousand long tons..	1,067	9,087	974	7,987	(8)	(8)	1,016	7,936
Salt..........thousand short tons..	23,844	148,887	21,911	141,486	25,160	155,839	25,479	161,140
Sand and gravel..........do....	632,255	599,750	684,498	652,789	730,205	728,712	[15] 709,495	[15] 719,952
Slate..........short tons..	632	11,029	(9)	(9)	(9)	(9)	(9)	(9)
Sodium carbonate (natural)..........do....	652,717	17,792	628,619	17,032	735,261	19,078	808,624	20,865
Sodium sulfate (natural)..........do....	331,382	6,542	347,445	6,716	402,743	7,689	449,631	8,706
Stone [10]..........thousand short tons..	532,791	814,373	535,923	826,685	584,163	911,982	[15] 616,735	[15] 952,454
Sulfur:								
Frasch-process mines..........thousand long tons..	5,035	122,915	4,644	109,272	5,222	121,777	5,003	115,494
Other mines..........long tons..	172,169	1,521	153,574	1,505	151,932	1,418	(8)	(8)
Talc, soapstone, and pyrophyllite..........short tons..	684,453	4,796	718,165	4,718	[6] 791,558	[6] 5,641	734,473	5,378
Tripoli..........do....	50,717	195	47,044	183	52,968	219	57,713	247
Vermiculite..........thousand short tons..	184	2,603	191	2,728	207	3,082	199	3,108
Value of items that cannot be disclosed:								
Aplite, brucite (1957–59), calcium-magnesium chloride, diatomite, epsom salts from epsomite (1957), graphite, iodine, kyanite, lithium minerals, greensand marl, nitrogen compounds (1957–58), olivine, staurolite (1957–58, 1960), sharpening stones (1957–58), wollastonite, and value indicated by footnote 8..........	....	35,565	....	39,765	....	50,470	....	44,395
Total nonmetals [11]..........	....	3,267,000	....	[6] 3,346,000	....	[6] 3,721,000	....	3,730,000
Metals:								
Antimony ore and concentrate..short tons, antimony content..	710	(12)	716	(12)	688	(12)	635	(12)
Bauxite..........long tons, dried equivalent..	1,416,172	12,868	1,310,685	12,815	1,700,235	17,725	1,997,827	21,107
Beryllium concentrate..........short tons, gross weight..	521	276	[6] 505	[6] 243	[6] 425	[6] 179	509	162
Chromite..........do....	166,157	7,816	143,795	6,187	[13] 105,000	[13] 3,765	[13] 107,000	[13] 3,813
Cobalt (content of concentrate)..........thousand pounds..	4,123	(12)	4,832	(12)	2,944	(12)	(12)	(12)
Columbium-tantalum concentrate [14]..........pounds..	370,483	(12)	428,347	(12)	189,263	(12)	....	....
Copper (recoverable content of ores, etc.)..........short tons..	1,086,859	654,289	979,329	515,127	824,846	506,455	1,080,169	693,468
Gold (recoverable content of ores, etc.)..........troy ounces..	1,793,597	62,776	1,739,249	60,874	[6] 1,602,931	[6] 56,103	1,666,772	58,336
Iron ore, usable (excluding byproduct iron sinter) thousand long tons, gross weight..	104,157	865,703	66,288	569,154	59,164	514,067	82,957	723,496
Lead (recoverable content of ores, etc.)..........short tons..	338,216	96,730	267,377	62,566	255,586	58,786	246,669	57,722
Manganese ore (35 percent or more Mn) short tons, gross weight..	366,334	29,363	327,309	23,637	[6] 229,199	[6] 17,904	80,021	5,352
Manganiferous ore (5 to 35 percent Mn)..........do....	865,127	5,413	520,601	3,532	[6] 470,600	[6] 3,153	658,455	4,466
Mercury..........76-pound flasks..	34,625	8,552	38,067	8,720	31,256	7,110	33,223	7,002
Molybdenum (content of concentrate)..........thousand pounds..	57,143	67,605	42,328	50,371	51,603	64,655	69,941	87,406

Nickel (content of ore and concentrate) short tons	12,901	([12])	13,489	([12])	13,374	([12])	14,079	([12])
Rare-earth and thorium concentrates do	3,079	653	2,021	286	1,143	206	([12])	([12])
Silver (recoverable content of ores, etc.) thousand troy ounces	38,165	34,541	34,111	30,872	31,194	28,233	30,766	27,846
Tin (content of ore and concentrate) long tons	----------	----------	----------	----------	50	60	10	12
Titanium concentrate:								
Ilmenite short tons, gross weight	782,975	21,802	565,164	11,152	637,263	12,106	789,283	14,655
Rutile do	10,644	1,544	1,863	210	8,648	877	9,433	879
Tungsten ore and concentrate short tons, 60-percent WO_3 basis	5,520	8,186	3,788	3,991	3,649	4,502	7,325	9,815
Uranium ore short tons	3,682,543	81,181	5,178,315	116,397	6,934,927	141,349	7,970,211	152,188
Vanadium (recoverable in ore and concentrate) do	3,691	([12])	3,030	10,817	3,719	13,278	4,971	[15] 17,749
Zinc (recoverable content of ores, etc.) do	531,735	123,235	412,005	84,113	425,303	97,787	435,427	112,365
Value of items that cannot be disclosed: Magnesium chloride for magnesium metal, manganiferous residuum, platinum-group metals (crude), zirconium concentrate, and values indicated by footnote 12	----------	[6] 54,145	----------	[6] 23,245	----------	21,763	----------	23,078
Total metals	----------	2,137,000	----------	[6] 1,594,000	----------	1,570,000	----------	2,021,000
Grand total mineral production	----------	18,113,000	----------	[6] 16,529,000	----------	[6] 17,241,000	----------	17,892,000

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2] Includes small quantity of anthracite mined in States other than Pennsylvania.
[3] Preliminary figure.
[4] Grindstones, pulpstones, millstones, grinding pebbles, and tubemill liners, weight not recorded; excludes value of sharpening stones (1957–58), value for which is included with "Nonmetal items that cannot be disclosed."
[5] Excludes tubemill liners, value for which is included with "Nonmetal items that cannot be disclosed."
[6] Revised figure.
[7] Weight not recorded.
[8] Figure withheld to avoid disclosing individual company confidential data; value included with "Nonmetal items that cannot be disclosed."
[9] Beginning with 1958 slate included with stone.
[10] Excludes abrasive stone, bituminous limestone, bituminous sandstone, and ground soapstone, all included elsewhere in table.
[11] Total adjusted to eliminate duplicating value of clays and stone.
[12] Figure withheld to avoid disclosing individual company confidential data; value included with "Metal items that cannot be disclosed."
[13] Excludes quantity consumed by American Chrome Co.
[14] Total weight of columbite-tantalite plus $(Cb-Ta)_2O_5$ content of euxenite.
[15] Final figure. Supersedes preliminary figure given in commodity chapter.

TABLE 3.—Minerals produced in the United States and principal producing States in 1960

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

TABLE 3.—Minerals produced in the United States and principal producing States in 1960—Continued

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

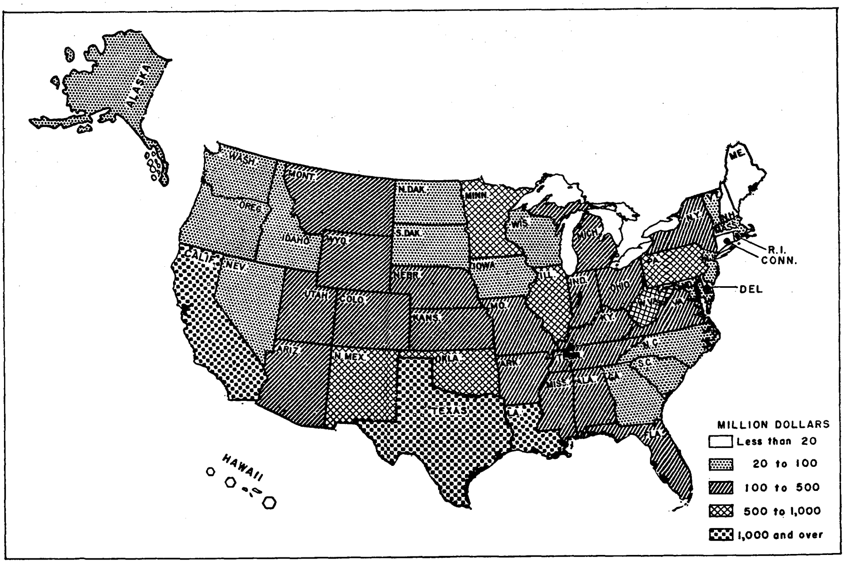

FIGURE 2.—Value of mineral production in the United States, 1960, by States

TABLE 4.—Value of mineral production in the United States and principal minerals produced in 1960

(Thousand dollars)

State	1957	1958	1959	1960			
				Value	Rank	Percent of U.S. total	Principal minerals in order of value
Alabama	$209,549	$188,938	$200,847	$217,617	19	1.22	Coal, cement, stone, iron ore.
Alaska	28,792	21,450	20,495	21,858	44	.12	Coal, gold, sand and gravel, petroleum.
Arizona	372,641	314,520	326,862	415,776	14	2.32	Copper, sand and gravel, cement, zinc.
Arkansas	142,685	132,520	140,594	155,039	26	.87	Petroleum, bauxite, stone, sand and gravel.
California	1,650,035	1,500,367	1,433,626	1,402,214	3	7.84	Petroleum, natural gas, cement, sand and gravel.
Colorado	338,504	306,566	314,677	342,223	17	1.91	Petroleum, molybdenum, natural gas, uranium.
Connecticut	16,055	13,128	12,930	15,255	45	.09	Stone, sand and gravel, lime, clays.
Delaware	1,042	1,142	1,284	989	50	.01	Sand and gravel, stone, clays.
District of Columbia	72	72	75	71	----------	[1]	
Florida	140,467	142,114	163,446	176,920	24	.99	Phosphate rock, stone, cement, titanium.
Georgia	69,799	75,106	86,262	91,203	30	.51	Clays, stone, cement, sand and gravel.
Hawaii	5,930	6,298	7,630	9,254	47	.05	Stone, sand and gravel, pumice, cement.
Idaho	73,502	64,648	70,209	57,441	35	.32	Silver, phosphate rock, lead, zinc.
Illinois	576,324	576,862	572,275	590,800	8	3.30	Petroleum, coal, stone, sand and gravel.
Indiana	198,034	197,677	206,359	206,882	20	1.16	Coal, cement, stone, petroleum.
Iowa	68,986	85,356	88,557	95,030	29	.53	Cement, stone, sand and gravel, gypsum.
Kansas	511,513	503,788	508,077	483,958	10	2.70	Petroleum, natural gas, cement, stone.
Kentucky	449,390	402,121	418,821	413,517	15	2.31	Coal, petroleum, stone, natural gas.
Louisiana	1,517,522	1,523,370	1,766,269	1,967,652	2	11.00	Petroleum, natural gas, natural gas liquids, sulfur.
Maine	12,711	12,574	13,278	13,648	46	.08	Cement, sand and gravel, stone, mica.
Maryland	39,625	45,735	53,189	55,527	37	.31	Cement, stone, sand and gravel, coal.
Massachusetts	24,789	23,887	25,916	27,588	42	.15	Sand and gravel, stone, lime, clays.
Michigan	404,673	343,487	381,297	429,055	13	2.40	Iron ore, cement, petroleum, sand and gravel.
Minnesota	584,038	395,880	347,178	515,255	9	2.88	Iron ore, sand and gravel, stone, cement.
Mississippi	144,950	151,411	186,116	19 ,862	22	1.11	Petroleum, natural gas, cement, sand and gravel.
Missouri	152,913	144,120	157,189	156,033	25	.87	Cement, stone, lead, lime.
Montana	191,750	176,728	167,328	178,854	23	1.00	Petroleum, copper, sand and gravel, phosphate rock.
Nebraska	82,928	90,047	97,130	103,687	28	.58	Petroleum, cement, sand and gravel, stone.
Nevada	86,023	68,291	70,164	80,285	31	.45	Copper, sand and gravel, lime, iron ore.
New Hampshire	3,331	3,919	4,722	5,317	49	.03	Sand and gravel, mica, stone, feldspar.
New Jersey	64,642	50,380	59,479	56,409	36	.32	Stone, sand and gravel, iron ore, magnesium compounds.
New Mexico	551,155	559,777	592,535	652,200	7	3.65	Petroleum, natural gas, potassium salts, uranium.
New York	244,114	205,338	234,642	254,713	18	1.42	Cement, stone, sand and gravel, iron ore.
North Carolina	37,570	39,891	40,789	44,968	40	.25	Stone, sand and gravel, copper, feldspar.
North Dakota	56,702	59,445	67,342	78,275	32	.44	Petroleum, sand and gravel, coal, natural gas liquids.
Ohio	383,000	344,856	397,326	389,828	16	2.17	Coal, cement, stone, lime.
Oklahoma	809,004	761,936	765,439	779,116	5	4.36	Petroleum, natural gas, natural gas liquids, stone.
Oregon	42,820	45,190	49,842	54,419	38	.30	Stone, sand and gravel, cement, nickel.
Pennsylvania	1,077,157	882,040	862,150	824,493	4	4.61	Coal, cement, stone, petroleum.
Rhode Island	1,369	2,249	2,333	5,727	48	.03	Stone, sand and gravel.

South Carolina	22,168	22,412	30,598	30,001	41	.17	Cement, stone, clays, sand and gravel.
South Dakota	39,997	41,534	48,553	46,780	39	.26	Gold, sand and gravel, stone, cement.
Tennessee	128,739	124,934	140,738	143,439	27	.80	Stone, cement, zinc, coal.
Texas	4,484,538	4,033,311	4,219,757	4,134,901	1	23.11	Petroleum, natural gas, natural gas liquids, cement.
Utah	359,335	367,232	373,515	431,396	12	2.41	Copper, petroleum, coal, uranium.
Vermont	21,893	21,443	23,359	22,879	43	.13	Stone, asbestos, sand and gravel, talc.
Virginia	227,108	203,277	222,501	203,819	21	1.14	Coal, stone, cement, sand and gravel.
Washington	60,471	60,896	63,894	70,005	34	.39	Sand and gravel, cement, stone, zinc.
West Virginia	981,654	749,747	737,616	720,674	6	4.03	Coal, natural gas, natural gas liquids, stone.
Wisconsin	68,644	71,334	71,959	77,171	33	.43	Sand and gravel, stone, iron ore, cement.
Wyoming	352,532	369,938	393,841	442,738	11	2.47	Petroleum, uranium, natural gas, sodium carbonates and sulfates.
Total	18,113,000	16,529,000	17,241,00	17,892,000		100.00	Petroleum, coal, natural gas, cement.

[1] Less than 0.005 percent.

TABLE 5.—Mineral production [1] in the United States, by States

ALABAMA

Mineral	1957		1958		1959		1960	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement [2] .... thousand 376-pound barrels	13,000	$40,279	13,588	$42,930	14,819	$46,639	12,931	$42,706
Clays [3] .... thousand short tons	1,316	1,504	1,548	1,787	1,786	2,089	1,840	2,170
Coal .... do	13,260	86,114	11,182	72,360	11,947	78,212	13,011	92,439
Iron ore (usable) .... thousand long tons, gross weight	6,223	40,518	3,659	23,393	4,165	23,922	4,068	23,511
Lime .... thousand short tons	554	6,271	520	5,851	579	6,847	564	6,912
Mica (sheet) .... pounds	(4)	(4)	(4)	(4)	818	7	(4)	(5)
Natural gas .... million cubic feet	190	12	323	30	172	17	57	4
Petroleum (crude) .... thousand 42-gallon barrels	5,406	(4)	5,887	(4)	5,524	(4)	[6] 7,257	(4)
Sand and gravel .... thousand short tons	5,065	4,883	4,128	4,210	4,352	4,594	4,359	4,759
Stone [7] .... do	9,519	11,972	11,080	17,068	11,886	18,728	13,503	19,970
Talc .... short tons	1,600	3	(4)	(4)	(4)	(4)	(4)	(4)
Value of items that cannot be disclosed: Native asphalt, bauxite, slag cement, clays (kaolin), scrap mica, salt, stone (dimension limestone and marble, shell, 1957, 1959-60, crushed sandstone 1959-60), and values indicated by footnote 4	—	23,344	—	26,508	—	[8] 25,401	—	29,441
Total Alabama [9]	—	209,549	—	188,938	—	[8] 200,847	—	217,617

ALASKA

Mineral	1957		1958		1959		1960	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Antimony ore and concentrate .... short tons, antimony content	17	(4)	—	—	—	—	—	—
Chromite .... short tons, gross weight	4,207	$431	—	—	—	—	—	—
Clays .... thousand short tons	—	—	—	—	(10)	$1	1	$10
Coal .... do	842	7,296	759	$6,931	660	5,869	722	6,318
Copper (recoverable content of ores, etc.) .... short tons	(11)	(5)	5	3	36	22	41	26
Gem stones	(12)	(4)	(12)	(4)	(12)	18	(12)	(4)
Gold (recoverable content of ores, etc.) .... troy ounces	215,467	7,541	186,435	6,525	178,918	6,262	168,197	5,887
Lead (recoverable content of ores, etc.) .... short tons	9	3	2	(5)	—	—	23	5
Mercury .... 76-pound flasks	5,461	1,349	3,380	774	3,743	852	4,459	940
Natural gas .... million cubic feet	—	—	50	6	133	16	246	30
Peat .... short tons	—	—	—	—	—	—	376	(4)
Petroleum (crude) .... thousand 42-gallon barrels	—	—	29	(4)	187	295	[6] 558	[6] 1,228
Sand and gravel .... thousand short tons	6,096	8,799	4,255	3,871	5,859	5,265	6,013	5,483
Silver (recoverable content of ores, etc.) .... thousand troy ounces	29	26	24	22	21	19	26	23
Stone .... thousand short tons	528	1,953	615	2,065	89	377	275	852
Value of items that cannot be disclosed: Platinum-group metals, uranium ore, and values indicated by footnote 4	—	1,394	—	1,253	—	1,499	—	1,056
Total Alaska	—	28,792	—	21,450	—	20,495	—	21,858

ARIZONA

Beryllium concentrate...short tons, gross weight..	5	$2	18	$10	-------	-------	(11)	(5)
Clays [3]...thousand short tons..	118	177	119	179	120	$179	173	$260
Columbium-tantalum concentrate...pounds..	2,435	7	-------	-------	-------	-------	-------	-------
Coal...thousand short tons..	9	62	8	54	7	63	6	58
Copper (recoverable content of ores, etc.)...short tons..	515,854	310,544	485,839	255,551	430,297	264,202	538,605	345,784
Gem stones...	(12)	75	(12)	86	(12)	88	(12)	120
Gold (recoverable content of ores, etc.)...troy ounces..	152,449	5,336	142,979	5,004	124,627	4,362	143,064	5,007
Lead (recoverable content of ores, etc.)...short tons..	12,441	3,558	11,890	2,782	9,999	2,300	8,495	1,988
Lime...thousand short tons..	138	2,127	126	1,817	123	1,666	148	2,430
Manganese ore (35 percent or more Mn)...short tons, gross weight..	79,505	6,626	62,279	5,220	68,183	5,727	1,626	40
Manganiferous ore (5 to 35 percent Mn)...do....	-------	-------	1,455	32	10,693	234	8,677	190
Mercury...76-pound flasks..	28	7	53	12	(4)	(4)	(4)	(4)
Mica (scrap)...short tons..	1,650	17	1,717	25	3,069	55	(4)	(4)
Molybdenum (content of concentrate)...thousand pounds..	2,385	3,071	2,320	2,827	3,181	4,019	4,359	5,211
Natural gas...million cubic feet..	22	3	-------	-------	-------	-------	-------	-------
Perlite...short tons..	15,646	114	(4)	(4)	(4)	(4)	(4)	(4)
Petroleum (crude)...thousand 42-gallon barrels..	-------	-------	12	(4)	25	(4)	[6] 73	(4)
Pumice...thousand short tons..	397	640	401	1,025	487	1,153	703	1,164
Sand and gravel...do....	10,287	9,222	12,208	9,526	13,458	11,966	14,490	14,235
Silver (recoverable content of ores, etc.)...thousand troy ounces..	5,279	4,778	4,685	4,240	3,898	3,528	4,775	4,322
Stone...thousand short tons..	2,101	2,982	1,528	2,731	2,468	3,998	4,249	5,107
Tungsten concentrate...short tons, 60-percent WO_3 basis..	5	9	-------	-------	(11)	(4)	(4)	(4)
Uranium ore...short tons..	286,037	6,277	257,756	7,049	253,390	6,309	283,684	6,219
Vanadium (recoverable in ore and concentrate)...do....	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)
Zinc (recoverable content of ores, etc.)...do....	33,905	7,866	28,532	5,821	37,325	8,585	35,811	9,239
Value of items that cannot be disclosed: Asbestos, cement, clays (bentonite 1958-60), feldspar, fluorspar (1957-58), gypsum, nitrogen compounds (1957-58), pyrites, and values indicated by footnote 4...	-------	10,441	-------	11,734	-------	[8] 9,811	-------	16,115
Total Arizona [9]...	-------	372,641	-------	314,520	-------	[8] 326,862	-------	415,776

ARKANSAS

Barite...short tons..	477,327	$4,537	182,779	$1,668	338,539	$3,097	277,851	$2,578
Bauxite...long tons, dried equivalent..	1,356,898	12,314	1,257,916	[8] 12,311	1,631,643	17,048	1,932,071	20,469
Clays...thousand short tons..	617	1,586	578	1,578	782	2,406	815	2,456
Coal...do....	508	3,976	364	2,744	441	3,482	409	3,116
Gem stones...	(12)	(4)	(12)	23	(12)	18	(12)	38
Gypsum...thousand short tons..	(4)	(4)	(4)	(4)	(4)	(4)	67	208
Iron ore (usable)...thousand long tons, gross weight..	7	35	(4)	(4)	-------	-------	-------	-------
Lead (recoverable content of ores, etc.)...short tons..	-------	-------	-------	-------	38	9	-------	-------
Manganese ore (35 percent or more Mn)...short tons, gross weight..	23,261	1,726	22,221	1,737	17,742	1,398	-------	-------
Natural gas...million cubic feet..	31,327	2,256	32,890	2,664	40,674	3,539	55,451	6,599
Natural gas liquids:								
Natural gasoline and cycle products...thousand gallons..	39,869	2,313	37,197	2,574	40,730	2,523	34,558	2,148
LP gases...do....	54,034	2,097	53,518	2,743	55,731	3,048	73,252	3,735
Petroleum (crude)...thousand 42-gallon barrels..	31,047	90,657	28,700	80,934	26,329	72,931	[6] 28,953	[6] 80,200
Sand and gravel...thousand short tons..	8,599	6,949	8,644	7,039	11,696	11,857	8,192	10,262
Stone...do....	7,278	8,378	8,461	10,178	8,824	10,424	10,939	13,555
Zinc (recoverable content of ores, etc.)...short tons..	-------	-------	-------	-------	49	11	50	13
Value of items that cannot be disclosed: Abrasive stones, bromine, cement, lime, slate (1957), soapstone, and values indicated by footnote 4...	-------	6,933	-------	7,241	-------	10,042	-------	10,918
Total Arkansas [9]...	-------	142,685	-------	[8] 132,520	-------	[8] 140,594	-------	155,039

See footnotes at end of table.

TABLE 5.—Mineral production [1] in the United States, by States—Continued

CALIFORNIA

Mineral	1957 Quantity	1957 Value (thousands)	1958 Quantity	1958 Value (thousands)	1959 Quantity	1959 Value (thousands)	1960 Quantity	1960 Value (thousands)
Barite short tons	(4)	(4)	24,812	$272	28,143	$326	16,157	$181
Boron minerals do	541,124	$38,041	528,209	38,310	619,946	46,150	640,591	47,550
Cement [2] thousand 376-pound barrels	37,731	117,852	39,583	124,367	43,635	138,506	39,712	128,826
Chromite short tons, gross weight	34,901	2,789	20,588	1,646	(4)	(5)	----------	----------
Clays thousand short tons	[3] 2,729	[3] 5,740	2,394	5,012	2,726	5,646	2,899	5,663
Copper (recoverable content of ores, etc.) short tons	945	569	749	394	663	407	1,087	698
Feldspar long tons	67,869	581	71,193	624	76,489	[8] 824	76,010	886
Gem stones	(12)	100	(12)	150	(12)	150	(12)	150
Gold (recoverable content of ores, etc.) troy ounces	170,885	5,981	185,385	6,489	[8] 145,270	[8] 5,084	123,713	4,330
Gypsum thousand short tons	1,268	2,995	1,423	3,184	1,686	3,788	1,616	3,687
Lead (recoverable content of ores, etc.) short tons	3,458	989	140	33	227	52	440	103
Lime thousand short tons	325	5,408	262	4,470	358	5,817	345	5,628
Magnesium compounds from sea water and bitterns (partly estimated) short tons, MgO equivalent	74,295	5,077	74,132	4,854	87,968	6,336	86,532	6,233
Manganese ore (35 percent or more Mn) short tons, gross weight	9,009	802	17,644	1,516	19,354	1,663	----------	----------
Manganiferous ore (5 to 35 percent Mn) do	----------	----------	----------	----------	129	(4)	96	(4)
Mercury 76-pound flasks	16,511	4,078	22,365	5,123	17,100	3,890	18,764	3,955
Natural gas million cubic feet	492,338	116,684	465,582	108,481	485,655	119,471	517,535	138,182
Natural gas liquids:								
Natural gasoline and cycle products thousand gallons	843,378	81,355	853,045	68,485	834,258	68,023	794,657	62,496
LP gases do	390,743	20,421	342,992	18,678	396,331	21,260	408,378	21,482
Peat short tons	35,916	424	28,617	374	34,604	449	33,091	481
Perlite do	15,109	113	14,883	114	(4)	(4)	(4)	(4)
Petroleum (crude) thousand 42-gallon barrels	339,646	1,035,920	313,672	909,649	308,946	787,812	[6] 304,356	[6] 748,716
Pumice thousand short tons	459	1,510	377	1,670	574	2,162	427	1,895
Salt do	1,330	8,721	1,297	(4)	1,388	(4)	1,443	(4)
Sand and gravel do	78,983	87,030	84,137	95,340	87,945	108,909	87,679	107,503
Silver (recoverable content of ores, etc.) thousand troy ounces	522	473	188	170	173	156	180	163
Stone thousand short tons	41,351	53,591	32,423	48,345	32,134	49,090	33,075	49,842
Talc, pyrophyllite and soapstone short tons	133,915	1,526	129,638	1,339	[8] 144,816	[8] 1,490	130,539	1,396
Tungsten concentrate short tons, 60-percent WO_3 basis	1,750	2,735	(4)	(4)	(4)	(4)	(4)	(4)
Wollastonite short tons	----------	----------	1,652	17	(4)	(4)	(4)	(4)
Zinc (recoverable content of ores, etc.) do	2,969	689	51	10	78	18	465	120
Value of items that cannot be disclosed: Asbestos, bromine, calcium-magnesium chloride, carbon dioxide (1957, 1959-60), masonry cement, clay (kaolin 1957), coal (lignite), diatomite, fluorspar (1957-58, 1960), iodine, iron ore, lithium minerals (1958-60), magnesite (1958-60), mica (1958, 1960), molybdenum, platinum-group metals (crude), potassium salts, pyrites, rare-earth metal concentrates, slate (1957), sodium carbonates and sulfates, strontium minerals (1957, 1959), sulfur ore, uranium ore, and values indicated by footnote 4	----------	65,352	----------	68,564	----------	[8] 73,397	----------	79,470
Total California [9]	----------	1,650,035	----------	1,500,367	----------	[8] 1,433,626	----------	1,402,214

Beryllium concentrate .... short tons, gross weight..	182	$91	[8] 176	[8] $63	[8] 221	[8] $67	304	$53
Carbon dioxide, natural .... thousand cubic feet..	(4)	(4)	(4)	(4)	175,223	(4)	155,871	20
Clays .... thousand short tons..	403	978	449	1,111	417	1,160	490	1,424
Coal .... do....	3,594	21,831	2,974	19,305	3,294	21,034	3,607	21,090
Columbium-tantalum concentrate[13] .... pounds..	103	(5)	2,280	7	----------	----------	----------	----------
Copper (recoverable content of ores, etc.) .... short tons..	5,115	3,079	4,193	2,206	2,940	1,805	3,247	2,085
Feldspar .... long tons..	43,818	307	34,648	237	(4)	(4)	(4)	(4)
Gem stones	(12)	35	(12)	38	(12)	43	(12)	45
Gold (recoverable content of ores, etc.) .... troy ounces..	87,928	3,078	79,539	2,784	61,097	2,138	61,269	2,144
Gypsum .... thousand short tons..	(4)	(4)	103	341	106	385	82	296
Iron ore (usable) .... thousand long tons, gross weight..	(4)	(4)	(4)	(4)	11	78	11	80
Lead (recoverable content of ores, etc.) .... short tons..	21,003	6,007	14,112	3,302	12,907	2,969	18,080	4,231
Lime .... thousand short tons..	2	45	(4)	(4)	(4)	(4)	(4)	(4)
Manganese ore (35 percent or more Mn) .... short tons, gross weight..	175	14	210	17	1,218	102	----------	----------
Mica:								
Scrap .... short tons..	312	6	387	6	68	1	340	4
Sheet .... pounds..	14	(5)	----------	----------	----------	----------	----------	----------
Natural gas .... million cubic feet..	95,259	9,526	82,464	8,659	99,899	10,989	107,404	12,781
Natural gas liquids:								
Natural gasoline .... thousand gallons..	(4)	(4)	49,505	3,410	47,424	2,811	73,179	4,138
LP gases .... do....	(4)	(4)	68,027	3,343	77,637	3,671	104,275	4,938
Peat .... short tons..	3,550	(4)	7,143	41	6,674	35	9,384	37
Petroleum (crude) .... thousand 42-gallon barrels..	54,982	166,046	48,736	145,721	46,440	134,676	[6] 47,165	[6] 136,779
Pumice .... thousand short tons..	25	53	34	65	40	66	32	70
Pyrites .... thousand long tons..	62	(4)	67	359	(4)	(4)	(4)	(4)
Rare-earth and thorium concentrates .... short tons..	749	24	650	35	9	1	(11)	(5)
Sand and gravel .... thousand short tons..	16,400	13,994	20,626	17,842	20,897	18,817	19,053	16,882
Silver (recoverable content of ores, etc.) .... thousand troy ounces..	2,788	2,523	2,056	1,860	1,341	1,213	1,659	1,502
Stone .... thousand short tons..	2,438	4,168	2,930	4,943	2,824	5,537	2,442	4,651
Tin (content of ore and concentrate) .... long tons..	----------	----------	----------	----------	50	60	10	12
Tungsten concentrate .... short tons, 60-percent WO_3 basis..	45	55	(4)	(4)	(4)	(4)	(4)	(4)
Uranium ore .... short tons..	740,055	15,605	939,706	22,486	1,044,089	22,546	1,149,583	23,462
Vanadium .... do....	3,132	(4)	2,396	(4)	2,949	(4)	4,026	(4)
Zinc (recoverable content of ores, etc.) .... do....	47,000	10,904	37,132	7,575	35,388	8,139	31,278	8,070
Value of items that cannot be disclosed: Cement, fluorspar, molybdenum, perlite, salt, and values indicated by footnote 4	----------	81,907	----------	62,855	----------	79,229	----------	99,743
Total Colorado[9]	----------	338,504	----------	[8] 306,566	----------	[8] 314,677	----------	342,223

See footnotes at end of table.

TABLE 5.—Mineral production [1] in the United States, by States—Continued

CONNECTICUT

Mineral	1957 Quantity	1957 Value (thousands)	1958 Quantity	1958 Value (thousands)	1959 Quantity	1959 Value (thousands)	1960 Quantity	1960 Value (thousands)
Beryllium concentrate .... short tons, gross weight..	(4)	(4)	(4)	(4)	13	$8	16	$9
Clays .... thousand short tons..	308	$409	199	$299	280	368	207	308
Gem stones	(12)	(4)	(12)	3	(12)	5	(12)	7
Lime .... thousand short tons..	30	503	29	464	(4)	(4)	35	616
Peat .... short tons..	2,004	11	1,764	11	2,090	13	(4)	(4)
Sand and gravel .... thousand short tons..	4,777	5,042	5,019	5,479	4,749	4,912	6,575	5,960
Stone .... do....	6,199	10,040	4,223	6,863	4,462	7,088	5,057	8,313
Value of items that cannot be disclosed: Feldspar, sheet mica (1957–58, 1960), and values indicated by footnote 4	....	119	....	89	....	636	....	140
Total Connecticut [14]	....	16,055	....	13,128	....	12,930	....	15,255

DELAWARE

Mineral	1957 Quantity	1957 Value (thousands)	1958 Quantity	1958 Value (thousands)	1959 Quantity	1959 Value (thousands)	1960 Quantity	1960 Value (thousands)
Sand and gravel .... thousand short tons..	974	$860	1,090	$962	1,241	$1,071	1,084	$907
Value of items that cannot be disclosed: Nonmetals and values indicated by footnote 4	....	182	....	180	....	213	....	82
Total Delaware	....	1,042	....	1,142	....	1,284	....	989

FLORIDA

Mineral	1957 Quantity	1957 Value (thousands)	1958 Quantity	1958 Value (thousands)	1959 Quantity	1959 Value (thousands)	1960 Quantity	1960 Value (thousands)
Clays .... thousand short tons..	422	$6,067	450	$5,808	[3] 245	[3] $6,171	[3] 252	[3] $6,357
Gem stones	....	....	....	....	(12)	3	(12)	(5)
Lime .... thousand short tons..	(4)	(4)	(4)	(4)	111	1,238	151	2,611
Natural gas .... million cubic feet..	34	4	35	5	34	5	30	5
Peat .... short tons..	37,844	195	36,438	165	34,446	158	39,275	162
Petroleum (crude) .... thousand 42-gallon barrels..	461	(4)	449	(4)	424	(4)	[6] 368	(4)
Phosphate rock .... thousand long tons..	10,191	64,789	10,851	68,951	11,564	71,208	12,321	82,530
Sand and gravel .... thousand short tons..	6,753	6,148	5,490	4,389	6,674	5,177	6,757	5,559
Stone .... do....	21,786	30,467	[7] 23,549	[7] 30,983	[7] 26,917	[7] 35,940	[7] 27,629	[7] 37,419
Titanium concentrates .... thousand short tons, gross weight..	263	10,643	190	5,495	262	7,196	286	7,489
Zirconium concentrate .... short tons..	56,802	1,976	30,302	1,018	(4)	(4)	(4)	(4)
Value of items that cannot be disclosed: Cement, clays (kaolin and miscellaneous clay 1959–60), magnesium compounds (1959–60), rare-earth metals concentrates (1957–59), staurolite, stone (dimension limestone 1958–59, calcareous marl 1960), and values indicated by footnote 4	....	22,514	....	28,510	....	40,034	....	38,151
Total Florida [9]	....	140,467	....	142,114	....	[8] 163,446	....	176,920

GEORGIA

Clays......thousand short tons..	2,707	$30,120	2,942	$31,253	3,352	$36,232	3,519	$40,160
Coal......do....	13	63	9	44	7	34	4	21
Iron ore (usable)......thousand long tons, gross weight..	443	2,109	209	1,008	186	945	128	613
Manganese ore (35 percent or more Mn)......short tons, gross weight..	(4)	(4)	(4)	(4)	1,547	(4)	----------	----------
Manganiferous ore (5 to 35 percent Mn)......do....	2,203	(4)	(4)	(4)	(4)	(4)	(4)	(4)
Mica (sheet)......pounds..	16,933	158	15,102	82	18,461	119	10,218	89
Peat......short tons..	4,690	45	4,491	(4)	4,288	(4)	6,904	73
Sand and gravel......thousand short tons..	2,127	2,096	2,631	2,693	2,909	2,982	3,338	3,047
Stone......do....	[7] 9,065	[7] 15,833	12,129	31,108	13,771	35,973	14,297	37,033
Talc and soapstone......short tons..	49,372	106	(4)	(4)	53,692	107	40,200	88
Value of items that cannot be disclosed: Barite, bauxite, beryllium concentrate (1957), cement, feldspar, gem stones, iron ore (pigment material), scrap mica, slate (1957), stone (dimension and crushed marble and crushed sandstone 1957), and values indicated by footnote 4......	----------	20,081	----------	10,145	----------	10,979	----------	11,181
Total Georgia [9]......	----------	69,799	----------	75,106	----------	86,262	----------	91,203

HAWAII

Cement......thousand 376-pound barrels..	----------	----------	----------	----------	----------	----------	113	$571
Clays......thousand short tons..	2	$3	(4)	(4)	(4)	(4)	(4)	(4)
Lime......do....	8	271	8	$260	(4)	(4)	(4)	(4)
Pumice......do....	266	493	260	481	276	$548	361	676
Salt......do....	(10)	15	(10)	(4)	----------	----------	----------	----------
Sand and gravel......do....	286	538	438	1,112	463	1,253	490	1,324
Stone......do....	2,585	4,632	2,377	4,446	3,034	5,480	3,535	6,443
Value of items that cannot be disclosed: Other nonmetals and values indicated by footnote 4......	----------	----------	----------	13	----------	363	----------	353
Total Hawaii [13]......	----------	5,930	----------	6,298	----------	7,630	----------	9,254

See footnotes at end of table.

TABLE 5.—Mineral production [1] in the United States, by States—Continued

IDAHO

Mineral	1957 Quantity	1957 Value (thousands)	1958 Quantity	1958 Value (thousands)	1959 Quantity	1959 Value (thousands)	1960 Quantity	1960 Value (thousands)
Antimony ore and concentrate.....short tons, antimony content..	664	[4]	677	[4]	678	[4]	635	[4]
Beryllium concentrate.....short tons, gross weight..	1	[5]	-----	-----	-----	-----	-----	-----
Clays [3].....thousand short tons..	23	$16	27	$20	39	$33	36	$29
Cobalt (content of concentrate).....thousand pounds..	2,618	[4]	3,078	[4]	1,141	[4]	-----	-----
Columbium-tantalum concentrate.....pounds..	364,768	[4]	422,612	[4]	189,263	[4]	-----	-----
Copper (recoverable content of ores, etc.).....short tons..	7,912	4,763	9,846	5,179	8,713	5,350	4,208	2,702
Gold (recoverable content of ores, etc.).....troy ounces..	12,301	431	15,896	556	10,479	367	6,135	215
Iron ore (usable).....thousand long tons..	[4]	[4]	1	14	6	56	9	[4]
Lead (recoverable content of ores, etc.).....short tons..	71,637	20,488	53,603	12,543	62,395	14,351	42,907	10,040
Mercury.....76-pound flasks..	2,260	558	2,625	601	1,961	446	1,538	324
Mica:								
Scrap.....short tons..	-----	-----	1	[5]	-----	-----	-----	-----
Sheet.....pounds..	1,240	9	1,968	14	[4]	[4]	[4]	[4]
Nickel (content of ore and concentrate).....short tons..	37	55	29	[4]	[4]	[4]	-----	-----
Phosphate rock.....thousand long tons..	1,307	5,684	1,291	5,652	1,610	7,412	2,177	11,044
Pumice.....thousand short tons..	100	168	108	172	93	137	56	88
Rare-earth metals concentrates.....short tons..	366	[4]	692	[4]	522	80	-----	-----
Sand and gravel.....thousand short tons..	6,665	5,274	6,879	6,404	9,184	8,080	7,088	6,594
Silver (recoverable content of ores, etc.).....thousand troy ounces..	15,067	13,637	15,953	14,438	16,637	15,057	13,647	12,351
Stone.....thousand short tons..	1,542	2,759	1,391	1,794	1,079	1,931	1,318	2,141
Titanium concentrate.....short tons, gross weight..	28,397	[4]	2,223	[4]	[4]	[4]	2,014	30
Tungsten concentrate.....short tons, 60-percent WO_3 basis..	35	[4]	[4]	[4]	-----	-----	-----	-----
Uranium ore.....short tons..	[4]	[4]	[4]	[4]	3,374	30	[4]	[4]
Zinc (recoverable content of ores, etc.).....do....	57,831	13,417	49,725	10,144	55,699	12,811	36,801	9,495
Value of items that cannot be disclosed: Barite, cement, clays (fire clay, bentonite 1958, 1960), abrasive garnet, gem stones, gypsum (1958–59), peat, zirconium concentrate (1958), and values indicated by footnote 4. Excludes values of raw materials used in manufacturing cement.....	-----	6,243	-----	7,117	-----	4,068	-----	2,388
Total Idaho.....	-----	73,502	-----	64,648	-----	70,209	-----	57,441

ILLINOIS

Mineral	1957 Quantity	1957 Value (thousands)	1958 Quantity	1958 Value (thousands)	1959 Quantity	1959 Value (thousands)	1960 Quantity	1960 Value (thousands)
Cement.....thousand 376-pound barrels..	8,575	$26,356	9,618	$30,858	9,925	$31,794	9,139	$30,732
Clays.....thousand short tons..	1,917	5,155	2,335	5,910	2,229	4,950	2,356	5,479
Coal.....do....	46,993	187,908	43,912	176,614	45,466	184,412	45,977	184,087
Fluorspar.....short tons..	169,939	8,827	152,087	7,931	112,469	5,908	134,529	6,936
Gem stones.....	[12]	2	[12]	1	[12]	1	[12]	[4]
Lead (recoverable content of ores, etc.).....short tons..	2,970	849	1,610	377	2,570	591	3,000	702

Natural gas ... million cubic feet	9,647	1,495	12,983	1,921	13,739	1,910	11,666	1,458
Natural gas liquids:								
Natural gasoline and cycle products ... thousand gallons	(4)	(4)	22,380	1,645	(4)	(4)	16,496	1,313
LP gases ... do	(4)	(4)	353,129	20,866	(4)	(4)	358,366	19,941
Peat ... short tons	11,480	106	11,588	72	9,117	72	6,179	28
Petroleum (crude) ... thousand 42-gallon barrels	77,083	240,499	80,275	240,825	76,727	229,414	[6] 78,840	[6] 233,366
Sand and gravel ... thousand short tons	30,151	32,572	29,866	33,453	30,241	33,717	33,138	36,255
Stone ... do	31,861	41,835	35,016	44,245	35,294	45,081	41,721	55,593
Zinc (recoverable content of ores, etc.) ... short tons	22,185	5,147	24,940	5,088	26,815	6,167	29,550	7,624
Value of items that cannot be disclosed: Lime, tripoli, and values indicated by footnote 4	------------	27,898	------------	9,573	------------	30,897	------------	10,796
Total Illinois [9]	------------	576,324	------------	576,862	------------	[8] 572,275	------------	590,800
INDIANA								
Abrasive stones ... short tons	4	$8	10	$10	5	$13	(4)	(4)
Cement ... thousand 376-pound barrels	[3] 12,598	[3] 40,742	[3] 14,730	[3] 48,858	14,245	47,231	14,052	$48,310
Clays ... thousand short tons	1,475	2,569	1,370	2,477	1,692	2,915	1,822	3,396
Coal ... do	15,841	62,055	15,022	58,506	14,804	59,954	15,538	61,570
Natural gas ... million cubic feet	671	88	378	59	484	92	342	61
Peat ... short tons	13,805	130	12,106	145	15,393	202	27,486	290
Petroleum (crude) ... thousand 42-gallon barrels	12,662	39,632	11,864	35,711	11,554	34,315	[6] 11,590	[6] 34,075
Sand and gravel ... thousand short tons	16,750	14,206	16,862	15,045	20,357	17,924	20,752	18,377
Stone ... do	14,460	33,094	15,394	31,974	18,544	37,682	18,956	34,920
Value of items that cannot be disclosed: Cement (masonry and natural cement 1957–58), gypsum, and values indicated by footnote 4	------------	7,675	------------	7,539	------------	[8] 8,817	------------	8,569
Total Indiana [9]	------------	198,034	------------	197,677	------------	[8] 206,359	------------	206,882
IOWA								
Cement ... thousand 376-pound barrels	10,823	$34,881	12,675	$41,741	13,170	$44,048	12,517	$44,204
Clays ... thousand short tons	[3] 752	[3] 944	[3] 837	[3] 1,054	912	1,168	1,022	1,345
Coal ... do	1,312	4,543	1,179	4,147	1,180	4,214	1,068	3,845
Gypsum ... do	1,123	3,773	1,230	4,491	1,318	5,587	1,283	5,428
Sand and gravel ... do	12,042	8,927	12,411	10,965	13,484	11,658	14,692	13,516
Stone ... do	15,214	18,768	21,045	26,138	20,501	25,759	23,185	30,321
Value of items that cannot be disclosed: Fire clay (1956–58), gem stones (1960), lime, and peat (1957–58, 1960)	------------	614	------------	633	------------	520	------------	660
Total Iowa [9]	------------	68,986	------------	85,356	------------	88,557	------------	95,030

See footnotes at end of table.

TABLE 5.—Mineral production[1] in the United States, by States—Continued

KANSAS

Mineral	1957 Quantity	1957 Value (thousands)	1958 Quantity	1958 Value (thousands)	1959 Quantity	1959 Value (thousands)	1960 Quantity	1960 Value (thousands)
Cement [3] ....thousand 376-pound barrels..	8,178	$24,814	9,600	$30,047	10,405	$32,282	8,162	$26,373
Clays ....thousand short tons..	909	1,240	875	1,145	1,021	1,271	894	1,224
Coal ....do....	749	3,331	823	3,711	772	3,607	888	4,197
Gem stones............	----------	----------	----------	----------	(12)	1	(12)	(5)
Helium............thousand cubic feet..	36,743	570	27,888	432	21,643	343	21,696	350
Lead (recoverable content of ores, etc.)............short tons..	4,257	1,217	1,299	304	481	111	781	183
Natural gas............million cubic feet..	586,690	66,883	561,816	64,047	604,410	72,529	634,410	74,226
Natural gas liquids:								
Natural gasoline............thousand gallons..	119,247	6,569	110,293	6,229	107,814	5,576	115,868	6,694
LP gases............do....	103,494	4,042	115,175	5,193	124,874	6,658	127,270	6,343
Petroleum (crude)............thousand 42-gallon barrels..	123,614	372,078	119,942	359,826	119,543	347,870	[6] 113,455	[6] 329,020
Salt............thousand short tons..	1,018	10,353	1,073	11,348	1,123	13,670	1,213	14,109
Sand and gravel............do....	9,345	6,175	10,317	6,769	11,334	7,937	9,710	6,808
Stone [7]............do....	10,412	11,926	12,424	15,036	13,999	17,108	11,814	15,031
Zinc (recoverable content of ores, etc.)............short tons..	15,859	3,679	4,421	902	1,017	234	2,117	546
Value of items that cannot be disclosed: Natural cement, gypsum, pumice, stone (dimension 1957-59 and crushed sandstone), and values indicated by footnote 4............	----------	1,191	----------	1,627	----------	2,012	----------	1,436
Total Kansas [9]............	----------	511,513	----------	503,788	----------	[8] 508,077	----------	483,958

KENTUCKY

Mineral	1957 Quantity	1957 Value (thousands)	1958 Quantity	1958 Value (thousands)	1959 Quantity	1959 Value (thousands)	1960 Quantity	1960 Value (thousands)
Barite............short tons..	----------	----------	----------	----------	26,598	$335	(4)	(4)
Clays............thousand short tons..	894	$3,915	737	$2,957	984	3,595	[3] 951	[3] $2,646
Coal............do....	74,667	338,109	66,312	289,385	62,810	270,139	66,846	282,395
Fluorspar............short tons..	20,626	979	25,861	1,201	18,579	887	25,855	1,173
Lead (recoverable content of ores, etc.)............do....	411	118	516	121	409	94	558	131
Natural gas............million cubic feet..	70,024	16,666	72,248	17,412	73,504	17,420	75,329	18,380
Natural gas liquids:								
Natural gasoline............thousand gallons..	34,956	1,935	37,926	2,165	35,868	2,133	(4)	(4)
LP gases............do....	176,033	7,403	150,655	8,491	213,171	12,267	(4)	(4)
Petroleum (crude)............thousand 42-gallon barrels..	17,029	53,301	17,509	51,652	27,272	76,634	[6] 21,144	[6] 60,260
Sand and gravel............thousand short tons..	4,482	4,556	4,685	4,835	5,081	5,568	5,113	5,763
Stone............do....	12,718	16,714	12,597	17,360	[7] 16,063	[7] 22,215	[7] 15,810	[7] 21,493
Zinc (recoverable content of ores, etc.)............short tons..	837	194	1,258	257	673	155	869	224
Value of items that cannot be disclosed: Native asphalt (1957), cement, ball clay (1960), gem stones (1960), stone (crushed sandstone 1960), silver, and values indicated by footnote 4............	----------	6,211	----------	7,059	----------	8,202	----------	22,080
Total Kentucky [9]............	----------	449,390	----------	402,121	----------	[8] 418,821	----------	413,517

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LOUISIANA

Clays ... thousand short tons	[3] 642	[3] $642	[3] 755	[3] $755	[3] 904	[3] $904	749	$749
Natural gas ... million cubic feet	2,078,901	232,837	2,451,587	316,255	2,670,271	411,222	2,988,414	511,019
Natural gas liquids:								
Natural gasoline and cycle products ... thousand gallons	775,009	63,956	783,099	50,371	846,110	60,295	875,567	66,214
LP gases ... do	335,142	14,888	410,869	21,435	540,046	25,877	606,023	28,147
Petroleum (crude) ... thousand 42-gallon barrels	329,896	1,094,402	313,891	1,023,517	362,666	1,145,569	[6] 394,360	[6] 1,237,823
Salt ... thousand short tons	3,461	18,944	3,442	18,960	4,807	20,918	4,792	21,959
Sand and gravel ... do	12,579	14,730	15,061	17,119	16,052	20,111	14,319	19,106
Stone ... do	4,383	7,152	5,453	9,532	5,670	10,874	[7] 4,691	[7] 8,882
Sulfur (Frasch-process) ... thousand long tons	2,156	52,690	2,028	47,651	2,252	52,779	2,256	52,639
Value of items that cannot be disclosed: Cement, clay (bentonite 1957–59), gypsum, lime, stone (crushed miscellaneous 1960), and values indicated by footnote 4	------------	18,966	------------	20,475	------------	20,286	------------	24,042
Total Louisiana [15]	------------	1,517,522	------------	1,523,370	------------	[8] 1,766,269	------------	1,967,652

MAINE

Beryllium concentrate ... short tons, gross weight	4	$2	([11])	([5])	3	$2	([4])	([4])
Clays ... thousand short tons	30	28	23	$26	25	26	41	$50
Feldspar ... long tons	14,330	92	13,034	83	([4])	([4])	([4])	([4])
Gem stones	([12])	1	([12])	5	([12])	10	([12])	15
Mica:								
Scrap ... short tons	6	([5])	104	3	157	4	171	6
Sheet ... pounds	25,453	202	20,097	278	22,360	237	26,842	275
Peat ... short tons	3,770	175	([4])	([4])	([4])	([4])	------------	------------
Sand and gravel ... thousand short tons	8,037	3,099	8,941	3,746	9,452	3,644	9,833	3,892
Stone ... do	889	3,076	880	2,760	819	2,766	1,012	3,851
Value of items that cannot be disclosed: Cement, lime (1957–58), slate (1957), and values indicated by footnote 4	------------	6,617	------------	6,363	------------	7,050	------------	5,990
Total Maine [15]	------------	12,711	------------	12,574	------------	13,278	------------	13,648

MARYLAND

Clays [3] ... thousand short tons	631	$963	605	$815	661	$944	612	$853
Coal ... do	748	3,082	838	3,161	842	3,188	748	2,799
Gem stones	([12])	([4])	([12])	2	([12])	2	([12])	2
Natural gas ... million cubic feet	4,649	1,218	4,266	1,148	4,373	1,181	4,065	1,081
Sand and gravel ... thousand short tons	8,679	11,594	8,513	11,368	10,034	12,983	10,076	13,221
Stone ... do	6,140	13,392	6,721	14,387	7,445	15,476	7,944	16,962
Value of items that cannot be disclosed: Beryllium concentrate (1957), cement, ball clay, greensand marl, mica (1957), lime, potassium salts, talc and soapstone, and values indicated by footnote 4	------------	10,664	------------	16,224	------------	21,416	------------	22,779
Total Maryland [9]	------------	39,625	------------	45,735	------------	[8] 53,189	------------	55,527

See footnotes at end of table.

TABLE 5.—Mineral production [1] in the United States, by States—Continued

MASSACHUSETTS

Mineral	1957 Quantity	1957 Value (thousands)	1958 Quantity	1958 Value (thousands)	1959 Quantity	1959 Value (thousands)	1960 Quantity	1960 Value (thousands)
Clays .... thousand short tons	78	$98	85	$111	101	$229	83	$71
Gem stones	------	------	(12)	(5)	(12)	1	(12)	1
Lime .... thousand short tons	137	2,233	139	2,121	144	2,289	154	2,370
Peat .... short tons	600	(4)	1,014	(4)	773	(4)	(4)	(4)
Sand and gravel .... thousand short tons	9,900	9,691	10,620	10,035	13,210	11,786	14,789	13,013
Stone .... do	4,877	13,165	4,649	12,354	5,102	12,375	5,247	12,782
Value of items that cannot be disclosed: Nonmetals and values indicated by footnote 4	------	6	------	9	------	6	------	8
Total Massachusetts [15]	------	24,789	------	23,887	------	25,916	------	27,588

MICHIGAN

Mineral	1957 Quantity	1957 Value (thousands)	1958 Quantity	1958 Value (thousands)	1959 Quantity	1959 Value (thousands)	1960 Quantity	1960 Value (thousands)
Cement .... thousand 376-pound barrels	22,045	$71,606	20,912	$70,432	23,026	$77,324	22,361	$77,694
Clays .... thousand short tons	1,842	1,982	1,663	1,813	1,771	1,937	1,738	1,904
Copper (recoverable content of ores, etc.) .... short tons	58,400	35,157	58,005	30,511	55,300	33,954	56,385	36,199
Gypsum .... thousand short tons	1,386	4,823	1,331	4,824	1,721	6,595	1,463	5,609
Iron ore (usable) .... thousand long tons, gross weight	13,123	111,484	8,111	69,845	7,247	62,921	10,792	95,791
Lime .... thousand short tons	(4)	(4)	(4)	(4)	862	11,748	1,177	15,730
Manganiferous ore (5 to 35 percent Mn) .... short tons, gross weight	123,547	(4)	112,536	(4)	------	------	180,460	(4)
Natural gas .... million cubic feet	9,122	1,715	14,243	2,649	18,916	4,350	20,790	4,449
Peat .... short tons	80,271	1,406	107,342	1,684	191,661	2,357	214,402	2,755
Petroleum (crude) .... thousand 42-gallon barrels	10,169	31,117	9,308	27,366	10,439	30,691	[6] 15,665	[6] 45,585
Salt .... thousand short tons	5,225	41,073	4,267	33,018	4,485	35,725	4,088	33,759
Sand and gravel .... do	41,838	35,144	39,871	34,616	48,052	41,193	46,910	39,304
Silver (recoverable content of ores, etc.) .... thousand troy ounces	430	389	------	------	------	------	------	------
Stone .... thousand short tons	34,495	34,176	27,188	26,846	30,095	30,379	31,256	32,274
Value of items that cannot be disclosed: Bromine, calcium-magnesium chloride, gem stones, magnesium compounds, natural gas liquids, potassium salts, and values indicated by footnote 4	------	40,324	------	45,558	------	49,371	------	45,864
Total Michigan [9]	------	404,673	------	343,487	------	[8] 381,297	------	429,055

MINNESOTA

Mineral	1957 Quantity	1957 Value (thousands)	1958 Quantity	1958 Value (thousands)	1959 Quantity	1959 Value (thousands)	1960 Quantity	1960 Value (thousands)
Clays .... thousand short tons	[3] 97	[3] $113	92	$150	153	$267	[3] 125	[3] $163
Gem stones	(12)	(4)	(12)	(4)	(12)	(4)	(12)	2
Iron ore (usable) .... thousand long tons, gross weight	67,656	541,474	42,503	354,528	36,109	306,920	54,723	470,874
Manganiferous ore (5 to 35 percent Mn) .... short tons, gross weight	692,295	(4)	370,603	(4)	429,102	(4)	441,028	(4)
Peat .... short tons	1,300	(4)	(4)	(4)	------	------	1,465	72
Sand and gravel .... thousand short tons	28,493	19,385	29,634	21,680	28,486	20,726	30,302	24,611

Stone ... do	[7] 2,968	[7] 8,175	3,519	9,560	3,639	9,461	4,234	10,034
Value of items that cannot be disclosed: Abrasive stones, cement, fire clay (1957, 1960), lime, manganese ore (1957), stone (crushed sandstone, 1957, calcareous marl, 1957), and values indicated by footnote 4	------------	15,107	------------	10,154	------------	9,993	------------	9,765
Total Minnesota [15]	------------	584,038	------------	395,880	------------	347,178	------------	515,255
MISSISSIPPI								
Clays ... thousand short tons	616	$3,635	576	$3,338	747	$4,064	1,017	$4,786
Iron ore (usable) ... thousand long tons	([16])	1	([16])	([5])	------------	------------	------------	------------
Natural gas ... million cubic feet	169,967	17,507	160,143	22,260	162,095	25,125	172,478	32,426
Natural gas liquids:								
Natural gasoline and cycle products ... thousand gallons	25,152	1,469	25,738	1,658	23,207	1,495	23,648	1,552
LP gases ... do	10,044	472	9,208	503	8,141	465	10,151	564
Petroleum (crude) ... thousand 42-gallon barrels	38,922	113,263	39,512	113,004	49,620	140,921	[6] 51,819	[6] 146,648
Sand and gravel ... thousand short tons	5,172	4,344	6,545	6,240	7,520	7,743	6,181	5,568
Stone ... do	[7] 60	[7] 54	[7] 102	[7] 92	[7] 126	[7] 114	807	808
Value of items that cannot be disclosed: Certain metals and nonmetals	------------	4,694	------------	4,820	------------	6,751	------------	7,271
Total Mississippi [15]	------------	144,950	------------	151,411	------------	[8] 186,116	------------	198,862
MISSOURI								
Barite ... short tons	317,350	$3,938	199,268	$2,666	296,093	$3,924	180,702	$2,588
Cement ... thousand 376-pound barrels	[3] 10,794	[3] 34,307	12,116	40,657	13,947	46,974	12,183	42,330
Clays ... thousand short tons	2,648	7,648	2,060	5,986	2,635	6,898	2,540	7,207
Coal ... do	2,976	12,691	2,592	11,111	2,748	11,937	2,890	12,450
Copper (recoverable content of ores, etc.) ... short tons	1,604	966	1,429	752	1,065	654	1,087	698
Iron ore (usable) ... thousand long tons, gross weight	530	4,625	387	3,820	349	3,278	365	3,760
Lead (recoverable content of ores, etc.) ... short tons	126,345	36,135	113,123	26,471	105,165	24,188	111,948	26,196
Lime ... thousand short tons	1,393	16,475	1,173	14,136	1,324	15,714	1,254	14,701
Natural gas ... million cubic feet	12	2	------------	------------	------------	------------	75	19
Nickel (content of ore and concentrate) ... short tons	([4])	([4])	763	([4])	([4])	([4])	([4])	([4])
Petroleum (crude) ... thousand 42-gallon barrels	65	([4])	84	([4])	75	([4])	[6] 72	([4])
Sand and gravel ... thousand short tons	8,480	8,942	8,972	9,728	10,279	11,406	10,207	11,601
Silver (recoverable content of ores, etc.) ... thousand troy ounces	184	166	251	227	340	308	16	14
Stone ... thousand short tons	22,098	29,836	24,276	32,878	26,939	36,435	27,180	37,878
Zinc (recoverable content of ores, etc.) ... short tons	2,951	685	362	74	92	21	2,821	728
Value of items that cannot be disclosed: Native asphalt, masonry cement (1957), cobalt, gem stones, manganese ore (1957–58), and values indicated by footnote 4	------------	2,793	------------	2,037	------------	[8] 2,288	------------	2,066
Total Missouri [9]	------------	152,913	------------	144,120	------------	[8] 157,180	------------	156,033

See footnotes at end of table.

TABLE 5.—Mineral production [1] in the United States, by States—Continued

MONTANA

Mineral	1957 Quantity	1957 Value (thousands)	1958 Quantity	1958 Value (thousands)	1959 Quantity	1959 Value (thousands)	1960 Quantity	1960 Value (thousands)
Chromite......short tons, gross weight..	119,149	$3,921	119,057	(4)	[17] 105,000	[17] $3,765	[17] 107,000	[17] $3,813
Clay [3]......thousand short tons..	32	24	23	$19	46	48	63	77
Coal: Bituminous and lignite......do....	413	2,161	305	1,475	345	1,478	313	1,188
Copper (recoverable content of ores, etc.)......short tons..	91,512	55,090	90,683	47,699	65,911	40,469	91,972	59,046
Fluorspar......do....	64,339	(4)	53,654	(4)	18,542	(4)	31,273	(4)
Gold (recoverable content of ores, etc.)......troy ounces..	32,766	1,147	26,003	910	28,551	999	45,922	1,607
Iron ore (usable)......thousand long tons, gross weight..	36	(4)	14	(4)	50	254	55	293
Lead (recoverable content of ores, etc.)......short tons..	13,300	3,804	8,434	1,974	7,672	1,765	4,879	1,142
Manganese ore (35 percent or more Mn)......short tons, gross weight..	68,298	(4)	53,123	4,036	21,604	1,520	29,036	1,996
Manganiferous ore (5 to 35 percent Mn)......do....	4,547	(4)	(4)	(4)	2,415	34	676	11
Mica, sheet......pounds..	13	(5)	(4)	(4)	(4)	(5)	(4)	(4)
Natural gas......million cubic feet..	28,638	2,062	27,989	1,903	30,743	2,306	33,418	2,373
Petroleum (crude)......thousand 42-gallon barrels..	27,172	73,364	27,957	74,086	29,857	76,434	[6] 30,240	[6] 72,878
Phosphate rock......thousand long tons..	534	3,825	(4)	(4)	(4)	(4)	(4)	(4)
Sand and gravel......thousand short tons..	11,403	8,732	13,432	12,593	10,930	12,587	12,589	11,657
Silver (recoverable content of ores, etc.)......thousand troy ounces..	5,558	5,030	3,630	3,286	3,420	3,096	3,607	3,265
Stone......thousand short tons..	2,567	3,654	1,786	2,468	1,186	1,691	1,183	1,576
Tungsten ore and concentrate......short tons, 60-percent WO_3 basis..	661	(4)	......	......	......	......	(4)	(4)
Uranium ore......short tons..	(4)	(4)	689	20	2,890	(4)	1,726	29
Zinc (recoverable content of ores, etc.)......do....	50,520	11,721	33,238	6,781	27,848	6,405	12,551	3,238
Value of items that cannot be disclosed: Barite, cement, clays (bentonite 1957–59, fire clay), gem stones, gypsum, lime, natural gas liquids, pyrites (1957–59), rare-earth metal concentrates (1958–59), talc, vanadium (1957), vermiculite, and values indicated by footnote 4......	......	17,951	......	20,318	......	15,248	......	15,217
Total Montana [15]......	......	191,750	......	176,728	......	[8] 167,328	......	178,854

NEBRASKA

Mineral	1957 Quantity	1957 Value (thousands)	1958 Quantity	1958 Value (thousands)	1959 Quantity	1959 Value (thousands)	1960 Quantity	1960 Value (thousands)
Clays......thousand short tons.	134	$135	108	$110	131	$133	108	$109
Gem stones......	(12)	2	(12)	2	(12)	3	(12)	4
Natural gas......million cubic feet..	14,249	2,280	11,405	1,711	13,128	2,087	15,258	2,670
Natural gas liquids:								
Natural gasoline......thousand gallons..	(4)	(4)	10,870	727	(4)	(4)	(4)	(4)
LP gases......do....	(4)	(4)	31,178	1,565	(4)	(4)	(4)	(4)
Petroleum (crude)......thousand 42-gallon barrels..	19,586	58,366	20,373	59,897	22,881	65,897	[6] 24,428	[6] 70,108
Sand and gravel......thousand short tons..	7,944	5,889	10,441	7,945	11,202	8,301	10,876	8,746
Stone......do....	3,065	3,749	3,555	4,747	3,236	5,235	3,336	5,651

Value of items that cannot be disclosed: Cement, pumice, and values indicated by footnote 4	------------	13,670	------------	14,603	------------	17,679	------------	18,384
Total Nebraska [9]	------------	82,928	------------	90,047	------------	[8] 97,130	------------	103,687
NEVADA								
Antimony ore and concentrate .... short tons, antimony content	29	$9	39	$8	10	$2	------------	------------
Barite .... short tons	109,663	721	59,407	[8] 403	91,298	623	85,711	$580
Clays .... thousand short tons	12	20	(4)	(4)	(4)	(4)	(4)	(4)
Copper (recoverable content of ores, etc.) .... short tons	77,750	46,806	66,137	34,788	57,375	35,228	77,485	49,745
Fluorspar .... do	(4)	(4)	12,338	340	16,743	407	18,505	388
Gem stones	(12)	100	(12)	100	(12)	100	(12)	100
Gold (recoverable content of ores, etc.) .... troy ounces	76,752	2,686	105,087	3,678	113,443	3,971	58,187	2,037
Gypsum .... thousand short tons	674	(4)	686	2,306	818	2,738	802	2,721
Iron ore (usable) .... thousand long tons, gross weight	904	5,341	594	3,149	698	3,712	734	3,648
Lead (recoverable content of ores, etc.) .... short tons	5,979	1,710	4,150	971	1,357	312	987	231
Manganese ore (35 percent or more Mn) .... short tons, gross weight	129,046	(4)	127,322	7,566	[8] 56,611	[8] 3,918	49,076	3,301
Manganiferous ore (5 to 35 percent Mn) .... do	------------	------------	------------	------------	200	(4)	(4)	(4)
Mercury .... 76-pound flasks	6,313	1,559	7,336	1,681	7,156	1,628	7,821	1,648
Petroleum (crude) .... thousand 42-gallon barrels	44	76	40	69	32	(4)	[6] 25	(4)
Sand and gravel .... thousand short tons	5,233	5,190	5,503	5,311	6,436	7,522	4,085	5,224
Silver (recoverable content of ores, etc.) .... thousand troy ounces	959	868	933	844	611	553	707	640
Stone .... thousand short tons	925	1,585	813	1,335	840	1,587	579	1,350
Talc and soapstone .... short tons	7,467	57	5,391	41	5,824	50	4,882	30
Tungsten concentrate .... short tons, 60-percent WO_3 basis	1,196	1,676	(4)	(4)	(4)	(4)	(4)	(4)
Zinc (recoverable content of ores, etc.) .... short tons	5,292	1,228	91	19	217	50	420	108
Value of items that cannot be disclosed: Brucite (1957–59), diatomite, lime, magnesite, molybdenum, perlite, pumice, salt, sulfur ore, uranium ore, and values indicated by footnote 4	------------	16,756	------------	6,020	------------	8,458	------------	9,091
Total Nevada [15]	------------	86,023	------------	[8] 68,291	------------	[8] 70,164	------------	80,285
NEW HAMPSHIRE								
Beryllium concentrate .... short tons, gross weight	4	$2	14	$8	20	$12	14	$8
Clays .... thousand short tons	37	51	26	26	26	26	27	27
Gem stones	(12)	(5)	(12)	5	(12)	10	(12)	15
Mica:								
Sheet .... pounds	53,554	460	81,472	646	119,163	1,133	80,065	904
Scrap .... short tons	522	17	314	12	(4)	(4)	415	14
Peat .... do	85	(4)	100	(4)	25	(4)	23	(4)
Sand and gravel .... thousand short tons	4,505	1,970	4,940	2,620	5,124	2,887	6,621	3,687
Stone .... do	(4)	(4)	(4)	(4)	82	488	104	594
Value of items that cannot be disclosed: Abrasive stones (1957), feldspar, and values indicated by footnote 4	------------	831	------------	602	------------	166	------------	68
Total New Hampshire	------------	3,331	------------	3,919	------------	4,722	------------	5,317

See footnotes at end of table.

TABLE 5.—Mineral production[1] in the United States, by States—Continued

NEW JERSEY

Mineral	1957		1958		1959		1960	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays....thousand short tons	[3] 593	[3] $1,872	684	$2,181	700	$1,895	664	$1,597
Gem stones	(12)	(5)	(12)	4	(12)	6	(12)	7
Iron ore (usable)....thousand long tons, gross weight	877	16,668	(4)	(4)	(4)	(4)	(4)	(4)
Peat....short tons	(4)	(4)	18,397	185	28,300	278	25,100	192
Sand and gravel....thousand short tons	10,323	17,619	9,877	16,145	11,033	18,620	11,594	19,511
Stone....do	8,792	21,222	8,229	19,193	10,079	22,133	10,202	22,814
Zinc (recoverable content of ores, etc.)[18]....short tons	12,530	2,857	607	125	----------	----------	----------	----------
Value of items that cannot be disclosed: Ball clay (1957), lime, magnesium compounds, manganiferous residuum, greensand marl, uranium ore (1960), and values indicated by footnote 4. Excludes limestone used in manufacturing lime	----------	4,404	----------	12,547	----------	16,547	----------	12,288
Total New Jersey	----------	64,642	----------	50,380	----------	59,479	----------	56,409

NEW MEXICO

Mineral	1957 Quantity	1957 Value (thousands)	1958 Quantity	1958 Value (thousands)	1959 Quantity	1959 Value (thousands)	1960 Quantity	1960 Value (thousands)
Barite....short tons	4,441	$98	(4)	(4)	320	$6	492	$10
Beryllium concentrate....short tons, gross weight	29	15	27	$16	11	6	----------	----------
Carbon dioxide, natural....thousand cubic feet	(4)	(4)	(4)	(4)	(4)	(4)	230,115	(4)
Clays [3]....thousand short tons	33	83	40	73	45	77	56	132
Coal....do	137	829	117	719	149	837	295	1,747
Columbium-tantalum concentrate....pounds	866	1	----------	----------	----------	----------	----------	----------
Copper (recoverable content of ores, etc.)....short tons	67,472	40,618	55,540	29,214	39,688	24,369	67,288	43,199
Fluorspar....do	----------	----------	----------	----------	200	7	----------	----------
Gem stones	(12)	30	(12)	28	(12)	39	(12)	40
Gold (recoverable content of ores, etc.)....troy ounces	3,212	112	3,378	118	3,155	110	5,423	190
Gypsum....thousand short tons	----------	----------	----------	----------	----------	----------	55	193
Helium....thousand cubic feet	69,336	1,189	29.793	502	16,903	264	43,494	684
Iron ore (usable)....thousand long tons, gross weight	(16)	1	(16)	(4)	(16)	(4)	1	27
Lead (recoverable content of ores, etc.)....short tons	5,294	1,514	1,117	261	829	191	1,996	467
Lime....thousand short tons	24	290	21	260	16	209	36	496
Manganese ore (35 percent or more Mn)....short tons, gross weight	25,459	2,114	28,866	2,333	27,528	2,248	----------	----------
Manganiferous ore (5 to 35 percent Mn)....do	42,535	152	(4)	(4)	(4)	(4)	(4)	(4)
Mica:								
Scrap....short tons	1,347	47	787	24	210	7	235	7
Sheet....pounds	2,134	16	1,791	18	247	2	(4)	(4)
Natural gas....million cubic feet	723,004	67,962	761,446	79,190	739,660	73,966	798,928	85,485

Natural gas liquids:								
Natural gasoline and cycle products ... thousand gallons	309,010	19,941	258,312	15,131	264,133	16,859	321,667	20,412
LP gases ... do	375,930	13,046	458,178	17,331	552,257	22,320	645,116	28,788
Perlite ... short tons	187,259	1,568	202,046	1,790	240,642	2,121	240,593	2,119
Petroleum (crude) ... thousand 42-gallon barrels	94,759	283,128	98,515	293,974	105,692	301,394	[6] 107,940	[6] 307,491
Potassium salts ... thousand short tons, K_2O equivalent	2,080	77,197	1,978	69,106	2,189	74,117	2,440	80,023
Pumice ... thousand short tons	321	756	507	959	493	1,023	365	827
Salt ... do	53	429	31	275	36	322	39	331
Sand and gravel ... do	7,991	7,803	13,205	11,413	12,460	13,332	7,419	7,459
Silver (recoverable content of ores, etc.) ... thousand troy ounces	309	280	159	144	159	144	304	275
Stone ... thousand short tons	1,348	1,618	1,730	1,507	461	542	1,277	1,692
Uranium ore ... short tons	1,175,742	20,538	1,888,499	32,264	3,269,826	53,463	3,793,494	61,827
Zinc (recoverable content of ores, etc.) ... do	32,680	7,582	9,034	1,843	4,636	1,066	13,770	3,553
Value of items that cannot be disclosed: Cement (1960), fire clay, molybdenum, magnesium compounds, vanadium, and values indicated by footnote 4	------------	2,276	------------	1,345	------------	3,771	------------	5,266
Total New Mexico [15]	------------	551,155	------------	559,777	------------	[8] 592,535	------------	652,200

NEW YORK

Clays ... thousand short tons	1,002	$1,270	1,085	$1,419	1,309	$1,714	1,172	$1,717
Emery ... short tons	11,893	184	7,687	126	8,555	150	8,169	142
Gem stones	(12)	5	(12)	8	(12)	8	(12)	9
Gypsum ... thousand short tons	864	3,749	834	3,869	919	4,663	755	3,928
Iron ore (usable) ... thousand long tons, gross weight	3,329	44,567	1,944	25,683	2,044	28,050	2,484	32,377
Lead (recoverable content of ores, etc.) ... short tons	1,667	477	579	135	481	111	775	181
Natural gas ... million cubic feet	2,869	815	2,808	859	2,915	889	4,990	1,542
Peat ... short tons	(4)	(4)	13,606	117	12,875	138	10,042	146
Petroleum (crude) ... thousand 42-gallon barrels	2,677	12,662	1,763	7,457	1,970	8,353	[6] 1,801	[6] 8,357
Salt ... thousand short tons	3,691	28,002	3,896	30,609	4,011	30,958	4,008	30,763
Sand and gravel ... do	25,640	26,480	24,730	27,541	27,943	31,415	30,687	35,152
Silver (recoverable content of ores, etc.) ... thousand troy ounces	64	58	67	60	52	47	49	45
Slate ... thousand short tons	59	961	(19)	(19)	(19)	(19)	(19)	(19)
Stone ... do	24,265	43,276	22,598	38,219	28,640	46,556	29,802	46,955
Zinc (recoverable content of ores, etc.) ... short tons	64,659	15,001	53,014	10,815	43,464	9,997	66,364	17,122
Value of items that cannot be disclosed: Beryllium concentrate (1960), cement, abrasive garnet, iron oxide pigments (1957-58), lime, talc, titanium concentrate, wollastonite, and values indicated by footnote 4	------------	70,699	------------	61,859	------------	76,904	------------	81,831
Total New York [9]	------------	244,114	------------	205,338	------------	[8] 234,642	------------	254,713

See footnotes at end of table.

TABLE 5.—Mineral production [1] in the United States, by States—Continued

NORTH CAROLINA

Mineral	1957		1958		1959		1960	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Abrasive stones ... short tons	[12]	[20] $5	[12]	[20] $2	[21] 191	[21] $5	[12]	[20] $2
Beryllium concentrate ... short tons, gross weight	1	1	[11]	[5]	----	----	----	----
Clays [3] ... thousand short tons	2,392	1,407	2,046	1,187	2,524	1,522	2,476	1,548
Feldspar ... long tons	233,439	2,728	[4]	[4]	[4]	[4]	270,761	2,781
Gem stones	[12]	[5]	[12]	1	[12]	9	[12]	4
Gold (recoverable content of ores, etc.) ... troy ounces	1,373	48	876	31	965	34	1,826	64
Lead (recoverable content of ores, etc.) ... short tons	9	3	----	----	----	----	424	99
Mica:								
Scrap ... do	53,452	1,173	50,897	1,041	47,736	1,212	47,281	1,100
Sheet ... pounds	577,607	1,575	521,701	1,722	505,623	1,755	430,193	1,411
Sand and gravel ... thousand short tons	6,829	5,724	7,044	5,880	8,580	7,426	8,801	7,453
Silver (recoverable content of ores, etc.) ... thousand troy ounces	12	11	15	14	16	15	212	192
Stone ... thousand short tons	[7] 9,455	[7] 12,839	12,385	19,132	12,859	20,302	14,721	23,296
Talc and pyrophyllite ... short tons	120,905	558	126,158	614	127,296	647	100,593	549
Tungsten concentrate ... short tons, 60-percent WO_3 basis	1,828	[4]	[4]	[4]	[4]	[4]	[4]	[4]
Zinc (recoverable content of ores, etc.) ... short tons	2	[5]	----	----	----	----	----	----
Value of items that cannot be disclosed: Abrasive stone (grinding pebbles and tube-mill liners, 1957–58, millstones 1959), asbestos, clay (bentonite 1957, kaolin 1958–60), copper, iron ore (1959–60), lithium minerals, olivine, slate (1957), stone (dimension granite, crushed basalt, dimension and crushed marble, crushed limestone, and crushed sandstone 1957), and values indicated by footnote 4	----	11,498	----	10,267	----	7,862	----	6,469
Total North Carolina	----	37,570	----	39,891	----	40,789	----	44,968

NORTH DAKOTA

Mineral	1957 Quantity	1957 Value (thousands)	1958 Quantity	1958 Value (thousands)	1959 Quantity	1959 Value (thousands)	1960 Quantity	1960 Value (thousands)
Clays [3] ... thousand short tons	54	$67	54	$66	61	$79	102	$129
Coal (lignite) ... do	2,561	5,947	2,314	5,409	2,413	5,426	2,525	5,790
Gem stones	[12]	[5]	[12]	1	[12]	1	[12]	1
Natural gas ... million cubic feet	15,450	1,468	17,325	1,672	17,915	1,774	19,483	2,221
Petroleum (crude) ... thousand 42-gallon barrels	13,259	41,501	14,259	42,634	17,824	49,907	[6] 21,954	[6] 59,495
Pumice ... thousand short tons	2	2	11	11	----	----	----	----
Sand and gravel ... do	7,048	4,967	11,464	6,605	9,883	6,516	8,648	6,904
Stone ... do	29	52	23	35	48	84	28	44
Value of items that cannot be disclosed: Clays (bentonite, fire clay, 1960), natural gas liquids, salt (1960), and values indicated by footnote 4	----	2,698	----	3,012	----	3,555	----	3,691
Total North Dakota	----	56,702	----	59,445	----	[8] 67,342	----	78,275

OHIO

Abrasive stones, grindstones and pulpstones ... short tons	1,505	$132	852	$83	1,081	$101	([4])	([4])
Cement ... thousand 376-pound barrels	16,238	52,184	15,700	53,043	18,994	63,935	17,480	$61,478
Clays ... thousand short tons	6,136	16,073	5,220	13,082	5,478	15,346	5,165	14,325
Coal ... do	36,862	146,134	32,028	126,241	35,112	135,729	33,957	130,877
Gem stones	-----------	-----------	([12])	([5])	([12])	2	([12])	3
Lime ... thousand short tons	2,763	38,383	2,411	32,471	3,190	45,121	3,117	44,403
Natural gas ... million cubic feet	30,384	7,201	31,786	6,802	34,664	8,042	36,074	8,477
Peat ... short tons	5,478	102	5,660	104	5,813	73	6,755	93
Petroleum (crude) ... thousand 42-gallon barrels	5,478	17,694	6,260	18,091	5,978	17,157	[6] 4,960	[6] 14,731
Salt ... thousand short tons	2,825	16,936	2.443	17,443	2,858	20,486	3.108	24.149
Sand and gravel ... do	30,596	37,503	29,624	36,619	38,604	45,139	[23] 37,943	[23] 44,979
Stone ... do	[7] 37.451	[7] 61,847	29.122	49,782	[7] 36,155	[7] 59,326	[7] 35,856	[7] 59,479
Value of items that cannot be disclosed: Gypsum, natural gasoline (1957–58), stone (dimension limestone 1957, 1960, and calcareous marl, 1957, 1959–60), and values indicated by footnote 4	-----------	2,453	-----------	1,905	-----------	[8] 2,027	-----------	1,826
Total Ohio [9]	-----------	383,000	-----------	344,856	-----------	[8] 397,326	-----------	389,828

OKLAHOMA

Clays [3] ... thousand short tons	641	$642	576	$579	966	$970	734	$739
Coal ... do	2,195	14,165	1,629	10,858	1,525	10,272	1,342	9,113
Helium ... thousand cubic feet	-----------	-----------	-----------	-----------	98,749	1,619	289,068	4,691
Lead (recoverable content of ores, etc.) ... short tons	7,183	2,054	3,692	864	601	138	936	219
Natural gas ... million cubic feet	719,794	59,743	696,504	70,347	811,508	81,151	824,266	98,088
Natural gas liquids:								
Natural gasoline and cycle products ... thousand gallons	460,644	25,329	440,798	26,029	448,353	29,443	531,995	33,074
LP gases ... do	587,140	21,824	657,114	25,822	675,869	27,070	762,258	32,409
Petroleum (crude) ... thousand 42-gallon barrels	214,661	650,423	200,699	594,069	198,090	578,423	[6] 192,288	[6] 561,481
Salt ... thousand short tons	7	63	4	41	([4])	([4])	3	16
Sand and gravel ... do	4,960	4,507	7,232	5,859	6,002	5,927	6,424	7,468
Stone ... do	12,016	14,064	10,794	12,232	12,683	14,980	[7] 14,054	[7] 16,098
Tripoli ... short tons	22,236	67	([4])	([4])	([4])	([4])	([4])	([4])
Zinc (recoverable content of ores, etc.) ... do	14,951	3,469	5,267	1,074	1,049	241	2,332	602
Value of items that cannot be disclosed: Native asphalt, clay (bentonite), cement, gem stones (1959–60), gypsum, lime, manganese ore (1957), pumice, stone, (crushed granite 1960), and values indicated by footnote [4]	-----------	14,573	-----------	16,022	-----------	18,156	-----------	16,756
Total Oklahoma 4	-----------	809,004	-----------	761,936	-----------	[8] 765,439	-----------	779,116

See footnotes at end of table.

TABLE 5.—Mineral production [1] in the United States, by States—Continued

OREGON

Mineral	1957		1958		1959		1960	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Chromite ... short tons, gross weight	7,900	$675	4,133	([4])	-----------	-----------	-----------	-----------
Clays ... thousand short tons	240	266	252	$293	294	$308	318	$370
Copper (recoverable content of ores, etc.) ... short tons	23	14	10	5	-----------	-----------	6	4
Gold (recoverable content of ores, etc.) ... troy ounces	3,381	118	1,423	50	686	24	835	29
Lead (recoverable content of ores, etc.) ... short tons	5	1	1	([5])	-----------	-----------	-----------	-----------
Mercury ... 76-pound flasks	3,993	986	2,276	521	1,224	278	513	108
Nickel (content of ore and concentrate) ... short tons	12,276	([4])	12,697	([4])	12,374	([4])	13,115	5,246
Pumice ... thousand short tons	123	294	138	331	([4])	([4])	([4])	([4])
Sand and gravel ... do	12,843	13,481	10,464	10,265	18,087	15,506	17,673	16,170
Silver (recoverable content of ores, etc.) ... thousand troy ounces	16	14	3	2	([22])	([5])	([22])	([5])
Stone ... thousand short tons	10,583	11,745	15,077	15,621	13,341	16,126	16,864	19,620
Value of items that cannot be disclosed: Asbestos (1959-60), carbon dioxide, cement, diatomite, gem stones, iron ore (pigment material, 1957, 1959), lime (1957-58, 1960), tungsten concentrate (1957), uranium ore (1957, 1960), and values indicated by footnote 4	-----------	16,154	-----------	19,311	-----------	[8] 18,607	-----------	14,124
Total Oregon [9]	-----------	42,820	-----------	45,190	-----------	[8] 49,842	-----------	54,419

PENNSYLVANIA

Mineral	1957		1958		1959		1960	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement ... thousand 376-pound barrels	44,680	$148,130	42,115	$142,399	43,356	$150,918	38,320	$131,763
Clays ... thousand short tons	4,074	22,012	[3] 3,318	[3] 17,051	3,466	17,196	[3] 3,557	[3] 16,536
Coal:								
Anthracite ... do	25,338	227,754	21,171	187,898	20,649	172,320	18,817	147,116
Bituminous ... do	85,365	492,539	67,771	373,812	65,347	345,332	65,425	345,971
Cobalt (content of concentrate) ... thousand pounds	599	([4])	564	([4])	280	([4])	([4])	([4])
Gem stones	([12])	([4])	([12])	2	([12])	3	([12])	4
Lime ... thousand short tons	1,298	18,406	1,003	14,161	1,263	18,261	1,120	16,277
Natural gas ... million cubic feet	101,801	31,660	95,869	27,131	99,366	29,015	113,928	36,229
Natural gas liquids:								
Natural gasoline ... thousand gallons	3,106	192	1,608	107	2,884	184	1,399	85
LP gases ... do	1,211	106	1,363	123	1,484	36	1,580	138
Peat ... short tons	26,086	236	23,623	203	26,948	262	30,837	325
Petroleum (crude) ... thousand 42-gallon barrels	8,179	38,687	6,472	26,535	6,160	25,872	[6] 6,258	[6] 28,474
Sand and gravel ... thousand short tons	12,406	19,570	11,825	19,180	14,257	23,233	13,011	21,204
Slate ... do	139	4,005	([19])	([19])	([19])	([19])	([19])	([19])
Stone ... do	43,258	73,090	40,049	69,694	43,682	77,421	42,136	74,168
Zinc (recoverable content of ores, etc.) [18] ... short tons	-----------	-----------	10,812	2,229	16,718	3,828	13,746	3,559
Value of items that cannot be disclosed: Clays (kaolin 1958, 1960), copper, gold, graphite (1959-60), iron ore, mica, pyrites, pyrophyllite and soapstone, silver, tripoli, and values indicated by footnote 4	-----------	16,613	-----------	15,960	-----------	15,812	-----------	17,430
Total Pennsylvania [9]	-----------	1,077,157	-----------	882,040	-----------	[8] 862,150	-----------	824,493

RHODE ISLAND								
Sand and gravel thousand short tons	1,058	$1,060	2,038	$1,883	1,740	$1,588	1,535	$1,355
Stone do	[7] 4	[7] 14	[7] 3	[7] 8	(4)	(4)	1,810	4,372
Value of items that cannot be disclosed: Nonmetals and values indicated by footnote 4		295		358		745		
Total Rhode Island		1,369		2,249		2,333		5,727
SOUTH CAROLINA								
Clays thousand short tons	937	$5,161	929	$5,157	1,160	$5,920	1,297	$6,201
Mica (sheet) pounds	2,278	12	1,144	8	251	3	101	1
Peat short tons			4,865	(4)	4,194	(4)	(4)	(4)
Sand and gravel thousand short tons	2,647	2,571	2,946	2,858	3,104	3,077	3,029	3,048
Stone [7] do	3,413	4,581	3,637	5,229	6,248	8,647	5,994	8,178
Zirconium concentrate short tons	(4)	(4)	141	5				
Value of items that cannot be disclosed: Barite, cement, feldspar (1959-60), gem stones (1958), kyanite, scrap mica, pyrites (1960), rare-earth metal concentrates (1957-58), staurolite (1957-58), stone (dimension granite 1957, 1960 crushed limestone, crushed sandstone 1959-60 calcareous marl 1957-59) titanium (1957-58), vermiculite, and values indicated by footnote 4		10,491		9,586		13,640		13,559
Total South Carolina [15]		22,168		22,412		30,598		30,001
SOUTH DAKOTA								
Beryllium concentrate short tons, gross weight	268	$145	240	$129	156	$84	167	$88
Clays [3] thousand short tons	176	176	155	155	227	227	202	202
Coal (lignite) do	21	79	20	78	22	88	20	83
Columbium-tantalum concentrate pounds	2,311	6	4,294	10				
Copper (recoverable content of ores, etc.) short tons							1	1
Feldspar long tons	41,316	267	23,229	145	30,825	196	45,588	292
Gem stones	(12)	15	(12)	16	(12)	20	(12)	20
Gold (recoverable content of ores, etc.) troy ounces	568,130	19,885	570,830	19,979	577,730	20,221	554,771	19,417
Gypsum thousand short tons	13	53	12	49	19	78	22	89
Mica:								
Scrap short tons	1,626	43	1,003	24	158	5	205	10
Sheet pounds	9,093	46	16,772	68	38,775	158	30,887	145
Petroleum (crude) thousand 42-gallon barrels	54	(4)	58	(4)	151	(4)	[6] 281	(4)
Sand and gravel thousand short tons	14,758	8,001	14,705	9,179	17,775	11,058	13,548	9,359
Silver (recoverable content of ores, etc.) thousand troy ounces	135	122	153	138	124	113	108	98
Stone thousand short tons	1,718	5,068	1,395	4,095	2,721	7,243	3,149	7,909
Uranium ore short tons	69,800	760	35,489	530	45,734	606	41,104	586
Value of items that cannot be disclosed: Cement, clays (bentonite), iron ore (1957, 1960), lime, lithium minerals (1958-60), vanadium (1960), and values indicated by footnote 4		6,090		7,555		[8] 9,401		9,376
Total South Dakota [9]		39,997		41,534		[8] 48,553		46,780

See footnotes at end of table.

TABLE 5.—Mineral production [1] in the United States, by States—Continued

TENNESSEE

Mineral	1957		1958		1959		1960	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement........thousand 376-pound barrels..	7,415	$22,806	8,375	$26,408	9,153	$28,934	8,246	$27,384
Clays........thousand short tons..	1,154	4,228	935	4,210	1,146	4,952	1,270	4,537
Coal........do....	7,955	31,147	6,785	25,969	5,913	23,581	5,930	21,154
Copper (recoverable content of ores, etc.)........short tons..	9,790	5,894	9,109	4,791	11,490	7,055	12,723	8,168
Gem stones........	....	....	(12)	1	(12)	(5)	(12)	1
Gold (recoverable content of ores, etc.)........troy ounces..	172	6	124	4	99	3	123	4
Iron ore (usable)........thousand long tons, gross weight..	(4)	(4)	(4)	(4)	21	111	(4)	(4)
Lime........thousand short tons..	94	1,134	(4)	(4)	(4)	(4)	(4)	(4)
Manganese ore (35 percent or more Mn)........short tons, gross weight..	12,938	1,007	5,935	452	7,586	589	283	15
Manganiferous ore (5 to 35 percent Mn)........do....	....	....	....	....	56	1	(4)	(4)
Natural gas........million cubic feet..	38	6	54	9	52	9	63	11
Petroleum (crude)........thousand 42-gallon barrels..	7	(4)	7	(4)	[7] 6	(4)	[6] 6	(4)
Phosphate rock........thousand long tons..	1,812	12,514	1,903	13,041	1,755	13,255	1,939	15,424
Sand and gravel........thousand short tons..	5,617	6,641	5,612	6,671	6,221	7,570	6,293	7,655
Silver (recoverable content of ores, etc.)........thousand troy ounces..	54	49	44	40	60	54	65	58
Stone........thousand short tons..	[7] 15,354	[7] 24,155	[7] 16,850	[7] 26,814	18,767	29,094	20,074	29,942
Zinc (recoverable content of ores, etc.)........short tons..	58,063	13,470	59,130	12,062	89,932	20,684	91,394	23,579
Value of items that cannot be disclosed: Barite, fluorspar (1957), scrap mica, pyrites, stone (crushed sandstone 1957–58, crushed granite 1957, dimension limestone 1958) and values indicated by footnote 4........	....	8,029	....	6,884	....	7,392	....	7,570
Total Tennessee [9]........	....	128,739	....	124,934	....	[8] 140,738	....	143,439

TEXAS

Mineral	1957 Quantity	1957 Value (thousands)	1958 Quantity	1958 Value (thousands)	1959 Quantity	1959 Value (thousands)	1960 Quantity	1960 Value (thousands)
Cement........thousand 376-pound barrels..	22,144	$68,541	25,875	$79,756	27,991	$88,067	23,365	$76,577
Clays [3]........thousand short tons..	2,992	4,934	3,720	5,424	3,870	5,703	3,302	5,058
Gem stones........	(12)	100	(12)	100	(12)	100	(12)	100
Gypsum........thousand short tons..	1,043	3,343	1,240	4,120	1,351	4,770	1,131	3,960
Helium........thousand cubic feet..	204,286	3,353	294,452	4,807	238,113	3,918	120,921	2,044
Lime........thousand short tons..	796	7,489	691	7,146	809	8,530	821	9,087
Natural gas........million cubic feet..	5,156,215	500,153	5,178,073	517,807	5,718,993	617,651	5,892,704	665,876
Natural gas liquids:								
Natural gasoline and cycle products........thousand gallons..	2,944,381	201,423	2,871,589	204,501	2,790,155	209,238	2,880,906	207,583
LP gases........do....	3,831,664	147,618	3,786,575	151,896	4,353,368	181,148	4,476,142	200,478
Petroleum (crude)........thousand 42-gallon barrels..	1,073,867	3,338,119	940,166	2,872,389	971,978	2,893,146	[6] 933,632	[6] 2,766,972
Salt........thousand short tons..	4,612	17,104	3,843	15,115	4,519	17,498	4,756	18,222
Sand and gravel........do....	23,685	23,427	32,871	30,808	35,295	34,726	29,844	30,754
Stone........do....	31,248	36,153	36,076	40,912	42,172	47,787	39,029	45,088

Sulfur (Frasch-process) .... thousand long tons..	2,879	70,226	2,616	61,621	2,970	68,998	2,747	62,855
Talc and soapstone .... short tons..	47,780	199	60,827	168	60,945	283	67,031	336
Value of items that cannot be disclosed: Abrasive stones (1957, 1959), native asphalt, bromine, clay (fuller's earth), coal (lignite), feldspar, graphite, iron ore, magnesium chloride (for metal), magnesium compounds (except for metal), mercury, pumice (1957-58), sodium sulfate, and uranium ore	------	71,510	------	46,891	------	48,544	------	49,666
Total Texas [9]	------	4,484,538	------	4,033,311	------	[8] 4,219,757	------	4,134,901
UTAH								
Asphalt and related bitumens, native: Gilsonite .... short tons..	207,704	$4,259	317,280	$4,864	379,362	$9,385	383,037	$10,020
Carbon dioxide, natural .... thousand cubic feet..	(4)	(4)	90,207	6	69,625	5	60,425	4
Clays [3] .... thousand short tons..	164	473	157	488	185	484	143	416
Coal .... do....	6,858	40,263	5,328	30,340	4,545	27,982	4,955	31,458
Copper (recoverable content of ores, etc.) .... short tons..	237,857	143,190	189,184	99,511	144,715	88,855	218,049	139,987
Fluorspar .... do....	11,087	387	16,109	564	(4)	(4)	1,912	51
Gem stones	(12)	12	(12)	40	(12)	134	(12)	72
Gold (recoverable content of ores, etc.) .... troy ounces..	378,438	13,245	307,824	10,774	239,517	8,383	368,255	12,889
Iron ore (usable) .... thousand long tons, gross weight..	4,156	30,383	3,514	25,202	2,842	19,979	3,334	23,862
Lead (recoverable content of ores, etc.) .... short tons..	44,471	12,719	40,355	9,443	36,630	8,425	39,398	9,219
Lime .... thousand short tons..	53	821	80	1,513	90	1,773	127	2,672
Manganese ore (35 percent or more Mn) .... short tons, gross weight..	142	12	1,043	84	1,511	124	------	------
Mica (sheet) .... pounds..	------	------	12	(5)	------	------	------	------
Natural gas .... million cubic feet..	16,824	2,473	19,247	2,829	38,921	5,527	51,040	9,187
Natural gasoline .... thousand gallons..	(4)	(4)	240	15	(4)	(4)	(4)	(4)
Petroleum (crude) .... thousand 42-gallon barrels..	4,367	9,913	24,811	74,185	39,959	114,283	[6] 37,599	[6] 103,021
Phosphate rock .... thousand long tons..	114	756	(4)	(4)	(4)	(4)	(4)	(4)
Pumice .... thousand short tons..	36	148	41	84	39	81	60	134
Salt .... do....	221	2,013	184	2,275	209	2,453	231	3,092
Sand and gravel .... do....	26,958	15,485	25,304	14,379	8,843	6,436	6,848	6,182
Silver (recoverable content of ores, etc.) .... thousand troy ounces..	6,199	5,610	5,278	4,777	3,734	3,380	4,783	4,329
Stone .... thousand short tons..	7,854	8,540	13,126	13,949	3,338	4,048	1,837	3,087
Uranium ore .... short tons..	1,075,759	32,501	1,239,767	38,583	1,210,654	37,310	1,089,757	27,843
Vanadium .... do....	509	(4)	376	(4)	536	(4)	462	(4)
Zinc (recoverable content of ores, etc.) .... do....	40,846	9,476	44,982	9,176	35,223	8,101	35,476	9,153
Value of items that cannot be disclosed: Barite (1959-60), cement, clay (kaolin), gypsum, molybdenum, LP-gases (1959-60), perlite, potassium salts, pyrites (1959-60), and values indicated by footnote 4	------	27,651	------	25,214	------	27,396	------	36,047
Total Utah [15]	------	359,335	------	367,232	------	[8] 373,515	------	431,396

See footnotes at end of table.

TABLE 5.—Mineral production [1] in the United States, by States—Continued

Mineral	1957		1958		1959		1960	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
VERMONT								
Copper (recoverable content of ores, etc.)......short tons..	3,405	$2,050	475	$250	----------	----------	----------	----------
Gem stones......	----------	----------	(12)	1	(12)	$1	(12)	$1
Gold (recoverable content of ores, etc.)......troy ounces..	62	2	----------	----------	----------	----------	----------	----------
Pyrites......thousand long tons..	10	56	----------	----------	----------	----------	----------	----------
Sand and gravel......thousand short tons..	2,216	1,051	1,882	1,316	2,320	1,590	1,809	1,218
Silver (recoverable content of ores, etc.)......thousand troy ounces..	37	33	5	5	----------	----------	----------	----------
Slate......thousand short tons..	(4)	3,269	(19)	(19)	(19)	(19)	(19)	(19)
Stone......do....	557	11,404	808	15,789	944	17,372	2,114	17,444
Value of items that cannot be disclosed: Asbestos, clays, lime, talc, and values indicated by footnote 4......	----------	4,058	----------	4,106	----------	4,420	----------	4,240
Total Vermont [15]......	----------	21,893	----------	21,443	----------	23,359	----------	22,879
VIRGINIA								
Clays......thousand short tons..	803	$986	1,153	$1,143	1,346	$1,396	1,348	$1,395
Coal......do....	29,506	153,959	26,826	130,319	29,769	139,224	27,838	122,723
Gem stones......	----------	----------	(12)	3	(12)	4	(12)	5
Lead (recoverable content of ores, etc.)......short tons..	3,143	899	2,934	687	2,770	637	2,152	504
Lime......thousand short tons..	510	6,029	471	5,533	765	8,168	711	8,028
Manganese ore (35 percent or more Mn)......short tons, gross weight..	12,655	1,058	8,128	647	6,232	499	----------	----------
Manganiferous ore (5 to 35 percent Mn)......do....	----------	----------	56	1	(4)	(4)	----------	----------
Mica, sheet......pounds..	529	6	147	2	108	1	103	1
Natural gas......million cubic feet..	2,465	661	2,521	681	2,280	597	2,227	604
Petroleum (crude)......thousand 42-gallon barrels..	5	(4)	4	(4)	6	(4)	[6] 6	(4)
Sand and gravel......thousand short tons..	7,047	9,877	7,158	10,834	8,452	12,369	7,666	11,432
Silver (recoverable content of ores, etc.)......thousand troy ounces..	(4)	(4)	2	2	1	1	----------	----------
Slate......thousand short tons..	(4)	1,003	(19)	(19)	(19)	(19)	(19)	(19)
Stone......do....	[7] 14,244	[7] 21,158	15,413	27,504	17,787	31,447	[23] 19,358	[23] 33,019
Zinc (recoverable content of ores, etc.) [18]......short tons..	23,080	5,277	18,472	3,808	20,334	4,662	19,885	5,142
Value of items that cannot be disclosed: Aplite, cement, feldspar, gypsum, iron oxide pigment materials (1957, 1960), kyanite, pyrites, salt, stone (dimension miscellaneous, dimension sandstone and calcareous marl 1957), talc and soapstone, titanium concentrate, and values indicated by footnote 4......	----------	29,746	----------	25,471	----------	28,848	----------	25,958
Total Virginia [9]......	----------	227,108	----------	203,277	----------	[8] 222,501	----------	203,819

WASHINGTON

Abrasive stone: Pebbles (grinding)......short tons..	25	(5)	18	(5)	(4)	(5)	(4)	(5)
Chromite......short tons, gross weight..	----------	----------	17	$2	----------	----------	----------	----------
Clays......thousand short tons..	298	$488	[3] 196	[3] 183	[3] 180	[3] $171	[3] 169	[3] $162
Coal......do....	360	2,761	252	1,968	242	1,841	228	1,721
Copper (recoverable content of ores, etc.)......short tons..	1,700	1,023	52	27	49	30	78	50
Gem stones......	(12)	75	(12)	75	(12)	(4)	(12)	(4)
Gypsum......thousand short tons..	6	(4)	(4)	(4)	(4)	(4)	(4)	(4)
Iron ore (usable)......thousand long tons..	4	(4)	4	(4)	4	5	----------	----------
Lead (recoverable content of ores, etc.)......short tons..	12,734	3,642	9,020	2,111	10,310	2,371	7,725	1,808
Manganese ore (35 percent or more Mn)......short tons, gross weight..	----------	----------	----------	----------	83	(4)	----------	----------
Peat......short tons..	39,364	153	34,642	116	32,884	124	27,770	121
Petroleum (crude)......thousand 42-gallon barrels..	5	(4)	4	(4)	1	(4)	[6] 1	(4)
Pumice......thousand short tons..	(4)	(4)	(4)	(4)	9	112	(4)	(4)
Sand and gravel......do....	20,415	17,510	24,389	20,086	21,360	18,576	25,297	18,979
Stone......do....	8,897	11,645	7,837	9,991	12,278	13,587	13,897	15,796
Talc and soapstone......short tons..	4,065	25	4,000	21	4,073	23	2,406	12
Uranium ore......do....	(4)	(4)	(4)	(4)	152,336	(4)	171,255	3,223
Zinc (recoverable content of ores, etc.)......do....	24,000	5,568	18,797	3,835	17,111	3,936	21,317	5,500
Value of items that cannot be disclosed: Barite, carbon dioxide, cement, fire clay (1958-60), diatomite, epsomite (1957), gold, lime (1957), magnesite, mercury (1957-58), olivine, silver, strontium minerals (1957-59), tungsten (1957), and values indicated by footnote 4......	----------	18,950	----------	24,128	----------	25,054	----------	24,552
Total Washington [9]......	----------	60,471	----------	60,896	----------	63,894	----------	70,005

WEST VIRGINIA

Clays......thousand short tons..	708	$2,691	510	$1,960	596	$2,492	626	$2,639
Coal......do....	156,842	875,587	119,468	635,201	119,692	621,003	118,944	597,222
Gem stones......	----------	----------	----------	----------	(12)	1	(12)	1
Natural gas......million cubic feet..	202,440	48,181	204,581	50,734	204,633	53,205	208,757	54,694
Natural gas liquids:								
Natural gasoline......thousand gallons..	30,435	2,185	27,917	5,643	29,242	1,808	23,211	1,513
LP gases......do....	235,881	6,543	235,524	12,806	308,316	15,534	329,874	16,527
Petroleum (crude)......thousand 42-gallon barrels..	2,215	9,436	2,186	7,629	2,184	7,862	[6] 2,318	[6] 9,434
Salt......thousand short tons..	648	2,642	627	2,784	811	3,305	920	3,673
Sand and gravel......do....	5,354	9,893	5,253	11,729	4,854	10,513	4,506	9,802
Stone......do....	6,989	11,934	[7] 5,599	[7] 9,990	[7] 5,923	[7] 10,482	[7] 8,001	[7] 14,001
Value of items that cannot be disclosed: Bromine, calcium-magnesium chloride, cement, lime, manganese ore (1957), stone (crushed sandstone 1958, dimension sandstone 1959-60, calcareous marl 1959)......	----------	14,938	----------	13,067	----------	13,318	----------	13,195
Total West Virginia [9]......	----------	981,654	----------	749,747	----------	[8] 737,616	----------	720,674

See footnotes at end of table.

TABLE 5.—Mineral production [1] in the United States, by States—Continued

WISCONSIN

Mineral	1957 Quantity	1957 Value (thousands)	1958 Quantity	1958 Value (thousands)	1959 Quantity	1959 Value (thousands)	1960 Quantity	1960 Value (thousands)
Abrasive stones ... short tons	1,790	$43	858	$26	770	$27	397	$12
Clays ... thousand short tons	131	136	154	167	178	192	144	156
Iron ore (usable) ... thousand long tons, gross weight	1,576	(4)	867	(4)	701	(4)	1,502	(4)
Lead (recoverable content of ores, etc.) ... short tons	1,900	543	800	187	745	171	1,165	273
Lime ... thousand short tons	(4)	(4)	141	2,193	(4)	(4)	(4)	(4)
Peat ... short tons	400	(4)	(4)	(4)	7,500	(4)	8,500	(4)
Sand and gravel ... thousand short tons	29,394	18,694	39,383	25,845	41,999	27,535	35,681	25,648
Stone ... do	12,434	22,455	13,722	23,334	13,522	23,782	16,486	22,302
Zinc (recoverable content of ores, etc.) ... short tons	21,575	5,006	12,140	2,477	11,635	2,676	18,410	4,750
Value of items that cannot be disclosed: Cement, gem stones, and values indicated by footnote 4	------	22,590	------	18,083	------	18,541	------	25,619
Total Wisconsin [9]	------	68,644	------	71,334	------	71,959	------	77,171

WYOMING

Mineral	1957 Quantity	1957 Value (thousands)	1958 Quantity	1958 Value (thousands)	1959 Quantity	1959 Value (thousands)	1960 Quantity	1960 Value (thousands)
Beryllium concentrate ... short tons, gross weight	5	$3	17	$9	1	(5)	5	$2
Clays [3] ... thousand short tons	1,069	11,973	1,075	9,968	764	$9,449	788	9,571
Coal ... do	2,117	7,777	1,629	5,820	1,977	6,669	2,024	6,992
Copper (recoverable content of ores, etc.) ... short tons	4	2	(11)	(5)	------	------	------	------
Gem stones	(12)	55	(12)	52	(12)	76	(12)	68
Gold (recoverable content of ores, etc.) ... troy ounces	573	20	117	4	------	------	40	1
Gypsum ... thousand short tons	(4)	(4)	6	19	9	31	13	46
Iron ore (usable) ... thousand long tons, gross weight	736	(4)	557	(4)	503	2,923	(4)	(4)
Natural gas ... million cubic feet	117,256	10,201	121,682	10,221	156,978	12,715	181,610	21,793
Natural gas liquids:								
Natural gasoline ... thousand gallons	47,709	2,866	49,451	3,052	64,586	4,003	72,195	4,535
LP gases ... do	57,805	2,566	54,496	2,614	90,314	3,951	120,693	5,279
Petroleum (crude) ... thousand 42-gallon barrels	109,584	291,493	115,572	301,643	126,050	315,125	[6] 135,521	[6] 340,158
Phosphate rock ... thousand long tons	18	121	124	937	(4)	(4)	(4)	(4)
Pumice ... thousand short tons	49	41	45	40	94	77	33	30
Rare-earth metals concentrates ... short tons	2	5	------	------	------	------	------	------
Sand and gravel ... thousand short tons	2,425	1,905	5,333	4,760	4,692	3,982	5,928	5,356
Stone ... do	1,291	2,266	1,099	1,472	1,317	1,791	1,401	2,302

Uranium ore .... short tons..	274,699	4,669	651,790	13,286	864,582	17,610	1,357,225	27,387
Value of items that cannot be disclosed: Cement, clays (fire clay 1957–59, miscellaneous clay 1959–60), feldspar (1957–58), sheet mica (1959–60), silver (1957–58, 1960), sodium carbonates and sulfates, vanadium (1957–58), and values indicated by footnote 4	....	17,527	....	16,760	....	15,970	....	19,741
Total Wyoming [9]	....	352,532	....	369,938	....	[8] 393,841	....	442,738

[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] Figure withheld to avoid disclosing individual company confidential data.
[5] Less than $1,000.
[6] Preliminary figure.
[7] Excludes certain stone, included with "Value of items that cannot be disclosed."
[8] Revised figure.
[9] Total adjusted to eliminate duplicating value of clays and stone.
[10] Less than 1,000 short tons.
[11] Less than 1 ton.
[12] Weight not recorded.
[13] Total weight of columbite-tantalite plus $(Cb\text{-}Ta)_2O_5$ content of euxenite
[14] Total value adjusted to eliminate duplicating value of stone.
[15] Total has been adjusted to eliminate duplicating value of raw materials used in manufacturing cement and/or lime.
[16] Less than 1,000 long tons.
[17] Excludes quantity consumed by American Chrome Co.
[18] Recoverable zinc valued at the yearly average price of Prime Western slab zinc, East St. Louis market. Represents value established after transportation, smelting, and manufacturing charges have been added to the value of ore at mine.
[19] Beginning with 1958 slate included with stone.
[20] Millstones only.
[21] Grinding pebbles and tube-mill liners.
[22] Less than 1,000 troy ounces.
[23] Final figure; supersedes figure given in commodity chapter.

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TABLE 6.—Mineral production [1] in the Canal Zone and islands administered by the United States [2]

Mineral	1957		1958		1959		1960	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
American Samoa:								
Stone ... thousand short tons	34	$37	30	$59	178	$219	523	$261
Canal Zone:								
Sand and gravel ... do	------	------	41	34	14	21	65	68
Stone (crushed) ... do	59	99	140	237	223	270	203	306
Total Canal Zone	------	99	------	271	------	291	------	374
Canton:								
Sand and gravel ... thousand short tons	------	------	------	------	(3)	(4)	------	------
Stone (crushed) ... do	------	------	------	------	(3)	1	------	------
Guam:								
Sand and gravel ... do	1	1	9	23	28	20	1	1
Stone ... do	1,034	1,132	684	751	568	1,109	962	2,194
Total Guam	------	1,133	------	774	------	1,129	------	2,195
Johnston:								
Sand and gravel ... thousand short tons	------	------	------	------	------	------	1	4
Stone ... do	------	------	------	------	------	------	2	5
Total Johnston	------	------	------	------	------	------	------	9
Midway: Stone (crushed) ... thousand short tons	3,875	6,700	175	476	------	------	------	------
Virgin Islands: Stone (crushed) ... do	11	31	25	81	14	51	15	51
Wake: Stone (crushed) ... do	5	6	10	37	32	34	36	49

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2] Production data for Canton and Wake furnished by the U.S. Department of Commerce, Civil Aeronautics Administration; Midway and Johnston, by the U.S. Department of the Navy; Guam by the Government of Guam; American Samoa, by the Government of American Samoa.
[3] Less than 1,000 short tons.
[4] Less than $1,000.

TABLE 7.—Mineral production [1] in the Commonwealth of Puerto Rico

Mineral	1957		1958		1959		1960	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement.......thousand 376-pound barrels..	5, 552	$17, 232	4, 748	$15, 175	5, 392	$16, 982	5, 441	$14, 546
Clays.......thousand short tons..	159	140	165	83	167	83	160	102
Lime.......do....	(2)	(2)	(2)	(2)	10	321	1	15
Salt.......do....	10	104	1	14	3	38	....	....
Sand and gravel.......do....	497	754	476	763	530	888	8, 996	8, 669
Stone.......do....	2, 452	3, 505	1, 986	2, 768	2, 063	2, 878	4, 219	7, 661
Value of items that cannot be disclosed: Other nonmetals and values indicated by footnote 2.......	....	180	....	272	....	....	....	....
Total Puerto Rico [3].......	....	20, 265	....	17, 689	....	19, 700	....	29, 530

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

[2] Figure withheld to avoid disclosing individual company confidential data.

[3] Total adjusted to eliminate duplicating value of stone.

TABLE 8.—U.S. imports for consumption of principal minerals and products

Mineral	1959		1960	
	Quantity	Value (thousands)	Quantity	Value (thousands)
Metals:				
Aluminum:				
Metal — short tons	[1] 239,976	$111,259	154,706	$75,808
Scrap — do	10,919	3,299	5,042	1,598
Plates, sheets, bars, etc — do	[1] 50,628	[1] 34,869	36,677	25,872
Antimony:				
Ore (antimony content) — do	6,466	1,236	6,455	1,214
Needle or liquated — do	177	79	24	11
Metal — do	4,422	2,039	5,437	2,495
Oxide — do	2,056	825	2,368	972
Arsenic: White — do	19,386	1,342	12,825	1,046
Bauxite: Crude — thousand long tons	[1 2] 8,149	[1] 73,549	8,744	78,065
Beryllium ore — short tons	8,038	2,345	[2] 8,943	2,864
Bismuth (general imports) — pounds	457,163	825	1,167,019	2,131
Boron carbide — do	81,459	144	85,965	172
Cadmium:				
Metal — thousand pounds	1,638	1,744	942	1,157
Flue dust (cadmium content) — do	1,544	584	1,861	778
Calcium:				
Metal — pounds	7,425	8	12,618	15
Chloride — short tons	1,756	66	1,570	62
Chromate:				
Ore and concentrates (Cr_2O_3 content) — do	665,463	[1] 31,926	570,639	24,239
Ferrochrome (chromium content) — do	64,066	29,750	34,186	14,313
Metal — do	2,865	5,179	908	1,645
Cobalt:				
Metal — thousand pounds	20,087	35,926	10,801	17,093
Oxide (gross weight) — do	[1] 1,557	[1] 1,851	1,459	1,520
Salts and compounds (gross weight) — do	278	134	230	104
Columbium ore — pounds	3,395,816	2,652	5,051,800	3,687
Copper: (copper content)				
Ore — short tons	[1] 60	[1] 20	3,503	2,016
Concentrates — do	9,299	5,505	20,935	12,391
Regulus, black, coarse — do	7,113	4,260	185	80
Unrefined, black, blister — do	203	126	486	311
Refined in ingots, etc — do	237,304	146,478	171,021	109,760
Old and scrap — do	2,984	1,635	1,836	1,106
Old brass and clippings — do	1,257	698	309	184
Ferroalloys: Ferrosilicon (silicon content) — do	5,584	[1] 1,735	4,972	1,533
Gold:				
Ore and base bullion — troy ounces	444,416	15,522	460,579	16,080
Bullion — do	8,040,528	288,855	8,861,716	318,952
Iron ore:				
Ore — thousand long tons	[1] 35,617	[1] 312,447	34,585	321,693
Pyrites cinder — long tons	10,157	48	5,884	20
Iron and steel:				
Pig iron — short tons	[1] 699,593	[1] 35,493	330,847	18,351
Iron and steel products (major):				
Iron products — do	40,206	7,963	41,183	8,670
Steel products — do	4,574,745	556,253	3,528,826	485,901
Scrap — do	267,839	10,493	138,687	5,281
Tin-plate scrap — do	41,609	1,098	40,770	1,105
Lead:				
Ore, flue dust, matte (lead content) — do	[1] 136,526	[1] 27,035	137,574	27,816
Base bullion (lead content) — do	34	19	293	62
Pigs and bars (lead content) — do	262,632	54,667	213,147	45,017
Reclaimed, scrap, etc. (lead content) — do	7,897	1,304	5,598	1,034
Sheets, pipe, and shot — do	3,608	850	2,855	696
Babbitt metal and solder (lead content) — do	3,751	16,820	[3] 1,512	[3] 16,024
Type metal and antimonial lead (lead content) — short tons	5,020	1,204	3,819	956
Manufactures — do	1,398	586	2,097	710
Magnesium:				
Metallic and scrap — do	593	303	401	202
Alloys (magnesium content) — do	26	155	28	288
Sheets, tubing, ribbons, wire, and other forms (magnesium content) — do	26	121	4	61
Manganese:				
Ore (35 percent or more manganese) (manganese content) — short tons	887,681	74,648	1,082,218	82,289
Ferromanganese (manganese content) — do	70,232	14,067	92,594	19,008

See footnotes at end of table.

TABLE 8.—U.S. imports for consumption of principal minerals and products—Continued

Mineral	1959 Quantity	1959 Value (thousands)	1960 Quantity	1960 Value (thousands)
Metals—Continued				
Mercury:				
Compounds ... pounds	40,622	$118	114,305	$302
Metal ... 76-pound flasks	30,141	5,992	19,488	3,510
Minor metals: Selenium and salts ... pounds	273,929	1,761	[9] 175,761	[9] 972
Nickel:				
Ore and matte ... short tons	4,071	1,612	184	73
Pigs, ingots, shot, cathodes ... do	[1] 82,888	[1] 110,541	79,662	116,567
Scrap ... do	619	731	135	113
Oxide ... do	[2] 30,062	[2] 33,816	24,584	27,650
Platinum group:				
Unrefined materials:				
Ore and concentrates ... troy ounces	503	27	401	30
Grains and nuggets, including crude, dust, and residues ... troy ounces	77,763	5,447	30,338	2,201
Sponge and scrap ... do	[2] 5,666	[2] 420	3,095	212
Osmiridium ... do	2,121	76	------------	------------
Refined metal:				
Platinum ... do	[2] 260,524	[2] 17,241	238,307	18,917
Palladium ... do	610,740	9,374	368,256	8,189
Iridium ... do	7,772	402	4,253	283
Osmium ... do	1,223	65	277	17
Rhodium ... do	29,342	3,369	31,722	4,126
Ruthenium ... do	14,679	492	3,997	156
Radium:				
Radium salts ... milligrams	32,967	518	23,333	364
Radioactive substitutes	(4)	1,145	(4)	1,394
Rare earths: Ferrocerium and other cerium alloy ... pounds	16,070	59	21,391	78
Silver:				
Ore and base bullion ... thousand troy ounces	39,759	34,522	43,404	38,164
Bullion ... do	29,329	26,558	17,253	15,797
Tantalum: Ore ... pounds	652,839	1,166	709,936	1,137
Tin:				
Ore (tin content) ... long tons	10,773	23,282	14,026	31,104
Blocks, pigs, grains, etc ... do	[1] 43,578	[1] 96,855	39,488	86,221
Dross, skimmings, scrap, residues, and tin alloys, n.s.p.f ... long tons	[1] 3,350	[1] 6,469	809	1,642
Tinfoil, powder, flitters, etc	(4)	1,008	(4)	839
Titanium:				
Ilmenite ... short tons	371,687	7,991	265,645	5,067
Rutile ... do	23,228	2,943	29,235	3,611
Metal ... pounds	3,126,293	3,564	4,461,737	4,866
Ferrotitanium ... do	252,436	70	166,053	41
Compounds and mixtures ... do	5,722,512	1,088	12,258,035	2,413
Tungsten: (tungsten content)				
Ore and concentrates ... thousand pounds	5,435	4,235	3,525	3,478
Metal ... pounds	196,053	425	159,759	370
Ferrotungsten ... thousand pounds	533	526	167	207
Other ... pounds	93,963	105	36,666	62
Zinc:				
Ores (zinc content) ... short tons	[1] 424,134	[1] 37,475	382,707	38,696
Blocks, pigs, and slabs ... do	164,462	33,996	120,925	29,639
Sheets ... do	951	311	904	302
Old, dross, and skimmings ... do	1,138	142	1,205	189
Dust ... do	44	6	19	7
Manufactures	(4)	812	(4)	837
Zirconium: Ore, including zirconium sand ... short tons	54,878	1,517	34,280	1,234
Nonmetals:				
Abrasives: Diamonds (industrial) ... carats	[1,3] 13,095,218	[1,3] 62,626	[3] 13,101,110	[3] 51,727
Asbestos ... short tons	713,047	65,006	669,495	63,345
Barite:				
Crude and ground ... do	641,241	4,881	640,559	5,002
Witherite ... do	2,552	113	7,344	59
Chemicals ... do	6,045	551	4,986	576
Bromine ... pounds	[1] 237,473	[1] 118	145,943	111
Cement ... 376-pound barrels	5,264,996	13,773	4,098,236	10,306
Clays:				
Raw ... short tons	172,986	3,193	[3] 153,349	[3] 2,985
Manufactured ... do	3,494	95	6,666	118
Cryolite ... do	22,102	1,994	17,246	1,670
Feldspar: Crude ... long tons	45	5	44	5

See footnotes at end of table.

TABLE 8.—U.S. imports for consumption of principal minerals and products—Continued

Mineral	1959 Quantity	1959 Value (thousands)	1960 Quantity	1960 Value (thousands)
Nonmetals—Continued				
Fluorspar...short tons..	555,750	$13,368	534,020	$14,393
Gem stones:				
Diamonds...carats..	[1] 2,494,994	[1] 180,649	2,167,474	165,547
Emeralds...do....	88,875	2,450	81,207	1,463
Other...	(4)	29,421	(4)	25,470
Graphite...short tons..	37,048	1,527	[2] 48,324	[2] 1,755
Gypsum:				
Crude, ground, calcined...do....	[1] 6,132,650	[1] 11,908	5,306,975	9,045
Manufactures...	(4)	1,288	(4)	1,388
Iodine, crude...thousand pounds..	1,466	1,083	1,894	1,425
Kyanite...short tons..	5,633	252	6,052	265
Lime:				
Hydrated...do....	530	9	672	15
Other...do....	26,374	442	18,445	369
Dead-burned dolomite...do....	[1] 8,468	[1] 496	[2] 12,932	[2] 550
Magnesium:				
Magnesite...do....	155,634	9,871	118,779	7,789
Compounds...do....	15,849	562	14,971	546
Mica:				
Uncut sheet and punch...pounds..	[1] 3,220,412	[1] 7,305	1,088,021	2,081
Scrap...short tons..	4,644	57	6,240	86
Manufactures...do....	5,042	7,443	4,266	6,139
Mineral-earth pigments: Iron oxide pigments:				
Natural...do....	3,161	160	2,976	132
Synthetic...do....	7,776	1,144	7,516	1,100
Ocher, crude and refined...do....	213	13	230	14
Siennas, crude and refined...do....	1,399	95	649	64
Umber, crude and refined...do....	2,078	68	2,894	98
Vandyke brown...do....	202	14	195	14
Nitrogen compounds (major), including urea do....	[1 3] 1,472,507	65,265	[3] 1,214,198	[3] 55,638
Phosphate, crude...long tons..	139,891	3,421	129,290	3,754
Phosphatic fertilizers...do....	[1] 34,692	2,543	17,447	1,078
Pigments and salts:				
Lead pigments and salts...short tons..	13,233	2,695	15,729	3,224
Zinc pigments and salts...do....	19,147	3,678	15,582	3,052
Potash...do....	[1 5] 432,232	[1 5] 15,737	[5] 417,521	[5] 15,461
Pumice:				
Crude or unmanufactured...do....	21,721	152	6,556	58
Wholly or partly manufactured...do....	3,988	92	3,916	103
Manufactures, n.s.p.f...	(4)	20	(4)	36
Quartz crystal (Brazilian pebble)...pounds..	679,836	784	1,193,257	615
Salt...short tons..	1,024,629	5,438	1,057,028	4,484
Sand and gravel:				
Glass sand...do....	101	91	10,765	37
Other sand...do....	348,331	464	379,673	516
Gravel...do....	102,878	93	3,752	5
Sodium sulfate...thousand short tons..	122	2,580	167	3,473
Stone, including slate...	(4)	11,064	(4)	11,344
Strontium: Mineral...short tons..	8,139	225	6,185	160
Sulfur and pyrites:				
Sulfur:				
Ore...long tons..	11,593	255	104,708	2,272
Other forms, n.e.s...do....	630,895	13,646	634,130	13,185
Pyrites...do....	280,638	868	304,789	1,071
Talc: Unmanufactured...short tons..	25,351	861	23,975	849
Coal, petroleum, and related products:				
Carbon black:				
Acetylene black...pounds..	7,246,932	1,335	6,785,095	1,303
Gas black and carbon black...do....	346,771	69	719,164	134
Coal:				
Anthracite...short tons..	2,633	22	1,476	16
Bituminous, slack, culm, and lignite..do....	374,713	2,433	260,495	1,844
Briquets...do....	185	3	6,676	389
Coke...do....	123,255	1,441	125,160	1,483
Peat:				
Fertilizer grade...do....	277,006	13,003	254,794	13,011
Poultry and stable grade...do....	9,713	577	9,083	498

See footnotes at end of table.

TABLE 8.—U.S. imports for consumption of principal minerals and products—Continued

Mineral	1959		1960	
	Quantity	Value (thousands)	Quantity	Value (thousands)
Coal, petroleum, and related products—Continued				
Petroleum:				
Crude .... thousand barrels..	[1] 384, 597	[1] $872, 606	400, 846	$895, 036
Gasoline [6] .... do....	[1] 21, 176	[1] 73, 310	18, 870	62, 653
Kerosine [7] .... do....	125	536	70	224
Distillate oil [8] .... do....	[1] 14, 756	[1] 51, 418	9, 792	30, 958
Residual oil [8] .... do....	[1] 223, 414	[1] 454, 476	230, 396	482, 112
Unfinished oils .... do....	[1] 23, 127	[1] 65, 801	20, 430	55, 847
Asphalt .... do....	6, 982	17, 043	6, 257	14, 379
Miscellaneous [7] .... do....	25	333	76	631

[1] Revised figure.
[2] Adjusted by Bureau of Mines.
[3] Data known to be not comparable with prior years.
[4] Weight not recorded.
[5] Data covers some quantities furnished by Potash Institute; values adjusted by Bureau of Mines.
[6] Includes naphtha but excludes benzol, 1959—1,365,152 barrels ($13,782,172); 1960—907,791 barrels ($9,182,-726).
[7] Includes quantities imported free of duty for supplies of vessels and aircraft.
[8] Includes quantities imported free for manufacture in bond and export and for supplies of vessels and aircraft.
[9] Final figure; supersedes figure given in commodity chapter.

Compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

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

Mineral	1959		1960	
	Quantity	Value (thousands)	Quantity	Value (thousands)
Metals:				
Aluminum:				
Ingots, slabs, crude .... short tons..	[1] 121, 305	[1] $53, 619	284, 979	$128, 199
Scrap .... do....	[1] 32, 164	[1] 10, 384	79, 513	26, 905
Plates, sheets, bars, etc .... do....	9, 015	9, 977	18, 098	16, 266
Castings and forgings .... do....	1, 216	2, 842	1, 190	2, 849
Antimony: Metals and alloys, crude .... do....	9	4	59	47
Arsenic: Calcium arsenate .... pounds..	122, 920	12	289, 700	21
Bauxite, including bauxite concentrates long tons..	17, 403	1, 825	29, 317	2, 588
Aluminum sulfate .... short tons..	14, 487	573	12, 286	451
Other aluminum compounds .... do....	32, 049	4, 286	35, 144	5, 503
Beryllium .... pounds..	164, 460	1, 530	131, 648	1, 344
Bismuth: Metals and alloys .... do....	179, 744	261	156, 636	276
Cadmium .... thousand pounds..	900	1, 024	2, 448	3, 014
Calcium chloride .... short tons..	39, 929	1, 377	26, 792	1, 068
Chrome:				
Ore and concentrates:				
Exports .... do....	[1] 11, 080	[1] 531	5, 184	320
Reexports .... do....	[1] 26, 591	[1] 1, 065	19, 927	721
Chromic acid .... do....	596	349	982	546
Ferrochrome .... do....	6, 127	2, 096	15, 588	5, 249
Cobalt .... pounds..	694, 641	543	1, 798, 218	1, 313
Columbium metals, alloys, and other forms short tons..	15, 414	21	159, 309	157
Copper:				
Ores, concentrates, composition metal, and unrefined copper (copper content) short tons..	2, 982	1, 808	11, 111	6, 832
Refined copper and semimanufactures do....	196, 012	128, 577	512, 332	327, 940
Other copper manufactures .... do....	4, 352	3, 280	5, 181	4, 006
Copper sulfate or blue vitriol .... do....	2, 672	675	14, 841	3, 377
Copper base alloys .... do....	37, 607	30, 002	130, 922	69, 908
Ferroalloys:				
Ferrosilicon .... pounds..	21, 115, 496	981	11, 002, 848	867
Ferrophosphorus .... do....	99, 806, 945	1, 799	95, 794, 790	2, 095

See footnotes at end of table.

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

Mineral	1959		1960	
	Quantity	Value (thousands)	Quantity	Value (thousands)
Metals—Continued				
Gold:				
Ore and base bullion..........troy ounces..	20,498	$715	9,196	$322
Bullion, refined..........do....	29,104	1,218	37,676	1,326
Iron ore..........thousand long tons..	2,967	33,831	5,236	57,575
Iron and steel:				
Pig iron..........short tons..	[1] 10,438	[1] 547	111,773	5,174
Iron and steel products (major):				
Semimanufactures..........do....	[1] 1,069,886	[1] 213,318	2,332,753	444,895
Manufactured steel mill products short tons..	[1] 903,248	[1] 259,311	964,889	258,903
Advanced products..........	(2)	[1] 165,756	(2)	157,686
Iron and steel scrap: Ferrous scrap, including rerolling materials..........short tons..	[1] 4,939,043	[1] 167,716	7,189,614	241,900
Lead:				
Ore, matte, base bullion (lead content) short tons..	224	54	1,297	168
Pigs, bars, anodes..........do....	2,756	751	1,967	748
Scrap..........do....	1,141	291	2,579	361
Magnesium:				
Metal and alloys and semifabricated forms, n.e.c..........short tons..	2,377	2,028	5,125	3,695
Powder..........do....	12	32	7	23
Manganese.				
Ore and concentrates..........do....	5,702	819	5,139	719
Ferromanganese..........do....	947	388	751	202
Mercury:				
Exports..........76-pound flasks..	640	92	357	83
Reexports..........do....	553	119	317	62
Molybdenum:				
Ore and concentrates (molybdenum content)..........pounds..	18,852,279	24,778	30,244,496	39,847
Metals and alloys, crude and scrap..do....	15,172	22	295,004	368
Wire..........do....	12,395	250	9,639	278
Semifabricated forms, n.e.c..........do....	8,921	91	4,940	74
Powder..........do....	11,314	36	9,629	32
Ferromolybdenum..........do....	248,012	280	424,819	489
Nickel:				
Ore..........short tons..	----------	----------	1	4
Alloys and scrap (including Monel metal), ingots, bars, sheets, etc..........short tons..	11,818	11,967	52,468	27,128
Catalysts..........do....	597	1,162	761	1,240
Nickel-chrome electric resistance wire short tons..	139	598	235	969
Semifabricated forms, n.e.c..........do....	519	2,314	644	2,322
Platinum:				
Ore, concentrates, metal and alloys in ingots, bars, sheets, anodes, and other forms, including scrap..........troy ounces..	18,560	1,147	49,497	3,212
Palladium, rhodium, iridium, osmiridium, ruthenium, and osmium (metal and alloys including scrap)..........troy ounces..	12,845	390	15,652	504
Platinum group manufactures, except jewelry..........	(2)	2,306	(2)	2,978
Radium metal (radium content)...milligrams..	2,207	40	712	17
Rare earths:				
Cerium ores, metals, and alloys...pounds..	27,500	17	15,410	15
Lighter flints..........do....	13,343	50	27,517	118
Silver:				
Ore and base bullion thousand troy ounces..	103	93	291	266
Bullion, refined..........do....	9,077	8,381	26,302	24,236
Tantalum:				
Ore, metal, and other forms..........pounds..	16,478	242	49,965	555
Powder..........do....	1,988	76	[3] 1,174	[3] 49
Tin:				
Ingots, pigs, bars, etc.:				
Exports..........long tons..	943	1,890	608	1,294
Reexports..........do....	428	970	249	549
Tin scrap and other tin bearing material except tinplate scrap..........long tons..	7,713	1,231	4,397	1,355
Tin cans finished or unfinished..........do....	36,320	19,027	32,875	17,362

See footnotes at end of table.

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

Mineral	1959		1960	
	Quantity	Value (thousands)	Quantity	Value (thousands)
Metals—Continued				
Titanium:				
Ores and concentrates ---------- short tons --	4,656	$290	1,260	$167
Sponge (including iodide titanium) and scrap ---------- short tons --	496	543	879	869
Intermediate mill shapes ---------- do ----	380	2,770	359	2,038
Mill products, n.e.c ---------- do ----	119	2,391	67	1,200
Ferrotitanium ---------- do ----	321	146	245	157
Dioxide and pigments ---------- do ----	36,282	10,558	33,655	10,001
Tungsten: Ore and concentrates:				
Exports ---------- do ----	1	5	633	1,251
Reexports ---------- do ----	98	119	234	357
Vanadium ore and concentrates, pentoxide, etc. (vanadium content) ---------- pounds --	2,480,343	4,668	7,379,432	14,124
Zinc:				
Ores and concentrates (zinc content) short tons --	1	(4)	13	3
Slabs, pigs, or blocks ---------- do ----	11,629	2,673	75,145	18,122
Sheets, plates, strips, or other forms, n.e.c ---------- short tons --	3,529	2,708	3,324	2,443
Scrap (zinc content) ---------- do ----	11,332	1,053	12,169	1,499
Dust ---------- do ----	521	182	777	267
Semifabricated forms, n.e.c ---------- do ----	1,071	612	2,569	1,195
Zirconium:				
Ores and concentrates ---------- do ----	1,511	263	1,382	317
Metals and alloys and other forms pounds --	89,819	661	1,063,802	2,607
Nonmetals:				
Abrasives:				
Grindstones ---------- short tons --	401	52	319	56
Diamond dust and powder ---------- carats --	172,787	440	321,373	845
Diamond grinding wheels ---------- do ----	249,950	1,518	264,942	1,567
Other natural and artificial metallic abrasives and products ----------	(2)	[1] 21,090	(2)	24,082
Asbestos: Unmanufactured:				
Exports ---------- short tons --	4,317	763	5,461	845
Reexports ---------- do ----	144	30	64	12
Boron: Boric acid, borates, crude and refined ---------- pounds --	507,347,292	21,047	601,211,757	25,576
Bromine, bromides, and bromates ---------- do ----	9,171,539	2,594	10,241,178	2,898
Cement ---------- 376-pound barrels --	277,267	1,595	187,304	1,135
Clay:				
Kaolin or china clay ---------- short tons --	74,734	2,206	79,965	2,044
Fire clay ---------- do ----	[1] 137,490	[1] 2,484	177,578	3,305
Other clays ---------- do ----	276,715	8,800	271,956	8,360
Cryolite ---------- do ----	176	53	226	66
Fluorspar ---------- do ----	1,144	69	458	38
Graphite:				
Amorphous ---------- do ----	1,003	126	1,377	181
Crystalline flake, lump or chip ---------- do ----	169	61	164	51
Natural, n.e.c ---------- do ----	196	36	314	57
Gypsum:				
Crude, crushed or calcined thousand short tons --	14	641	17	687
Manufactures, n.e.c ----------	(2)	655	(2)	606
Iodine, iodide, iodates ---------- thousand pounds --	175	249	251	353
Kyanite and allied minerals ---------- short tons --	2,734	167	3,255	210
Lime ---------- do ----	52,780	1,000	61,056	992
Mica:				
Unmanufactured ---------- pounds --	1,072,894	126	701,926	113
Manufactured:				
Ground or pulverized ---------- do ----	8,915,109	459	7,077,245	370
Other ---------- do ----	216,040	653	243,354	828
Mineral-earth pigments: Iron oxide, natural and manufactured ----------	4,337	1,040	3,862	1,113
Nitrogen compounds (major) ---------- short tons --	747,024	37,415	623,370	33,063
Phosphate rock ---------- long tons --	3,139,722	28,602	4,246,291	37,543
Phosphatic fertilizers ---------- do ----	413,867	19,539	416,931	19,882
Pigments and salts (lead and zinc):				
Lead pigments ---------- short tons --	3,178	1,054	2,118	705
Zinc pigments ---------- do ----	3,054	864	2,327	694
Lead salts ---------- do ----	699	276	944	355
Potash:				
Fertilizer ---------- do ----	560,001	16,502	815,521	23,508
Chemical ---------- do ----	11,658	1,994	17,372	2,418
Quartz crystal (raw) ----------	(2)	166	(2)	354
Radioactive isotopes, etc ---------- curie --	112,204	1,283	146,983	1,286

See footnotes at end of table.

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

Mineral	1959		1960	
	Quantity	Value (thousands)	Quantity	Value (thousands)
Nonmetals—Continued				
Salt:				
Crude and refined ....short tons..	424,348	$2,660	421,764	$2,548
Shipments to noncontiguous Territories short tons..	13,652	1,031	14,311	1,042
Sodium and sodium compounds:				
Sodium sulfate ....do....	21,527	805	30,724	940
Sodium carbonate....thousand short tons..	153	5,644	155	5,143
Stone:				
Limestone, crushed, ground, broken short tons..	1,085,553	1,999	920,791	1,775
Marble and other building and monumental ....cubic feet..	425,194	1,262	431,262	1,250
Stone crushed, ground, broken..short tons..	157,911	3,388	153,106	2,659
Manufactures of stone ....do....	(2)	643	(2)	477
Sulfur:				
Crude ....long tons..	[1] 1,612,158	[1] 39,975	1,775,526	40,880
Crushed, ground, flowers of............do....	[1] 23,449	[1] 2,025	11,017	1,413
Talc:				
Crude and ground ....short tons..	58,751	1,532	59,457	1,801
Manufactures, n.e.c ....do....	197	175	158	92
Powders-talcum (face and compact)	(3)	1,276	(3)	1,378
Coal, petroleum and related products:				
Carbon black............thousand pounds...	513,143	45,798	543,032	49,600
Coal:				
Anthracite ....short tons..	1,787,558	28,931	1,430,156	22,717
Bituminous ....do....	[1] 37,253,431	[1] 349,521	36,491,424	331,212
Briquets ....do....	33,458	495	21,126	305
Coke ....do....	460,222	8,674	353,016	6,885
Petroleum:				
Crude ....thousand barrels..	2,524	6,990	3,087	8,032
Gasoline [5] ....do....	15,518	108,766	12,380	82,615
Kerosine ....do....	934	4,926	590	3,148
Distillate oil ....do....	[1] 12,698	[1] 46,213	9,760	35,088
Residual oil ....do....	21,319	45,685	18,695	43,412
Lubricating oil ....do....	[1] 13,484	181,931	15,320	207,200
Asphalt ....do....	813	4,623	787	4,501
Liquefied petroleum gases ....do....	2,251	6,791	2,989	9,646
Wax ....do....	1,031	22,202	1,334	26,445
Coke ....do....	4,680	19,608	6,858	27,009
Petrolatum ....do....	260	6,361	258	6,182
Miscellaneous ....do....	563	14,656	500	14,719

[1] Revised figure.
[2] Weight not recorded.
[3] Adjusted by Bureau of Mines.
[4] Less than $1,000.
[5] Includes naphtha, but excludes benzol: 1959—173,935 barrels ($2,340,389), 1960—561,193 barrels ($8,951,625).

Compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 10.—Comparison of world and United States production of principal metals and minerals

Mineral	1959 World	1959 United States		1960 World	1960 United States	
	Thousand short tons	Thousand short tons	Percent of world	Thousand short tons	Thousand short tons	Percent of world
Fuels:						
Coal:						
Bituminous	1,906,658	409,248	21	2,003,135	412,766	21
Lignite	682,946	2,780	(1)	708,330	2,746	(1)
Pennsylvania anthracite	187,100	20,649	11	189,500	18,817	10
Coke (excluding breeze):						
Gashouse [2]	50,670	(3)	(3)	51,300	(3)	(3)
Oven and beehive	289,689	55,864	19	306,720	57,229	19
Fuel briquets and packaged fuel	114,600	900	(1)	118,300	769	(1)
Natural gas (marketable) million cubic feet	(4)	12,046,115	(4)	(4)	(4)	(4)
Peat	76,700	419	(1)	75,700	471	(1)
Petroleum (crude) thousand barrels	7,133,663	2,574,590	36	7,683,752	2,574,933	34
Nonmetals:						
Asbestos	2,260	45	2	2,420	45	2
Barite	3,000	867	29	3,100	771	25
Cement [5] thousand barrels	1,724,403	355,734	21	1,859,415	334,130	18
Corundum	8	---	---	9	---	---
Diamonds thousand carats	26,800	---	---	27,300	---	---
Diatomite	960	450	47	960	450	47
Feldspar [6] thousand long tons	1,180	548	46	1,240	502	41
Fluorspar	1,855	185	10	2,160	230	11
Graphite	410	(3)	(3)	465	(3)	(3)
Gypsum	42,790	10,900	25	41,930	9,825	23
Magnesite	6,600	593	8	7,100	499	7
Mica (including scrap) thousand pounds	345,000	203,788	59	410,000	240,437	59
Nitrogen, agricultural [5 6 7]	9,700	2,698	28	10,031	2,872	29
Phosphate rock thousand long tons	36,960	15,869	43	40,100	17,506	44
Potash (K_2O equivalent)	9,400	2,383	25	10,000	2,639	26
Pumice	10,500	2,276	22	11,000	2,210	20
Pyrites thousand long tons	18,300	1,057	6	18,700	1,016	5
Salt [5]	88,200	25,163	29	94,200	25,479	27
Strontium [6]	11	(3)	(3)	11	---	---
Sulfur, elemental thousand long tons	8,985	5,326	59	10,095	5,804	57
Talc, pyrophyllite, and soapstone	2,260	792	35	2,450	734	30
Vermiculite [6]	260	207	80	269	199	74
Metals, mine basis:						
Antimony, (content of ore and concentrate) short tons	59,000	678	1	61,000	637	1
Arsenic [6]	47	5	11	62	(3)	(3)
Bauxite thousand long tons	22,600	1,700	8	27,060	1,998	7
Beryllium concentrate short tons	8,100	425	5	11,100	509	5
Bismuth thousand pounds	5,100	(3)	(3)	5,200	(3)	(3)
Cadmium do	19,800	8,602	43	21,700	10,180	47
Chromite	4,350	[8] 105	2	4,920	[8] 107	2
Cobalt (contained) [6] short tons	17,300	1,165	7	16,700	(3)	(3)
Columbium-tantalum concentrate [6] thousand pounds	6,050	189	3	6,350	---	---
Copper (content of ore and concentrate)	4,040	825	20	4,590	1,080	24
Gold thousand troy ounces	42,700	1,635	4	45,000	1,680	4
Iron ore thousand long tons	431,709	60,276	14	507,089	88,777	18
Lead (content of ore and concentrate)	2,530	256	10	2,560	247	10
Manganese ore (35 percent or more Mn)	14,226	229	2	14,832	80	(1)
Mercury thousand 76-pound flasks	233	31	13	254	33	13
Molybdenum (content of ore and concentrate) thousand pounds	70,200	50,956	73	89,400	68,237	76
Nickel (content of ore and concentrate)	314	12	4	358	13	4
Platinum groups (Pt, Pd, etc.) thousand troy ounces	1,010	15	1	1,190	24	2
Silver do	221,200	23,000	10	239,500	36,800	15
Tin (content of ore and concentrate) long tons	161,600	50	(1)	179,700	10	(1)
Titanium concentrates:						
Ilmenite [6]	1,937	635	33	2,226	786	35
Rutile [6]	106	9	8	115	9	8
Tungsten concentrate (60 percent WO_3) short tons	58,800	3,649	6	69,600	7,325	11
Vanadium (content of ore and concentrate) [6] short tons	5,324	3,719	70	6,980	4,971	71
Zinc (content of ore and concentrate)	3,360	425	13	3,510	435	12

See footnotes at end of table.

TABLE 10.—Comparison of world and United States production of principal metals and minerals—Continued

Mineral	1959 World	1959 United States		1960 World	1960 United States	
	Thousand short tons	Thousand short tons	Percent of world	Thousand short tons	Thousand short tons	Percent of world
Metals, smelter basis:						
Aluminum	4,500	1,954	43	5,010	2,014	40
Copper	4,190	842	20	4,950	1,234	25
Iron, pig (incl. ferroalloys)	247,000	62,135	25	285,000	68,620	24
Lead	2,410	341	14	2,530	382	15
Magnesium	83	31	37	104	40	38
Selenium [6] thousand pounds	1,719	799	46	1,777	620	35
Steel ingots and castings	336,400	93,446	28	381,200	99,282	26
Tellurium [6] thousand pounds	357	196	55	390	260	67
Tin thousand long tons	156	[9] 11	7	194	[9] 14	7
Uranium oxide (U_3O_8)[6] short tons	43,440	16,420	38	41,140	17,760	43
Zinc	3,090	799	26	3,220	804	25

[1] Less than 1 percent.
[2] Includes low- and medium-temperature and gashouse coke.
[3] Bureau of Mines not at liberty to publish U.S. figure separately.
[4] Data not available.
[5] Including Puerto Rico.
[6] World total exclusive of U.S.S.R.
[7] Year ended June 30 of year stated (United Nations)
[8] Produced for Federal Government only; excludes quantity consumed by American Chrome Company.
[9] U.S. imports of tin concentrates (tin content).

Compiled by Augusta E. Jann, Division of Foreign Activities.

Employment and Injuries in the Metal and Nonmetal Industries

By John C. Machisak [1]

THIS CHAPTER of the Minerals Yearbook presents injury experience and employment information for metal and nonmetal mines, sand and gravel pits, iron blast-furnace slag plants, metallurgical plants (including ore-dressing and nonferrous reduction plants and refineries), and stone quarries in the United States. The 1960 figures are based on reports received by the Bureau of Mines by May 31, 1961. These were made voluntarily in response to an annual canvass requesting injury and employment data for individual operations. The information for 1960 is preliminary and subject to revision. Injury experience and the accompanying employment data for all mineral industries can be found in volume III.

METAL MINES

Preliminary figures on metal mines for 1960 indicate a 5-percent decrease in the frequency of occurrence of fatal and nonfatal injuries per million man-hours of exposure to 31.71 from 33.27 in 1959. A decrease of 8 percent in the average number of men working in 1960 was noted, however, and man-days and man-hours of employment each increased 9 percent. The average employee worked an 8.02-hour shift and accumulated 2,036 hours in 1960, representing a 19-percent increase in the number of hours worked per man over 1959. The mines were active for an average of 254 days, an increase of 40 days when compared with 1959. These preliminary figures represent 1,491 active mines.

Copper.—The combined (fatal and nonfatal) injury-frequency rate for copper mines declined 16 percent in 1960. The total number of injuries was substantially the same as in 1959; the better rate in 1960 was due largely to the greater proportionate increase in the number of man-hours of employment rather than to a decrease in the number of disabling work injuries. The number of men working daily increased 10 percent, and man-hours of employment rose 32 percent. Copper mines were active an average of 278 days in 1960, an increase of 46

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days over the preceding year. The average employee accumulated 2,225 hours while working an 8-hour daily shift. Preliminary figures show a total of 130 mines reporting in 1960.

Gold Placer.—The safety record at gold-placer mining operations was more favorable than in 1959. The combined (fatal and nonfatal) injury-frequency rate of 40.38 represented a 19-percent decrease from 1959. Preliminary figures indicated a decline in both employment and man-hours; however, average active mine days increased 29 percent. The average employee in 1960 had a workyear of 1,689 hours, an increase of 27 percent over the 1959 figure of 1,335 hours. An average 8.2-hour daily shift was maintained throughout the year.

Gold-Silver.—Preliminary figures for 1960 at gold-silver lode mining operations indicate substantial decreases in both fatal and nonfatal injuries—63 and 43 percent, respectively. Fewer employees were reported, indicating a decline of over a million man-hours of employment in 1960. Of the 222 mines reporting, the average employee accumulated 1,983 hours during the year, while working an 8-hour daily shift.

Iron.—Employment in the iron-mining industry for 1960 indicated a 6-percent decline in the number of men working daily. Preliminary data reveal 27-percent increases in both man-days and man-hours of employment. Fatal and nonfatal injuries increased; however, an even greater increase in man-hours resulted in a slightly lower combined injury-frequency rate of 15.29 per million man-hours of employment. An approximate 8-hour shift was indicated, with 1,951 hours of work for the average employee during the year.

Lead-Zinc.—A decline was noted in employment and man-hours of work in the lead-zinc mines in 1960. Fatalities and nonfatal injuries show a combined injury-frequency rate of 74.87 compared with 56.65 in 1959, an increase of 32 percent. The figures indicate an average of 1,796 hours for each worker while working an 8-hour shift per day. Active mines reporting in 1960 increased substantially over 1959.

Miscellaneous Metals.—This group of mines includes those producing bauxite, beryl, chromite, manganese, mercury, molybdenum, titanium, rare-earth minerals, tungsten, uranium-vanadium, and other miscellaneous metals. Sharp increases were indicated in both fatal and nonfatal injuries—69 and 23 percent, respectively. The greatest number of injuries occurred in the uranium-vanadium mines. This industry alone accounted for 77 percent of all injuries that occurred in the miscellaneous metal-mines group. The average worker accumulated 2,131 hours and worked an 8.1-hour shift. Miscellaneous metal mines reporting activity during 1960, totaled 486.

TABLE 1.—Employment and injury experience at metal mines in the United States, by industry groups

Industry and year	Men working daily	Average active mine days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries: Fatal	Number of injuries: Nonfatal	Injury rate per million man-hours
Copper:							
1951-55 (average)	16,031	302	4,834	38,618	25	1,256	33.17
1956	18,147	317	5,756	45,981	28	1,463	32.43
1957	17,664	294	5,188	41,452	19	1,276	31.24
1958	14,972	261	3,912	31,295	20	911	29.75
1959	14,201	232	3,289	26,382	16	714	27.67
1960 [1]	15,648	278	4,351	34,824	16	794	23.26
Gold placer:							
1951-55 (average)	2,205	213	470	3,792	1	151	40.08
1956	1,539	206	317	2,698	----------	138	51.16
1957	1,551	186	288	2,380	2	140	59.67
1958	1,793	172	309	2,549	1	120	47.48
1959	1,648	160	263	2,200	1	109	50.01
1960 [1]	777	206	160	1,312	1	52	40.38
Gold-silver:							
1951-55 (average)	3,405	256	873	6,914	10	697	102.25
1956	2,631	259	682	5,454	4	473	87.46
1957	3,411	267	910	7,276	6	327	45.77
1958	3,687	248	914	7,306	2	304	41.88
1959	3,592	246	885	7,076	8	339	49.04
1960 [1]	3,047	248	755	6,044	3	194	32.60
Iron:							
1951-55 (average)	29,207	253	7,380	59,239	22	990	17.08
1956	26,817	234	6,281	50,376	19	723	14.73
1957	25,669	252	6,480	51,958	13	617	12.13
1958	21,382	206	4,411	35,374	14	432	12.61
1959	22,099	179	3,966	31,823	14	482	15.59
1960 [1]	20,752	243	5,049	40,494	16	603	15.29
Lead-zinc:							
1951-55 (average)	13,436	261	3,513	28,097	25	2,095	75.45
1956	11,041	269	2,967	23,745	23	1,548	66.16
1957	11,777	246	2,897	23,168	14	1,320	57.58
1958	8,298	244	2,023	16,160	19	834	52.79
1959	7,665	253	1,939	15,515	10	869	56.65
1960 [1]	6,082	225	1,367	10,926	10	808	74.87
Miscellaneous: [2]							
1951-55 (average)	5,819	251	1,460	11,761	11	913	78.56
1956	8,098	249	2,014	16,153	15	1,130	70.88
1957	8,385	237	1,988	15,946	17	874	55.88
1958	9,476	221	2,094	16,840	14	898	54.16
1959	9,352	231	2,161	17,580	16	768	44.60
1960 [1]	7,350	264	1,941	15,661	27	941	61.81
Total: [3]							
1951-55 (average)	70,102	264	18,530	148,422	95	6,102	41.75
1956	68,273	264	18,017	144,407	89	5,475	38.53
1957	68,457	259	17,751	142,181	71	4,554	32.53
1958	59,608	229	13,665	109,523	70	3,499	32.59
1959	58,557	214	12,503	100,576	65	3,281	33.27
1960 [1]	53,656	254	13,623	109,260	73	3,392	31.71

[1] Preliminary figures.
[2] Includes antimony, bauxite, beryl, chromite, cobalt, columbite-tantalite, magnesium, manganese, mercury, molybdenum, nickel, pyrite (excludes 1957, 1959, and 1960), rare-earth, titanium, tungsten, uranium-vanadium, zircon and other miscellaneous metals.
[3] Metals do not always add to totals due to rounding of figures.

NONMETAL MINES (EXCEPT STONE QUARRIES)

Nonmetal mines include those producing abrasives, asbestos, barite, boron minerals, clay, feldspar, mica, fluorspar, gypsum, magnesite, phosphate rock, potash, pumice, salt, sodium, sulfur, talc, soapstone, and other miscellaneous nonmetals. Due to changes in commodity classification, asphalt is included with the fuels industry and quartz with the miscellaneous stone group in the stone-quarrying industry in 1960.

In 1960, 4,253 less men were employed than in 1959, a decline of 23 percent. Man-hours worked decreased 17 percent, an increase (17) in the active days failing to overcome the sharp decline in the number of men employed. There were 19 fatalities reported, compared with 12 for the preceding year, an increase of 58 percent. However, there were 183 fewer nonfatal injuries, a decrease of 17 percent. The overall rates for the 2 years were approximately the same—30.01 in 1960 and 29.60 in 1959. The mines were active 256 days during the year, and each man accumulated 2,084 hours of work. The average length of shift was 8.15 hours.

Nonmetal Mills.—The number of men employed in nonmetal mills decreased 27 percent from 1959; the number of man-hours worked decreased 30 percent. The combined (fatal and nonfatal) injury-frequency rate decreased to 19.72 in 1960 from 23.89 in 1959. The mills were active 264 days and the average employee accumulated 2,142 hours while working an 8.11-hour shift.

Clay Mines and Mills.—Principal industrial clays are kaolin (china clay) bentonite, fuller's earth, ball clay, and fire clay. Table 4 shows annual comparisons of injury and employment data for clay mines and their accompanying mills. Employment decreased at both mines and mills compared with 1959. The mines were active 201 days, and the average man accumulated 1,622 hours while working an 8.05-hour shift. The overall (fatal and nonfatal) injury-frequency rate remained almost the same for both years (29.23 in 1959 and 29.67 in 1960). Clay mills operated 248 days, and the men averaged 2,031 hours of work during the year, while working an 8.21-hour shift. The overall injury-frequency rate in 1960 was 27.12 compared with 30.94 in 1959, a decrease of 12 percent.

TABLE 2.—Employment and injury experience at nonmetal mines (except stone quarries) in the United States [1]

Year	Men working daily	Average active mine days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rate per million man-hours
					Fatal	Nonfatal	
1951–55 (average)	13,005	285	3,704	30,046	16	1,211	40.84
1956	15,595	268	4,178	33,963	17	1,036	31.00
1957	17,921	262	4,691	37,877	9	1,112	29.60
1958	17,820	239	4,258	34,648	15	955	28.00
1959	18,773	239	4,492	36,625	12	1,072	29.60
1960 [2]	14,520	256	3,715	30,259	19	889	30.01

[1] Includes abrasives, asbestos, asphalt, barite, boron minerals, clay, feldspar-mica-quartz, fluorspar, gypsum, magnesite, phosphate rock, potash, pumice, salt, sodium, sulfur, talc and soapstone, and other miscellaneous nonmetals. Asphalt and quartz data not included in 1960, see text relating to nonmetal mines.

[2] Preliminary figures.

TABLE 3.—Employment and injury experience at nonmetal mills (except stone quarries) in the United States

Year	Men working daily	Average active mill days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rate per million man-hours
					Fatal	Nonfatal	
1956 [1]	17,585	288	5,056	40,675	7	1,157	28.62
1957	27,081	274	7,415	59,765	10	1,512	25.47
1958	32,401	272	8,809	71,161	9	1,490	21.06
1959	40,800	274	11,195	90,706	11	2,156	23.89
1960 [2]	29,810	264	7,874	63,854	13	1,246	19.72

[1] Clay included, beginning with 1956.
[2] Preliminary figures.

TABLE 4.—Employment and injury experience at clay mines and mills in the United States

Year	Men working daily	Average active days worked	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rate per million man-hours
					Fatal	Nonfatal	
Mine:							
1956	4,419	202	891	7,266	8	251	35.64
1957	5,024	208	1,046	8,355	3	320	38.66
1958	5,890	193	1,134	9,277	6	322	35.36
1959	5,922	192	1,137	9,475	6	271	29.23
1960 [1]	4,178	201	841	6,775	5	196	29.67
Mill:							
1956	7,759	280	2,176	17,552	2	709	40.51
1957	15,516	258	3,996	32,079	5	949	29.74
1958	16,530	255	4,221	34,096	5	896	26.43
1959	20,142	252	5,084	41,170	7	1,267	30.94
1960 [1]	15,211	248	3,766	30,900	6	832	27.12

[1] Preliminary figures.

SAND AND GRAVEL PLANTS

Preliminary figures for 1960 represented about 45 percent of the number of men employed in 1959 in commercial and noncommercial sand and gravel plants, and indicated an increase in the frequency of injuries in 1960 over the rate established in 1959. The combined (fatal and nonfatal) injury-frequency rate of 20.83 per million man-hours of worktime was 5 percent higher than the comparable rate for 1959. Each employee averaged 1,837 hours of work in 1960, slightly less than in the preceding year.

TABLE 5.—Employment and injury experience at sand and gravel plants in the United States

Year	Men working daily	Average active plant days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rate per million man-hours
					Fatal	Nonfatal	
1957 [1]	31,531	221	6,954	59,764	35	1,763	30.09
1958	51,122	211	10,763	92,456	25	1,698	18.64
1959	59,492	(2)	(2)	109,830	21	2,161	19.87
1960 [3]	26,832	(2)	(2)	49,300	23	1,004	20.83

[1] Employment data from Branch of Construction and Chemical Materials, Division of Minerals.
[2] Not available.
[3] Preliminary figures.

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SLAG (IRON BLAST-FURNACE) PLANTS

Reports from the 73 slag plants received in response to the Bureau's canvass for 1960, indicated a decline from the employment reported for the preceding year. The number of men working decreased 6 percent, and the number of man-hours worked decreased 2 percent. No fatal injuries were reported, and the number of nonfatal injuries declined. The preliminary frequency rate of 9.41 indicated an improvement in injury experience for the slag industry in 1960. Each employee accumulated an average of 2,150 hours of work during the year.

TABLE 6.—Employment and injury experience at slag plants (iron blast-furnace) in the United States

Year	Number of plants	Men working daily	Average active days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rate per million man-hours
						Fatal	Nonfatal	
1958	70	1,882	248	467	3.776	1	43	11.65
1959	71	1,789	254	455	3,681	1	43	11.95
1960 [1]	73	1,680	(2)	(2)	3,613		34	9.41

[1] Preliminary figures.
[2] Not available.

METALLURGICAL PLANTS

Reports from metallurgical plants (ore-dressing and primary nonferrous reduction and refinery plants) indicated an increase in the frequency of injuries. Workers in 1960 averaged 2,404 hours of employment, whereas the average per man in 1959 was 2,316 hours. Employees worked an 8-hour daily shift in both years.

TABLE 7.—Employment and injury experience at metallurgical plants in the United States

Year	Men working daily	Average active plant days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rate per million man-hours
					Fatal	Nonfatal	
1951-55 (average)	52,895	315	16,668	133,076	14	2,732	20.63
1956	65,681	327	21,470	171,578	20	2,543	14.94
1957	65,212	322	21,003	167,489	21	2,280	13.74
1958	52,109	302	15,733	125,773	12	1,698	13.60
1959	55,655	289	16,095	128,913	11	1,305	10.21
1960 [1]	44,130	300	13,257	106,067	11	1,251	11.90

[1] Preliminary figures.

ORE-DRESSING PLANTS

Ore-dressing plants include those performing the crushing, screening, washing, jigging, magnetic separation, flotation, and other milling operations of metallic ores. Indicated employment at metal-ore-dressing plants decreased 14 percent from the 1959 figure. A combined (fatal and nonfatal) injury-frequency rate of 11.18 per million man-hours of exposure indicated a 21-percent increase over 1959. Gold-silver, iron, and lead-zinc plants were fatality-free. Man-days and man-hours of employment showed little change, due to an increase in the number of days the mills were active. The average employee worked an 8-hour daily shift. Reports were received from 300 active operators.

TABLE 8.—Employment and injury experience at ore-dressing plants in the United States, by industry groups

Industry and year	Men working daily	Average active mill days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rate per million man-hours
					Fatal	Nonfatal	
Copper:							
1951-55 (average)	6,347	326	2,068	16,596	1	245	14.82
1956	6,683	344	2,301	18,400	3	184	10.16
1957	7,083	319	2,261	18,095	4	279	15.64
1958	6,468	283	1,828	14,618	1	140	9.65
1959	5,588	250	1,394	11,156		82	7.35
1960 [1]	5,230	314	1,641	13,129	3	111	8.68
Gold-silver:							
1951-55 (average)	534	293	157	1,242	1	42	34.64
1956	367	295	108	866		24	27.72
1957	468	267	125	1,001		20	19.99
1958	399	255	102	814		25	30.71
1959	410	270	111	888		18	20.26
1960 [1]	226	297	67	538		2	3.72
Iron:							
1951-55 (average)	4,063	240	975	7,861	1	76	9.80
1956	5,114	241	1,231	9,937	1	92	9.36
1957	5,218	262	1,367	11,004	1	67	6.18
1958	5,857	246	1,441	11,536	2	60	5.37
1959	6,324	196	1,240	10,035	1	56	5.68
1960 [1]	6,261	260	1,626	13,094		78	5.96
Lead-zinc:							
1951-55 (average)	3,698	254	940	7,538	1	189	25.21
1956	2,977	274	817	6,532	1	86	13.32
1957	3,280	252	826	6,609		104	15.74
1958	2,380	260	618	4,945		50	10.11
1959	1,659	259	430	3,435	1	51	15.14
1960 [1]	1,393	258	359	2,880		61	21.18
Miscellaneous metals: [2]							
1951-55 (average)	3,432	314	1,078	8,628	1	264	30.72
1956	4,120	294	1,211	9,704	4	293	30.60
1957	5,517	296	1,635	13,087	4	273	21.17
1958	4,573	270	1,236	9,886		192	19.42
1959	5,442	300	1,632	13,107	3	146	11.37
1960 [1]	3,524	312	1,101	8,824	2	173	19.83
Total: [3]							
1951-55 (average)	18,075	289	5,217	41,864	5	816	19.61
1956	19,261	294	5,668	45,440	9	679	15.14
1957	21,566	288	6,214	49,795	9	743	15.10
1958	19,677	266	5,225	41,799	3	467	11.24
1959	19,423	248	4,808	38,621	5	353	9.27
1960 [1]	16,634	288	4,794	38,466	5	425	11.18

[1] Preliminary figures.
[2] Includes antimony, bauxite, chromite, columbite-tantalite, manganese, mercury, molybdenum, titanium, tungsten, uranium-vanadium, and other miscellaneous metals.
[3] Metals do not always add to totals due to rounding of figures

NONFERROUS REDUCTION PLANTS AND REFINERIES

The reduction plants and refineries that comprise this section of the mineral industries are engaged in the primary extraction of nonferrous metals from ores and concentrates, and the refining of crude primary nonferrous metals. Employment and man-hours worked declined 24 and 25 percent, respectively, in 1960. No change was indicated in the number of fatalities reported; however, a decrease of 13 percent in nonfatal injuries was noted. Hours worked per employee in 1960 totaled 2,459 on the basis of an 8-hour shift per day. There were 72 active operations.

TABLE 9.—Employment and injury experience at primary nonferrous reduction and refinery plants in the United States, by industry groups

Industry and year	Men working daily	Average active smelter days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rate per million man-hours
					Fatal	Nonfatal	
Copper:							
1951-55 (average)	11,334	317	3,598	28,925	4	386	13.48
1956	12,194	323	3,937	31,497	2	469	14.95
1957	11,826	323	3,821	30,583	5	375	12.43
1958	10,801	312	3,370	26,966	4	426	15.95
1959	11,204	262	2,939	23,516	4	230	9.95
1960 [1]	12,009	308	3,693	29,445	3	370	12.67
Lead:							
1951-55 (average)	3,619	302	1,093	8,741	1	105	12.13
1956	3,758	314	1,181	9,449	6	138	15.24
1957	3,439	314	1,079	8,629	1	137	15.99
1958	2,999	297	890	7,120	2	118	16.85
1959	3,090	226	698	5,585	1	129	23.28
1960 [1]	2,732	265	724	5,793	1	101	17.61
Zinc:							
1951-55 (average)	9,298	348	3,231	25,707	2	768	29.95
1956	9,619	326	3,134	24,983	1	666	26.70
1957	9,263	326	3,023	24,083	4	632	26.41
1958	7,323	322	2,361	18,891	2	379	20.17
1959	7,243	327	2,370	18,951		361	19.05
1960 [1]	6,942	298	2,072	16,573	2	267	16.23
Miscellaneous metals: [2]							
1951-55 (average)	10,569	340	3,529	27,840	2	657	23.67
1956	20,849	362	7,550	60,209	2	591	9.85
1957	19,118	359	6,866	54,398	2	393	7.26
1958	11,309	344	3,886	30,998	1	308	9.97
1959	14,695	359	5,280	42,239	1	232	5.52
1960 [1]	5,813	340	1,974	15,790		88	5.57
Total: [3]							
1951-55 (average)	34,820	335	11,451	91,212	9	1,916	21.10
1956	46,420	340	15,802	126,138	11	1,864	14.86
1957	43,646	339	14,789	117,694	12	1,537	13.16
1958	32,432	324	10,508	83,974	9	1,231	14.77
1959	36,232	312	11,287	90,291	6	952	10.61
1960 [1]	27,496	308	8,463	67,601	6	826	12.31

[1] Preliminary figures.
[2] Includes aluminum, antimony, bauxite, chromite, cobalt, magnesium, tin, titanium and other miscellaneous metals.
[3] Metals do not always add to totals due to rounding of figures.

STONE QUARRIES

Injury and employment data for the quarrying industries indicated a decline of 9 percent in the combined injury-frequency rate from that of 1959, on the basis of reports from approximately 75 percent (based on men employed) of the quarry industry that reported in 1959. The number of men working daily and man-hours of employment decreased 24 and 26 percent, respectively. The average employee worked 2,135 hours compared with 2,178 in 1959, a 2-percent decrease. Man-days were not requested in the 1960 quarry canvass but may be calculated by dividing the man-hours of employment by the standard 8-hour workday.

Cement.—Reports from the cement industry, including both quarries and mills, indicated a less favorable injury experience than in the preceding year. Fatal and nonfatal injuries declined 29 and 15 percent, respectively. The combined injury rate rose from 4.86 in 1959 to 5.03 in 1960. The average employee accumulated 2,418 hours of worktime during the year, compared with 2,522 the preceding year, a 4-percent decrease.

Granite.—Injury experience at granite quarries and their related plants improved in 1960. Fatal and nonfatal injuries decreased 33 and 47 percent, respectively, causing a decline of 21 percent in the combined (fatal and nonfatal) frequency rate per million-hours of worktime. Fewer men at work were indicated, and each man worked an average of 1,930 hours, 9 percent less than the 2,115 hours reported in 1959.

Lime.—The safety record for quarries that produced limestone, chiefly for the manufacture of lime, improved slightly. One more fatality was reported than in 1959, however, nonfatal injuries decreased to 276 from 354, resulting in a drop of 22 percent. Each man worked an average of 2,409 hours, compared with 2,396 in 1959, a 1-percent increase.

Limestone.—The safety record at limestone quarries and related plants improved. The number of fatal and nonfatal injuries decreased 54 and 31 percent, respectively, resulting in a 2-percent decline in the combined (fatal and nonfatal) injury-frequency rate per million man-hours of employment. Each man averaged 1,968 hours of worktime in 1960, compared with 1,978 in 1959.

Marble.—Injury experience and employment data in the marble industry was less favorable than in 1959. Two fatalities occurred, and although nonfatal injuries dropped to 238 from 269, a decline of 12 percent, the overall (fatal and nonfatal) injury-frequency rate rose from 41.82 in 1959 to 47.42 in 1960, a 13-percent increase. Each employee worked an average of 2,075 hours compared with 2,094 in the preceding year, a decline of 1 percent.

Sandstone.—A less favorable trend was indicated in both injury experience and employment in the sandstone industry. One more fatality was reported in 1960 than in 1959. Nonfatal injuries decreased from 286 to 238 (17 percent), however, due to a sharp decline in man-hours of employment, the overall injury-frequency rate rose 23 percent to 53.01 from 43.04 in 1959. The average worker accumulated 1,573 hours of worktime, 194 fewer hours than the number worked during 1959.

Slate.—The overall record for safety at the slate quarries and plants improved. No fatal injuries were reported, and nonfatal injuries declined 37 percent from 152 in 1959, to 96 in 1960. The combined frequency rate (fatal and nonfatal) dropped to 50.21 from 53.84, a decrease of 7 percent. Each employee's worktime averaged 1,957 hours during 1960.

Traprock.—The overall injury experience and employment data of the traprock industry improved over that of 1959. Fatal injuries increased 33 percent, however, nonfatal injuries decreased 47 percent, resulting in a decline of 5 percent in the combined injury-frequency rate per million man-hours of employment. The average employee worked 1,730 hours in 1960, compared with 1,819 in 1959, a 5-percent decrease.

Miscellaneous Stone.—This category includes all stones not otherwise classified and was shown separately for the first time in 1957. Preliminary figures indicate improvement in injury experience. Fatal and nonfatal injuries declined 33 and 55 percent, respectively. The overall (fatal and nonfatal) frequency rate per million man-hours of exposure dropped from 49.78 in 1959 to 43.18 in 1960, a decrease of 13 percent. Each man averaged 1,610 hours of work, compared with 1,783 hours in 1959, a 10-percent decline.

TABLE 10.—Employment and injury experience at stone quarries in the United States, by industry groups

Industry and year	Men working daily	Average active mine days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rate per million man-hours
					Fatal	Nonfatal	
Cement: [1]							
1951–55 (average)	28,653	325	9,323	74,222	12	392	5.44
1956	27,923	329	9,183	73,554	12	318	4.49
1957	29,167	317	9,254	73,940	14	277	3.94
1958	29,908	296	8,864	70,910	9	297	4.32
1959	28,253	(2)	(2)	71,261	7	339	4.86
1960 [3]	24,184	(2)	(2)	58,477	5	289	5.03
Granite:							
1951–55 (average)	6,606	245	1,620	13,441	6	534	40.18
1956	6,052	233	1,409	11,658	8	472	41.17
1957	7,017	238	1,668	13,890	8	592	43.20
1958	7,522	242	1,824	14,590	4	708	48.80
1959	8,512	(2)	(2)	18,003	3	717	39.99
1960 [3]	6,251	(2)	(2)	12,065	2	379	31.58
Lime: [1]							
1951–55 (average)	8,776	294	2,579	20,762	7	524	25.58
1956	9,040	290	2,621	21,079	6	423	20.35
1957	8,220	284	2,332	18,683	1	447	23.98
1958	6,948	292	2,027	16,216	1	354	21.89
1959	7,800	(2)	(2)	18,686	7	354	19.32
1960 [3]	6,115	(2)	(2)	14,732	8	276	19.28
Limestone:							
1951–55 (average)	26,585	238	6,328	53,154	21	1,878	35.73
1956	26,398	231	6,088	51,164	17	1,660	32.78
1957	28,692	230	6,603	55,637	21	1,960	35.61
1958	29,649	245	7,266	58,128	23	2,026	35.25
1959	31,939	(2)	(2)	63,184	26	2,060	33.01
1960 [3]	22,698	(2)	(2)	44,672	12	1,427	32.21
Marble:							
1951–55 (average)	2,436	252	614	5,097	1	183	36.10
1956	2,523	253	639	5,304	2	191	36.39
1957	3,160	258	814	6,750	1	188	28.00
1958	3,126	246	771	6,164	1	219	35.69
1959	3,071	(2)	(2)	6,432	---	269	41.82
1960 [3]	2,439	(2)	(2)	5,061	2	238	47.42
Sandstone:							
1951–55 (average)	3,827	240	918	7,507	2	351	47.02
1956	3,522	234	824	6,754	1	327	48.56
1957	2,980	206	613	4,989	1	259	52.12
1958	3,504	215	752	6,017	1	281	46.87
1959	3,788	(2)	(2)	6,692	2	286	43.04
1960 [3]	2,530	(2)	(2)	3,980	3	208	53.01
Slate:							
1951–55 (average)	1,699	265	450	3,754	---	198	52.74
1956	1,395	250	349	2,936	---	126	42.92
1957	1,357	254	345	2,871	1	169	59.21
1958	1,429	255	364	2,915	---	128	43.91
1959	1,403	(2)	(2)	2,842	1	152	53.84
1960 [3]	977	(2)	(2)	1,912	---	96	50.21
Traprock:							
1951–55 (average)	2,910	232	676	5,868	3	249	42.94
1956	3,240	205	664	5,833	4	237	41.31
1957	2,883	215	620	5,332	6	277	53.08
1958	4,130	230	950	7,597	6	331	44.36
1959	4,808	(2)	(2)	8,746	3	443	51.00
1960 [3]	2,840	(2)	(2)	4,913	4	234	48.44
Miscellaneous stone: [4]							
1957	650	248	161	1,302	---	41	31.49
1958	2,232	240	535	4,284	---	228	53.22
1959	1,949	(2)	(2)	3,476	3	170	49.78
1960 [3]	1,122	(2)	(2)	1,806	2	76	43.18
Total: [5]							
1951–55 (average)	81,494	276	22,508	183,807	52	4,309	23.73
1956	80,093	272	21,776	178,281	50	3,754	21.34
1957	84,126	266	22,410	183,394	53	4,210	23.25
1958	88,448	264	23,353	186,821	45	4,572	24.71
1959	91,523	(2)	(2)	199,321	52	4,790	24.29
1960 [3]	69,156	(2)	(2)	147,620	38	3,223	22.09

[1] Includes burning or calcining and other mill operations.
[2] Not available.
[3] Preliminary figures.
[4] Not compiled before 1957.
[5] Stones do not always add to totals due to rounding of figures.

Abrasive Materials

By Henry P. Chandler [1] and Gertrude E. Tucker [2]

Contents

COMBINED tonnage of natural abrasives sold or used in the United States during 1960 was approximately the same as in 1959, but the combined value decreased 15 percent. Artificial abrasives produced in the United States and Canada gained 6 percent in tonnage and 3 percent in value. Abrasive imports and reexports declined, but abrasive exports showed a gain. Values of the grinding

TABLE 1.—Salient abrasive statistics in the United States

Kind	1951-55 (average)	1956	1957	1958	1959	1960
Natural abrasives (domestic) sold or used by producers:						
Tripoli ---short tons--	[1] 49, 662	45, 009	50, 717	47, 044	52, 968	57, 713
Value ---thousands--	[1] $213	$203	$195	$183	$219	$247
Special silica-stone products [2] short tons--	7, 190	6, 180	5, 847	4, 023	3, 672	2, 539
Value ---thousands--	$366	$411	$331	$305	$315	$240
Garnet ---short tons--	12, 396	9, 812	9, 776	12, 303	14, 568	10, 522
Value ---thousands--	$1, 076	$1, 073	$1, 080	$869	$1, 211	$986
Emery ---short tons--	10, 608	12, 153	11, 893	7, 687	8, 555	8, 169
Value ---thousands--	$146	$174	$184	$126	$150	$142
Artificial abrasives [3] ---short tons--	442, 092	431, 461	484, 702	334, 483	[4] 417, 569	441, 508
Value ---thousands--	$48, 827	$55, 692	$65, 634	$48, 806	[4] $62, 928	$64, 594
Foreign trade (natural and artificial abrasives):						
Imports for consumption (value) thousands--	$74, 128	$99, 968	$85, 097	$60, 733	[4] $91, 560	$84, 427
Exports (value) ---do----	$21, 704	$26, 845	$27, 589	$22, 469	[4] $23. 100	$26, 550
Reexports (value) ---do----	[5] $6, 354	$7, 755	$8, 702	$12, 964	$13, 700	$10, 409

[1] Data for 1955 only.
[2] See table 6 for kind of products.
[3] Production of silicon carbide and aluminum oxide (United States and Canada); shipments of metallic abrasives (United States).
[4] Revised figure.
[5] Average for 1954-55.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

wheels and coated abrasives sold in 1960 were 8 percent and 1 percent, respectively, below the previous year.

FOREIGN TRADE [3]

Imports of abrasive materials declined 8 percent in value compared with 1959, mainly because of a 20-percent decline in the value of industrial diamond imports. Imports of corundum were down 20 percent in tonnage and 39 percent in value. No importations of emery or garnet were reported. The value of imported coated abrasives increased 43 percent over 1959, and artificial abrasive imports rose 13 percent in tonnage and 15 percent in value during the same period. Changes in the imports of other materials were not significant.

Exports increased 15 percent in value over 1959; abrasive papers and cloths, aluminum oxide, and grinding wheels were the more important items in this increase.

Reexports were down 24 percent and, as in previous years, were largely industrial diamond. Canada, Belgium, and the United Kingdom took 81 percent of the total. The remainder was divided among 11 countries.

TRIPOLI [4]

Tripoli is the general name for a number of fine-grained, friable, minutely porous forms of decomposed siliceous rock. The term "tripoli" is applied to the material from the Missouri-Oklahoma field, while that from southern Illinois is often called amorphous silica. Materials from these producing areas and rottenstone from Pennsylvania are grouped together under the name tripoli for statistical purposes because of the similarity of their use. Domestic production of crude tripoli increased 9 percent in tonnage and 13 percent in value over 1959. Of the domestic sales of processed tripoli, 71 percent was for abrasive purposes. Imports were negligible.

Companies mining and processing tripoli, amorphous silica, or rottenstone were: Ozark Minerals Co., Elco, Ill. (amorphous silica); Tamms Industries Co., Tamms, Ill. (amorphous silica); American Tripoli Division, The Carborundum Co., Seneca, Mo., and Ottawa County, Okla. (tripoli); Penn Paint & Filler Co., Antes Fort, Pa. (rottenstone); and Keystone Filler & Manufacturing Co., Muncy, Pa. (rottenstone).

Price quotations on tripoli in E&MJ Metal and Mineral Markets were as follows (per pound, paper bags, minimum carlot 30 tons, f.o.b. Missouri): Once-ground through 40-mesh, rose- and cream-colored, 2.5 to 2.75 cents; double-ground through 110-mesh, rose and cream, 2.6 to 2.7 cents; and air-floated through 200-mesh, 2.75 to 3 cents.

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[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

[4] Tripoli is the only natural silica abrasive included in the abrasive materials canvass. Information on sands used for abrasive purposes, formerly given in the Abrasive Materials chapter, can be found in the Sand and Gravel chapter. Information on abrasive quartz, quartzite, and sandstone can be found in the Stone chapter.

TABLE 2.—U.S. imports for consumption of abrasive materials (natural and artificial), by kinds

Kind	1959 Quantity	1959 Value	1960 Quantity	1960 Value
Burrstones: Bound up into millstones......short tons..	----------	----------	1	$292
Hones, oilstones, and whetstones............number..	102,754	$51,385	124,850	61,668
Corundum (including emery):				
Corundum ore........................short tons..	3,335	125,954	2,654	77,243
Emery ore...................................do....	1,120	13,500	----------	----------
Grains, ground, pulverized, or refined........do....	[1] 9	[1] 1,305	4	411
Paper and cloth coated with sand, emery, or corundum....................................	(2)	1,021,513	(2)	1,458,130
Wheels, files, and other manufactures of emery short tons..	70	83,338	176	230,367
Wheels of corundum or silicon carbide.......do....	120	161,146		
Garnet in grains, or ground, pulverized..........do....	2	495	----------	----------
Tripoli, rottenstone, diatomaceous earth, and burrstones, in blocks, unmanufactured [3]......short tons..	150	6,187	38	1,604
Diamonds:				
Bort, manufactured......................carats..	2,504	173,671	(4)	(4)
Diamond dies, pierced or partially pierced, mounted or unmounted........................number..	(5)	(5)	[6] 355,034	[6] 290,040
Crushing bort (including all types of bort suitable for crushing).............................carats..	5,153,730	14,379,554	6,573,637	17,225,963
Other industrial diamonds (including glaziers' and engravers' diamonds unset and miners')..carats..	[1] 7,451,232	[1] 46,581,966	5,407,983	31,428,438
Carbonado and ballas......................do....	820	12,973	749	21,039
Dust and powder..........................do....	489,436	1,651,134	1,118,741	3,051,718
Flint, flints, and flintstones, unground.....short tons..	13,932	326,275	14,579	321,257
Grit, shot, and sand, of iron and steel...........do....	1,887	569,557	1,304	537,747
Artificial abrasives:				
Crude, not separately provided for:				
Carbides of silicon (carborundum, crystalon, carbolon, and electrolon).........short tons..	83,926	12,009,600	88,546	12,603,242
Aluminous abrasives, alundum, aloxite, exolon, and lionite......................short tons..	137,345	13,253,642	160,495	16,341,428
Other......................................do....	4,249	409,473	1,113	136,542
Manufactures:				
Grains, ground, pulverized, refined, or manufactured.......................short tons..	[1] 2,436	[1] 571,152	1,998	527,464
Wheels, files, and other manufactures, not separately provided for..........short tons..	102	156,057	181	112,873
Total..	----------	[1] 91,559,877	----------	[6] 84,427,466

[1] Revised figure.
[2] Quantity not recorded.
[3] Classified in 1959 as unmanufactured burrstones, 133 short tons, $1,519, and tripoli, rottenstone, and diatomaceous earth, 17 short tons, $4,668.
[4] Effective Jan. 1, 1960, manufactured diamond bort not separately classified.
[5] Not separately classified, included with manufactured bort.
[6] Owing to changes in classifications data not strictly comparable to earlier years.

Source: Bureau of the Census.

TABLE 3.—U.S. exports of abrasive materials, by kinds

Kind	1959		1960	
	Quantity	Value	Quantity	Value
Natural abrasives:				
Diamond grinding wheels, sticks, hones, and laps carats	249,950	$1,518,210	264,942	$1,566,547
Diamond dust and powder do	172,787	439,940	321,373	844,640
Diamond suitable only for industrial use do	178,595	843,848	306,331	1,297,096
Grindstones and pulpstones short tons	401	51,849	319	56,254
Emery powder, grains, and grits (natural) pounds	2,724,781	198,844	2,245,599	203,905
Corundum grains and grits (natural) do	182,534	40,250	109,078	33,202
Whetstones, sticks, etc. (natural) do	339,815	141,649	371,609	160,187
Natural abrasives not elsewhere classified do	21,051,629	1,130,505	20,709,234	1,098,352
Manufactured abrasives:				
Aluminum oxide, fused, crude, and grains do	[1]18,267,466	[1]2,976,357	21,934,978	3,411,213
Silicon carbide, fused, crude, and grains do	16,456,790	3,147,419	16,387,510	3,101,161
Alumina, unfused do	132,972	37,149	217,902	78,786
Manufactured abrasives, not elsewhere classified pounds	208,565	56,885	221,709	72,909
Abrasive pastes, compounds, and cake (except chemical) pounds	814,426	214,698	658,151	198,468
Grinding wheels, except diamond wheels do	3,003,754	3,694,510	3,441,572	4,040,291
Pulpstones of manufactured abrasives do	2,718,054	744,129	3,627,385	957,776
Whetstones, etc., of manufactured abrasives do	296,853	804,001	371,765	970,821
Abrasive paper and cloth (natural abrasives) reams	34,967	692,227	34,362	752,852
Abrasive paper and cloth (artificial abrasives) do	135,733	5,122,203	175,434	6,450,662
Metallic abrasives (except steel wool) pounds	12,989,766	1,245,770	13,072,035	1,255,224
Total	------------	[1]23,100,443	------------	26,550,346

[1] Revised figure.

Source: Bureau of the Census.

TABLE 4.—U.S. reexports of abrasive materials, by kinds

Kind	1959		1960	
	Quantity	Value	Quantity	Value
Natural abrasives:				
Diamond grinding wheels, sticks, hones, and laps carats	264	$1,360	655	$7,820
Diamond dust and powder do	252,035	715,595	312,557	866,546
Diamond suitable only for industrial use do	1,890,292	12,942,306	1,619,553	9,486,827
Emery powder, grains, and grits (natural) pounds	------------	------------	13,600	1,632
Whetstones, sticks, etc. (natural) do	------------	------------	1,584	1,292
Manufactured abrasives:				
Aluminum oxide, fused, crude, and grains do	------------	------------	25,460	2,148
Alumina, unfused do	12,860	948	------------	------------
Grinding wheels, except diamond wheels do	5,826	3,830	14,043	10,870
Abrasive paper and cloth (natural abrasives) reams	580	780	------------	------------
Abrasive paper and cloth (artificial abrasives) reams	1,090	27,804	76	3,262
Whetstones, etc., of manufactured abrasives pounds	------------	------------	7,116	4,664
Manufactured abrasives, not elsewhere classified pounds	10,814	7,079	49,412	23,761
Total	------------	13,699,702	------------	10,408,822

Source: Bureau of the Census.

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

Year	Abrasives		Filler		Other, including foundry facings		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1951-55 (average)	28,384	$1,010	[3] 7,581	[3] $173	[4] 3,577	[4] $127	39,542	$1,310
1956	32,189	1,328	7,274	173	3,875	116	43,338	1,617
1957	31,326	1,300	7,429	171	5,533	194	44,288	1,665
1958	29,994	1,257	7,385	178	4,778	159	42,157	1,594
1959	34,389	1,527	8,199	192	5,061	169	47,649	1,888
1960	37,050	1,589	9,590	206	5,258	167	51,898	1,962

[1] Includes amorphous silica and Pennsylvania rottenstone.
[2] Partly estimated.
[3] Includes some tripoli used for abrasive purposes in 1955.
[4] Includes some tripoli for filter block in 1955.

SPECIAL SILICA-STONE PRODUCTS

Grindstone sales were reported from Ohio; grinding pebbles from Arkansas, Minnesota, Washington, and Wisconsin; tube-mill liners from Minnesota and Wisconsin; natural material for oilstones and other sharpening stones from Arkansas and Indiana; and millstones from North Carolina.

TABLE 6.—Special silica-stone products sold or used by producers in the United States

Year	Grindstones		Grinding pebbles		Other products[1]		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1951-55 (average)	3,405	$218	2,839	$86	946	$62	7,190	$366
1956	[2] 2,789	[2] 262	2,330	71	1,061	78	6,180	411
1957	1,505	132	2,902	86	1,440	113	5,847	331
1958	852	83	1,985	97	1,186	125	4,023	305
1959	1,081	101	1,695	82	896	132	3,672	315
1960	(3)	(3)	1,132	65	1,407	175	2,539	240

[1] Includes grindstones (1960), pulpstones (1951-52), oilstones and other sharpening stones (1958-60), value of millstones (1951-53 and 1956-60), and tube-mill liners (1951-54 and 1956-60).
[2] Includes oilstones and other sharpening stones.
[3] Included with "Other products" to avoid disclosing individual company confidential data.

NATURAL SILICATE ABRASIVES

Garnet.—Sales of domestic garnet during 1960 were down 28 percent in tonnage and 19 percent in value from 1959. Domestic producers of garnet were Idaho Garnet Abrasive Co., Fernwood, Idaho; Porter Brothers Corp., Valley County, Idaho; J. R. Simplot Co., Boise, Idaho; Barton Mines Corp., North Creek, N.Y.; and Cabot Corp., Willsboro, N.Y. New York was the leading garnet-producing State.

A study of the garnet occurrences in the south-central Adirondacks of New York indicated that garnet is abundant only in the basic rocks. The size, shape, and composition of the red garnet nodules and their surrounding hornblende rings depend on the nature of the host rock.

The size of the hornblende rings seems to increase with the volume of the enclosed garnet.[5]

Exports of garnet continued from the Masasi District in Tanganyika, and the owners carried out geological studies and prospecting to establish satisfactory reserves.[6]

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

Year	Short tons	Value (thousands)	Year	Short tons	Value (thousands)
1951-55 (average)	12,396	$1,076	1958	12,303	$869
1956	9,812	1,073	1959	14,568	1,211
1957	9,776	1,080	1960	10,522	986

NATURAL ALUMINA ABRASIVES

Corundum.—A review of the references to corundum deposits in Georgia appeared in a State publication. Some 40 corundum occurrences were mentioned.[7]

Corundum maintained a limited area of use for optical and glass grinding, and for lapping applications. Accurate sizing of corundum powders improved their performance.[8]

Tanganyika Corundum Corp. continued exploration work on its deposit near Longido.[9]

TABLE 8.—World production of corundum by countries [1] [2]

(Short tons)

Country [1]	1951-55 (average)	1956	1957	1958	1959	1960
Argentina	57					
Australia	14					
India	498	395	497	435	236	268
Malaya, Federation of	11	[3] 100				
Mozambique	2					
Rhodesia and Nyasaland, Federation of:						
Nyasaland	40					
Southern Rhodesia	971	4,448	4,506	4,594	2,799	3,843
Union of South Africa	2,670	2,068	1,539	2,118	622	123
World total (estimate) [1] [2]	10,000	11,000	10,000	11,000	8,000	9,000

[1] Corundum is produced in U.S.S.R., data on production are not available, and estimate is included in the total.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Exports.

Compiled by Liela S. Price, Division of Foreign Activities.

[5] Bartholomé, P., Genesis of the Gore Mountain Garnet Deposit, New York: Econ. Geol., vol. 55, No. 2, March–April 1960, pp. 255–277.
[6] Mining Magazine (London), Tanganyika Mining Industry 1959: Vol. 102, No. 3, March 1960, p. 161.
[7] Furcron, A. S., Corundum in Georgia: Georgia Miner. Newsletter, vol. 8, No. 4, Winter 1960, pp. 167–177.
[8] Dumas, L. P., How More Accurate Sizing Improves Corundum Quality: Grinding and Finishing, vol. 6, No. 11, November 1960, pp. 59–61.
[9] Mining Magazine (London), Tanganyika Mining Industry 1959: Vol. 102, No. 3, March 1960, p. 161.

There was no commercial production of corundum in the United States or Canada during 1960, and corundum imports declined 20 percent.

Emery.—Domestic production of emery decreased 5 percent in both tonnage and value in 1960 from the previous year. No emery imports were reported during 1960.

TABLE 9.—Emery sold or used by producers in the United States

Year	Short tons	Value (thousands)	Year	Short tons	Value (thousands)
1951-55 (average)	10,608	$146	1958	7,687	$126
1956	12,153	174	1959	8,555	150
1957	11,893	184	1960	8,169	142

INDUSTRIAL DIAMOND

For the second consecutive year the world production of natural industrial diamond declined, due in 1960 to civil disturbances in the Republic of the Congo. All other diamond-producing countries either exceeded or equaled their 1959 output. By the end of 1960 diamond mining at Bakwanga in the Republic of the Congo, which had stopped during August, was resumed on a reduced scale.

During 1960 the annual report on the diamond industry from a Belgian source, with English and Dutch language editions, gave a comprehensive survey of all phases of that industry throughout the world.[10]

World Review.—By the end of 1961 over 95 percent of the world's natural industrial diamond production was to be under the jurisdiction and subject to the mining regulations of eight African countries.

A survey of world diamond mining and markets showed that no new deposits of any significance were found in 1960, but sales through the Central Selling Organization continued at a high level.[11]

TABLE 10.—U.S. imports for consumption of industrial diamond (excluding diamond dust and manufactured bort)

(Thousand carats and thousand dollars)

Year	Quantity	Value	Year	Quantity	Value
1951-55 (average)	13,424	$51,603	1958	9,500	$37,596
1956	16,166	73,291	1959	[1] 12,605	[1] 60,975
1957	12,220	50,063	1960	11,982	48,675

[1] Revised figure.

Source: Bureau of the Census.

[10] Moyar, A., The Diamond Industry in 1958–59: Vlaams Economist Verbond, Antwerp, 1960, 115 pp.

[11] Mining Journal (London), Diamonds, Gemstones and Abrasives: Ann. Rev., 1960, pp. 71, 73, 75.

TABLE 11.—U.S. imports for consumption of industrial diamond (including diamond dust), by countries

Year and country	Crushing bort (including all types of bort suitable for crushing)		Other industrial diamonds (including glaziers' and engravers' diamond, unset, and miners')		Carbonado and ballas		Dust and powder	
	Carats	Value	Carats	Value	Carats	Value	Carats	Value
1959:								
North America:								
Canada	119,368	$341,136	524,307	$3,039,969			19,484	$69,797
Mexico	110	275	56	3,352				
Total	119,478	341,411	524,363	3,043,321			19,484	69,797
South America:								
Brazil			7,263	127,012	820	$12,973		
British Guiana			1,913	43,195				
Venezuela			13,218	155,513				
Total			22,394	325,720	820	12,973		
Europe:								
Belgium-Luxembourg			1,311,217	12,429,877			11,884	33,176
France			22,981	259,754				
Germany, West	400	1,210	27,518	212,204				
Netherlands			91,486	876,103			1,024	2,506
Sweden							355	425
Switzerland			5,408	18,987			202,328	523,273
United Kingdom	579,680	1,620,761	3,953,640	22,730,180			86,766	532,926
Total	580,080	1,621,971	5,412,250	36,527,105			302,357	1,092,306
Asia: Israel			237,668	2,039,437			2,478	4,335
Africa:								
Belgian Congo	4,132,396	11,405,031	130,047	515,656			54,217	173,449
British West Africa, n.e.c.	23,600	66,264	12,000	33,779				
French West Africa and Republic of Togo			1,033	25,271				
Ghana			30,140	218,337				
Union of South Africa	298,176	944,877	[1] 1,081,337	[1] 3,853,340			110,900	311,247
Total	4,454,172	12,416,172	[1] 1,254,557	[1] 4,646,383			165,117	484,696
Grand total	5,153,730	14,379,554	[1] 7,451,232	[1] 46,581,966	820	12,973	489,436	1,651,134
1960:								
North America:								
Canada	123,107	485,190	477,188	2,649,590			4,366	6,344
Mexico			306	954				
Total	123,107	485,190	477,494	2,650,544			4,366	6,344
South America:								
Brazil			36,310	447,674	649	20,286		
British Guiana			795	17,995				
Venezuela			8,630	219,796				
Total			45,735	685,465	649	20,286		
Europe:								
Belgium-Luxembourg	654	1,864	1,122,977	8,294,157			7,576	20,616
Denmark	2,000	5,715						
France			49,787	337,822				
Germany, West	1,563	4,705	15,564	172,852			2,038	7,033
Netherlands	243,678	657,370	83,557	582,777			26,028	72,870
Spain			64	1,280				
Switzerland	1,120,442	2,980,378	5,015	35,975			410,240	1,079,296
United Kingdom	4,019,056	10,227,150	2,861,068	15,256,052	100	753	72,330	227,959
Total	5,387,393	13,877,182	4,138,032	24,680,915	100	753	518,212	1,407,774
Asia:								
Israel			4,495	39,607				
Japan			730	10,304				
Total			5,225	49,911				

[1] Revised figure.

TABLE 11.—U.S. imports for consumption of industrial diamond (including diamond dust), by countries—Continued

Year and country	Crushing bort (including all types of bort suitable for crushing)		Other industrial diamonds (including glaziers' and engravers' diamond, unset, and miners')		Carbonado and ballas		Dust and powder	
	Carats	Value	Carats	Value	Carats	Value	Carats	Value
Africa:								
Congo,[2] Republic of, and Ruanda-Urundi	53,081	$168,812	90,771	$321,284			19,915	$61,448
Ghana			48,520	410,432				
Liberia			176	3,528				
Western Africa, n.e.c[3]			7,488	156,615				
Union of South Africa	1,010,056	2,694,779	594,542	2,469,744			576,248	1,576,152
Total	1,063,137	2,863,591	741,497	3,361,603			596,163	1,637,600
Grand total	6,573,637	17,225,963	5,407,983	31,428,438	749	$21,039	1,118,741	3,051,718

[2] Effective July 1, 1960; formerly Belgian Congo.
[3] Effective July 1, 1960; formerly French West Africa and Republic of Togo.

Source: Bureau of the Census.

A series of articles appearing in a technical magazine described the mining and concentrating methods used at the principal African diamond fields, and the importance of diamond in African economy. The geology of the primary, alluvial, and marine terrace deposits; the type of diamond from each of these sources; and the prospecting methods used to evaluate the types of diamond occurrences were considered. To meet the increased demand for both gem and industrial diamond during the past 15 years called for new mining and concentrating methods and installation of new equipment by the larger producers. At many mines heavy-medium separators replaced diamond pans for preliminary concentration, followed by improved types of grease tables or belts, and electrostatic separators.[12]

A black diamond originating in the former French Equatorial Africa and weighing 740 carats was presented to the Smithsonian Institution, Washington, D.C. It was believed to be the largest mass of black diamond in any museum in the world.[13]

Some 5,000 words, terms, and symbols were defined in a glossary on diamond drilling.[14]

Africa.—During the first half of 1960 diamond production in the former Belgian Congo was 9,266,000 carats, a record 6-month output. On July 1, when the Republic of the Congo was inaugurated, civil disturbances began to affect the diamond mines of Kasai Province, and on August 28 the Bakwanga mine ceased operating. Nearly all the other diamond mines in the Province had already closed. By October many of the African miners at Bakwanga were willing to return to work, and a sufficient number of the Belgian technical staff had returned to make operations possible. By the end of 1960 operations

[12] Daily, Arthur F., Africa's Key Role in Diamond Mining: Min. World, vol. 22, No. 9, September 1960, pp. 38–43; How Diamonds Are Found and Mined in Africa: Vol. 22, No. 10, October 1960, pp. 36–41; How New Methods and New Equipment Increase Diamond Recovery in Africa: Vol. 22, No. 11, November 1960, pp. 32–37, 72.
[13] Chemistry, Museum Gets Black Diamond: Vol. 34, No. 4, December 1960, p. 16.
[14] Long, Albert E., A Glossary of the Diamond Drilling Industry: Bureau of Mines, Bull. 583, 1960, 98 pp.

TABLE 12.—World production of natural industrial diamond [1]

(Thousands carats)

Country	1958	1959	1960
Africa:			
Angola	400	500	400
Central African Republic [2]	60	60	50
Republic of Congo [3]	15,900	14,200	13,040
Republic of Ghana [4]	2,200	2,200	2,500
Republic of Guinea [5]	260 (Guinea and Ivory Coast combined)	400 (Guinea and Ivory Coast combined)	670
Republic of Ivory Coast [5]			120
Sierra Leone [6] [7]	1,400	1,150	1,450
South-West Africa	60	90	50
Tanganyika	290	350	250
Union of South Africa:			
"Pipe" mines:			
Premier	960	950	1,000
DeBeers Group	480	500	580
Others	70	70	100
"Alluvial" mines	100	150	160
Total Africa	22,200	20,620	20,370
Other areas:			
Brazil [7]	150	170	175
British Guiana	20	40	60
Venezuela	75	80	57
Australia, Borneo, India, and U.S.S.R. [7]	5	10	20
World total [7]	22,400	20,900	20,700

[1] Prepared jointly by the Bureau of Mines and Dr. George Switzer, Smithsonian Institution.
[2] Formerly French Equatorial Africa.
[3] Formerly Belgian Congo.
[4] Formerly Gold Coast.
[5] Formerly French West Africa.
[6] Includes unofficial production of Liberia.
[7] Estimate.

at the Bakwanga mine were nearly back to normal, but most of the smaller mines in Kasai remained closed. An uncertain transportation system made mine supplies hard to obtain, but enough were found to keep the mine going. The total diamond production in the Republic of the Congo for 1960 was slightly over 13 million carats, a drop of 1.2 million carats from 1959.[15] Mechanization was virtually completed at Bakwanga, 99.8 percent of the overburden and diamondiferous material was being handled mechanically, and the two hydroelectric stations met the power requirements.[16]

Marketing of the African miners' diamond production in Sierra Leone under the Alluvial Diamond Mining Scheme reduced illegal diamond exports from that country.[17]

It was reported that 966 alluvial diamond mining license holders and 13,000 laborers were working in the Sewa River diamond field of Sierra Leone in 1960.[18]

African diamond producers intensified their efforts to find new diamond deposits, using aerial photography and geophysical surveying in addition to the usual diamond prospecting methods.[19]

[15] Letters to Bureau of Mines, Aug. 4, 1960, Nov. 14, 1960, Jan. 7, 1961.
[16] Mining Journal (London), Société Minière du Bécéka: Vol. 255, No. 6516, July 8, 1960, p. 52.
[17] Mining Journal (London), Mining in Sierra Leone: Vol. 254, No. 6501, Mar. 25, 1960, pp. 354–355.
[18] Mining Magazine (London), Sierra Leone Diamonds: Vol. 103, No. 1, July 1960, pp. 17–18.
[19] Mining Journal (London), Prospecting Costs De Beers £1,000,000 a Year: Vol. 254, No. 6512, June 10, 1960, p. 685.

Portuguese Angola reported the highest diamond production in its history, and a program of expansion was outlined.[20]

A diamond recovery plant embodying new features in concentration and recovery was erected at the State Alluvial diamond mines at Alexander Bay, Union of South Africa.[21]

Only three of the five major kimberlite pipes in the vicinity of Kimberley were exploited in 1960. In two of the mines a block caving system was developed that materially reduced the cost of mining.[22] Also at Kimberley a new treatment and recovery plant capable of processing 20,000 tons of ore a day from these mines greatly reduced operating costs.[23]

At the diamond mines of South-West Africa processing improvements reduced the quantity but increased the diamond fraction of final concentrate reaching the sorting tables.[24]

Other Areas.—A new diamond discovery was reported in British Guiana, near Ekereku.[25]

A Russian article entitled "Diamond Districts of the Yakutian ASSR and Problems in Their Industrial Development" was reviewed by a member of the staff of the Bureau of Mines. Operational plans called for the full development of the "Mir" diamond pipe and adjoining diamondiferous placers by 1965, and a beginning of the exploitation of the "Udachnaya" pipe in 1970.[26]

One of the objectives of the 1959–65 National Plan for the U.S.S.R. was the organization and expansion of Siberian diamond production. The problems connected with diamond mining in such a remote region included the determination of suitable mining and recovery methods and development of an adequate power supply in an area of permafrost, with no natural fuels in the immediate vicinity. The nearest railroad was 800 miles away, river transportation was possible only in summer, and local supplies of building materials and food were inadequate. Most of the transport to the new diamond fields was by air.[27]

Russian industrialists stated the U.S.S.R. requirements of industrial diamond were 1 carat for each 10 tons of steel produced.[28]

Two discoveries were made in Borneo, one in Kahaju Hulu District,[29] and the other in Central Kalimantan.[30]

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[20] Mining Magazine (London), Monthly Review, Angola: Vol. 103, No. 1, July 1960, p. 6.

[21] Smit, D. B., Orsmond, N., and Strydon, J. E. De Lange, Diamond Recovery Plant, State Alluvial Diggings, Alexander Bay: Jour. South African Inst. Min. and Met. (Johannesburg), vol. 60, No. 9, April 1960, pp. 453–465.

[22] Gallagher, W. S., and Loftus, W. K. B., Block Caving Practice at De Beers Consolidated Mines, Ltd: Jour. South African Inst. of Min. and Met., vol. 60, No. 9, April 1960, pp. 405–429.

[23] Colvin, E., and Simpson, H. S., Treatment and Recovery Practice at Kimberley Mines of De Beers Consolidated Mines, Ltd: Jour. South African Inst. of Min. and Met., vol. 60, No. 10, May 1960, pp. 503–524.

[24] Devlin, S. W., The Treatment of Gravels for the Recovery of Diamonds at C.D.M.: Jour. South African Inst. of Min. and Met., vol. 60, No. 9. April 1960, pp. 430–452.

[25] Diamond News, Diamond Rush in British Guiana: Vol. 24, No. 3, December 1960, p. 13.

[26] Bureau of Mines, Mineral Trade Notes, Diamond: Vol. 50, No. 5, May 1960, pp. 7–12.

[27] South African Mining and Engineering Journal (Johannesburg), Developments on the Yalsutia Diamond Fields of Siberia: Vol. 71, No. 3530, pt. 2, Sept. 30, 1960, p. 823.

[28] Mining Journal (London), Diamonds in the Soviet Union: Vol. 255, No. 6518, July 22, 1960, p. 98.

[29] Mining Magazine (London), Diamond Rush in Borneo: Vol. 103, No. 2, August 1960, p. 103.

[30] Mining Journal (London), Mining Miscellany: Vol. 255, No. 6524, Sept. 2, 1960, p. 262.

The Geological Survey of India announced discovery of a diamond-bearing kimberlite pipe in the Panna District,[31] and diamond mining activity was reported at other points in that area.[32]

Technology.—*Natural Diamond.*—Natural diamond grit was processed to eliminate material with structural weaknesses. This improved diamond was incorporated in the metal-bonded grinding wheels used to smooth concrete surfaces of highways and airfield runways.[33]

The ability of diamond to reflect light was used to develop a separator to recover transparent and translucent diamond from the accompanying gangue. An electric detector picks up a flash of light from the diamond as it passes, and the diamond is mechanically deflected from the other material. Very dark or black diamond is not recoverable by this method.[34]

It was suggested that the source of the diamonds found in Wisconsin, Michigan, and Ohio might be discovered by tracing the occurrences of certain associated minerals, such as pyrope, to their point of origin.[35]

An improved finish on the edges of automobile safety glass was obtained by a process using industrial diamond and called pencil edging. By this process the rough edges that might develop into cracks are removed. The finished glass operates more easily in its guide channels and has an improved appearance.[36]

Standard bandsaw machines equipped with diamond bandsaws cut pattern shapes in glass-reinforced plastics, ceramics, marble, pure glass, and other hard and brittle materials that were difficult and expensive to shape by conventional grinding or cutting methods. Small diamond particles were bonded directly to the steel body of the band or wire.[37]

The metal-working industry continued to require better finishes and closer tolerances, and automation needed tooling materials that would perform consistently and for a long time. Diamond helped the tool engineers to meet these requirements.[38]

The importance of particle shape of the diamond material in grinding and lapping efficiency was indicated by tests conducted under working conditions.[39]

The cost of diamond used in industry can be reduced materially by proper selection and use.[40]

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[31] Mining Journal (London), Mineral Discoveries in India: Vol. 255, No. 6530, Oct. 14, 1960, p. 413.

[32] Mining World, India: Vol. 22, November 1960, pp. 78–79.

[33] South African Mining and Engineering Journal (Johannesburg), Union Heads World in Industrial Diamond Work: Vol. 71, No. 3508, pt. 1, Apr. 29, 1960, pp. 1031, 1033.

[34] Linari-Linholm, A. A., An Optical Method of Separating Diamond From Opaque Gravel: Inst. of Min. (London), preprint 38, 1960, 11 pp.

[35] Smith, C. H., Diamonds in the Great Lakes Area, a Geological Enigma: Canadian Min. Jour., vol. 81, No. 7, July 1960, pp. 51–52.

[36] Ceramic Industry, Diamonds Put Finish on Glass Edges: Vol. 75, No. 1, July 1960, p. 32.

[37] South African Mining and Engineering Journal (Johannesburg), Diamond Edge on Band Saw Cuts Refractory Materials: Vol. 71, No. 3533, pt. 2, Oct. 21, 1960, p. 1007.

[38] Taeyaerts, Jan, Design, Use and Care of Diamond Cutting Tools: Carbide Eng., vol. 12, No. 6, June 1960, pp. 14–18.

[39] Highberg, C. W., and Jausman, E. A., Particle Shape and Grinding Efficiency: Diamond Data (Newark, N.J.), vol. 1, No. 9, August–September 1960, pp. 1–4.

[40] Wizlarde, J., The Diamond Mine in Your Die Room: Wire and Wire Products, vol. 35, October 1960, pp. 1364–1365, 1433.

An improved process for reclaiming industrial diamond from wiping cloths was described,[41] and the importance of saving diamond swarf and sludge was discussed.[42]

Manufactured Diamond.—In manufacturing diamond, General Electric Co. preferred pure graphite as a source of carbon, and a metal catalyst, such as nickel. The basic equipment of the process was a container made of pyrophyllite, a natural aluminum silicate. This was enclosed by an assembly of units also made of pyrophyllite. A unique feature of pyrophyllite is that when it is subjected to high pressure its melting point rises from 2,400° to 4,800° F. The graphite and metal catalyst were electrically heated to the appropriate temperature, and at the same time pressure was applied until the desired operating conditions were achieved. The shape and color of the diamond particles produced seemed to vary according to the temperature of formation. Cubes and dark-colored material predominated at the lower end of the critical temperature range, with octahedra and light-colored material at the upper end. This feature enabled a considerable measure of control over the characteristics of the final product, which could be made to conform to certain desired specifications.[43]

Norton Co. of Worcester, Mass., developed a process for making diamond, but did not plan commercial production.[44]

Scientists at the Army Signal Corps Laboratory, Fort Monmouth, N.J.;[45] the Air Force Research Center, Bedford, Mass.;[46] and the Carnegie Institution, Washington, D.C.,[47] have made diamond crystals. These agencies were seeking to produce diamond with qualities of hardness, durability, and uniformity of structure suitable for use in transistors and other mechanisms that will be subjected to extreme temperature and pressure.

Experimental work on the synthesis and commercial production of diamond was conducted by N. V. Philips of Eindhoven, Netherlands.[48]

Because of the difficult operating conditions at the diamond fields of Central Siberia, the U.S.S.R. Academy of Sciences experimented in the production of synthetic diamond that could be made in more favorable localities, and at saving in cost and time.[49]

The Allmanna Svenska Elektriska AB, Vasteras, Sweden, was developing equipment to produce industrial diamond on a commercial basis.[50]

The De Beers Adamant Laboratory, Johannesburg, South Africa, developed manufactured diamond suitable for use in resinoid, ceramic,

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41 Jorczak, K. A., Reclamation of Diamonds From Machine Wiping Cloths: Off. Tech. Services, U.S. Department of Commerce, Washington 25, D.C., 11 pp.

42 Iron Age, Profits in Diamond Dust: Vol. 186, No. 12, Sept. 22, 1960, p. 15.

43 Journal of the Electrochemical Society, G.E. Reveals Details of Process of Making Diamonds: Vol. 107, No. 2, February 1960, p. 396.

44 American Ceramic Society Bulletin, Norton Reports Diamond Synthesis: Vol. 39. No. 6, June 15, 1960, p. 35.

45 Giardini, A. A., Tydings, J. E., and Levin, S. B., A Very High Pressure—High Temperature Research Apparatus and the Synthesis of Diamond: Am. Mineral., vol. 45, Nos. 1 and 2, January–February 1960, pp. 217, 221.

46 Jewelers' Circular-Keystone, U.S. Army, Air Force Synthesize Diamonds for Use as Transistors in Missile Field: Vol. 130, No. 7, April 1960, p. 123.

47 Electronic News, Synthetic Diamond Made at Carnegie: Vol. 5, No. 185, Feb. 1, 1960, p. 24.

48 Bureau of Mines, Mineral Trade Notes, Diamond: Vol. 50, No. 3, March 1960, pp. 15–16.

49 Engineering and Mining Journal, Soviets to Stress Synthetic Diamonds: Vol. 161, No. 12, December 1960, p. 150.

50 Diamond News, Several Firms Now Making Diamonds: Vol. 23, No. 3, December 1959, p. 11.

and metal-bonded grinding wheels. Continuous production was deemed to be technically and commercially possible, and a plant for making diamond was being built at Springs, east of Johannesburg. In the laboratory, material up to about 48-mesh was made with occasional particles up to 20-mesh. Several metal catalysts were used, but nickel seemed to be the most satisfactory. De Beers' manufactured diamond contained about 1 percent nickel. Production methods were similar to those used by General Electric Co. in the United States. This development was undertaken as a precaution to ensure a continuous supply of bort should production of natural material be curtailed.[51]

A paper on the history of diamond synthesis was presented at a technical meeting.[52]

ARTIFICIAL ABRASIVES

Production of crude artificial abrasives in the United States and Canada during 1960 increased 6 percent in tonnage and 3 percent in value over 1959. Nearly all of the crude artificial abrasives made in Canada were exported to the United States for processing. None were processed in Canada. Aluminum oxide production included 19,996 short tons of white high-purity material, valued at $3,598,915. Silicon carbide production was at 91 percent of capacity; aluminum oxide, 65 percent; and metallic abrasives, 42 percent. Nonabrasive uses took 28 percent of the silicon carbide and 5 percent of the aluminum oxide.

Sales of graded abrasive grain of all types to domestic users and manufacturers during 1960 declined 7 percent from the 1959 figure. However, the exports of manufactured abrasive grain increased 10 percent. The sales value of domestically produced bonded grinding wheels was nearly $160 million, 8 percent less than in 1959. Vitrified bonded grinding wheel sales were 44 percent of this total value; resinoid and shellac bonded wheels, 38 percent; rubber bonded, 5

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

Year	Silicon carbide [1]		Aluminum oxide [1] (abrasive grade)		Metallic abrasives [2]		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1951–55 (average)	79,221	$10,356	211,194	$21,526	151,677	$16,945	442,092	$48,827
1956	95,778	14,937	195,228	22,554	140,455	18,201	431,461	55,692
1957	124,688	19,152	228,511	28,202	131,503	18,280	484,702	65,634
1958	110,456	17,597	122,868	16,870	101,159	14,339	334,483	48,806
1959	132,458	21,987	158,392	22,072	[3] 126,719	[3] 18,869	[3] 417,569	[3] 62,928
1960	133,219	20,636	195,906	27,111	112,383	16,847	441,508	64,594

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

[51] Mining World, De Beers Develops Synthetic Industrial Diamond: Vol. 22, No. 1, January 1960, p. 29.
U.S. Consulate, Johannesburg, Union of South Africa, State Department Dispatch 164: Dec. 5, 1960.
Glass Industry, Synthetic Diamond Grit: Vol. 41, No. 11, November 1960, p. 649.
[52] Suits, C. G., The Synthesis of Diamond, A Case History in Modern Science: Presented before the Am. Chem. Soc., Rochester, N.Y., Nov. 3, 1960, 22 pp.

TABLE 14.—Production, shipments, and stocks of metallic abrasives in the United States, by products

Year and product	Manufactured		Sold or used		Stocks Dec. 31		Annual capacity (short tons)
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	
1959:							
Chilled iron shot and grit	48,101	$5,034	48,905	$5,304	7,490	$735	184,234
Annealed iron shot and grit	37,262	4,853	38,149	4,986	1,667	210	[1] 66,044
Steel shot [2]	38,311	7,637	38,166	8,171	6,910	1,531	78,425
Other types (including cut wire shot)	1,504	408	1,499	408	107	35	2,610
Total [3]	125,178	17,932	126,719	18,869	16,174	2,511	265,269
1960:							
Chilled iron shot and grit	38,891	4,086	38,974	4,195	7,407	709	157,789
Annealed iron shot and grit	32,190	4,151	32,342	4,178	1,515	183	[1] 65,744
Steel shot [2]	[4] 40,708	[4] 7,672	[4] 41,067	[4] 8,474	6,205	1,182	100,925
Other types (including cut wire shot)					453	78	4,355
Total	111,789	15,909	112,383	16,847	15,580	2,152	263,069

[1] Included in capacity of chilled iron shot and grit.
[2] Includes steel grit.
[3] Includes some revisions in previously published product detail.
[4] Combined to avoid disclosing individual company confidential data.

percent; and all other types including diamond grinding wheels, 13 percent. Coated abrasive sales by domestic manufacturers in 1960 totaled 2,167,819 reams, valued at $115,525,706. This was a decline of 5 percent in quantity and 1 percent in value from 1959. Percentages of the abrasives used in coated-abrasives manufacture were aluminum oxide, 41 percent; silicon carbide, 32 percent; garnet, 13 percent; flint, 11 percent; and emery, 3 percent. Of this total production, 63 percent was made with glue as the adhesive; 19 percent with waterproof adhesives; and 18 percent with resin adhesives.

American abrasive manufacturers were expanding their foreign operations in France,[53] Canada,[54] and Australia.[55]

Technology.—Properties, composition, and uses of the well-known kinds of abrasives, as well as the possibility of a "universal" abrasive, were the subject of a paper.[56]

The manufacture and use of coated abrasives were described.[57]

The term "toughness" as applied to an abrasive is its resistance to breakdown under the forces acting upon it during its use. While hardness is usually regarded as the essential property of an abrasive, toughness may be equally important. Heating certain kinds of abrasive grain to a predetermined temperature for a period of time increases their toughness. The mechanism by which the toughness of an abrasive was increased on heating had not been satisfactorily resolved.[58]

[53] Steel, U.S. Firms Active Abroad: Vol. 146, No. 16, Apr. 18, 1960, p. 111.
[54] Ceramic Age, Builds 10,000 Sq. Ft. Plant: Vol. 75, No. 3, March 1960, p. 45.
[55] Steel, U.S. Participation in World Marketing Widens: Vol. 147, No. 23, Dec. 5, 1960, p. 89.
[56] Beandin, L. J., Abrasives, Natural and Synthetic: Bull. Am. Ceram. Soc., vol. 39, No. 4, Apr. 15, 1960, p. 227.
[57] Coated Abrasives Manufacturers Institute, Coated Abrasives, Modern Tool of Industry: McGraw-Hill Book Co., Inc., New York, N.Y., 1958, 426 pp.
[58] Forchheimer, Otto L., Grit Hardness and Toughness, How Does It Affect Your Grinding Operation?: Grinding and Finishing, vol. 6, No. 11, November 1960, pp. 34–36, 39.

Artificial abrasive materials have a high resistance to reduction in size compared with some natural ones, and a table indicating the friability of several well-known abrasives was prepared.[59]

In measuring the abrasive resistance of coatings, an abrasive powder was propelled from a vibrating chamber through a nozzle onto the test specimen. Abrasive flow, pressure, distance, and angle of contact all were closely controlled. Abrasion resistance was measured by the time required to abrade through the coating, and was expressed in terms of a unit thickness. A good qualitative correlation was observed between test results and service performance of protective coatings applied to military aircraft.[60]

The Coated Abrasive Manufacturers Institute initiated a program to standardize abrasive-belt lengths as an aid to consumers, machinery builders, and the coated abrasives industry.[61] The recommended sizes were shown on a chart.

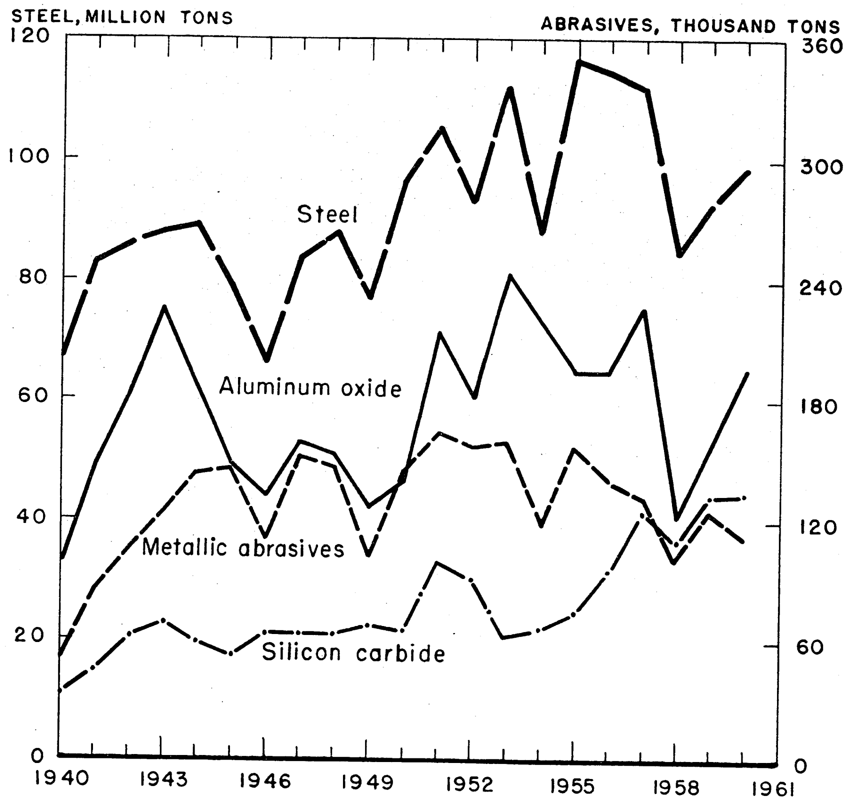

FIGURE 1.—Relationship between ingot-steel and artificial abrasives production, 1940–60.

[59] Cadwell, Donald E., and Duwell, Ernest J., Evaluating Resistance of Abrasive Grits to Comminution: Bull. Am. Ceram. Soc., vol. 39, No. 11, November 1960, pp. 663–667.

[60] National Bureau of Standards Technical News Bulletin, Improved Method for Measuring Abrasion Resistance of Coatings: Vol. 44, No. 7, July 1960, pp. 113–114.

[61] Grinding and Finishing, Abrasive Belt Lengths Standardized: Vol. 6, No. 10, October 1960, p. 31.

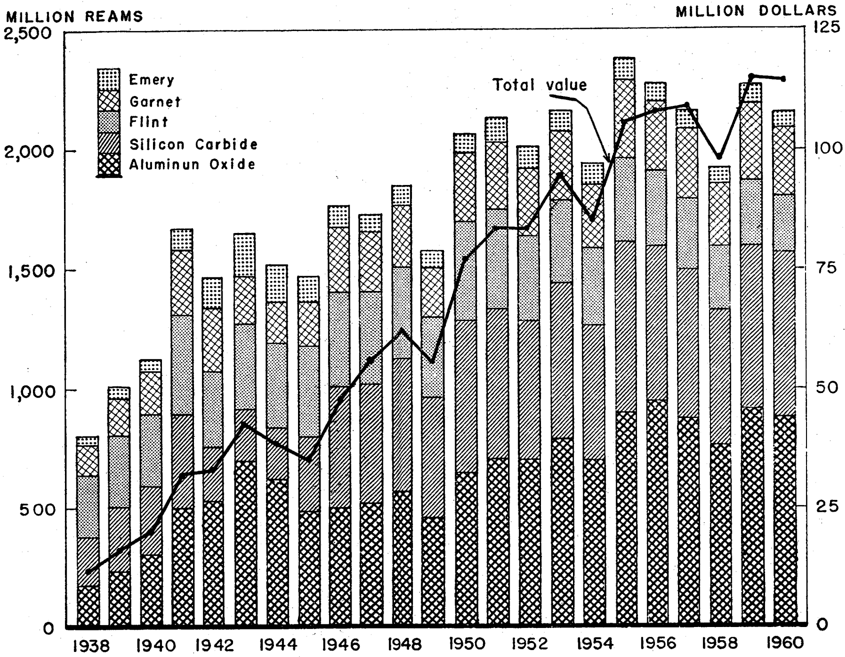

FIGURE 2.—Coated-abrasives industry in the United States, 1938–60.

TABLE 15.—Stocks of crude artificial abrasives and capacity of manufacturing plants, as reported by producers in the United States and Canada

(Thousand short tons)

Year	Silicon carbide		Aluminum oxide		Metallic abrasives [1]	
	Stocks Dec. 31	Annual capacity	Stocks Dec. 31	Annual capacity	Stocks Dec. 31	Annual capacity [2]
1951–55 (average)	18.9	113.5	37.6	267.9	12.1	242.9
1956	10.3	118.9	38.6	283.5	16.5	247.4
1957	14.0	131.9	36.7	298.7	16.5	255.0
1958	10.4	141.9	36.4	299.5	17.9	279.6
1959	10.6	142.0	29.2	299.5	16.2	265.3
1960	16.0	145.6	25.1	299.5	15.6	263.1

[1] United States only.
[2] Revised figures, 1955–59.

The productive life of coated abrasives can be lengthened 5 to 75 percent by proper control of heat and humidity in the storage area. Recommended storage conditions were reported to be a temperature near 70° F. with relative humidity between 35 and 50 percent.[62]

Cutting properties of grinding wheels depend on the physical properties of their abrasive particles and their behavior under heat and mechanical loads. A system of measuring the toughness of abrasive particles was developed to show the force necessary to break an abra-

[62] Grinding and Finishing, Better Storage of Coated Abrasives: Vol. 6, No. 2, February 1960, p. 35.

sive particle when exerted at a constant speed. A toughness scale was devised from the data obtained.[63]

The Grinding Wheel Institute began a study to develop and recommend abrasive standards. The problem was to be studied from manufacturing, buying, and application points of view.[64]

Experiments indicated that transistors made with silicon carbide might prove feasible, thus extending the range of operating temperatures well above those possible with germanium and silicon transistors.[65]

A radically new aluminum oxide abrasive promised to make a substantial contribution to the efficiency of grinding wheels used for stainless steel billet and slab grinding.[66] Minnesota de France, S.A., a subsidiary of Minnesota Mining and Manufacturing Co., opened a new coated-abrasive plant at Beauchamps, near Paris.[67]

While careful quality control programs had increased the cost of metallic abrasives, a more efficient work performance more than offset higher prices. Some users preferred chilled iron shot and grit for faster cleaning, or malleable iron because it was easier on machinery. A longer work life was claimed for steel abrasives, and size and breakdown characteristics were important factors in selection. Growing popularity of metallic abrasives prompted expansion, and special materials and shapes were often required.[68]

A survey conducted within the foundry industry showed that four factors should be considered in choosing a metallic abrasive: Time involved for the job, equipment wear, abrasive consumption, and desired finish. None of these factors should be considered individually.[69]

In descaling bar stock used in making industrial safety gratings, a mechanical descaler blasted all surfaces at one pass with steel abrasives. With the metal completely clean of rust and scale a better weld was obtained with less heat.[70]

Facts concerning the use of metallic shot and grit abrasives in blast cleaning were detailed in an illustrated booklet.[71]

MISCELLANEOUS MINERAL-ABRASIVE MATERIALS

In addition to the natural and manufactured abrasive materials for which data are included, many other minerals were used for abrasive purposes. A number of oxides, including tin oxides, magnesia, iron oxides (rouge and crocus), and cerium oxide, were employed as polishing agents. Certain carbides, such as boron carbide and tungsten carbide, were used for their abrasive properties, especially when extreme hardness was demanded. Other substances

[63] Peklenik, J., Testing the Toughness of Abrasive Particles: Ind. Diamond Rev., vol. 20, No. 238, September 1960, pp. 166–172.
[64] Purchasing Week, Abrasive Producers Launch Drive to Forge Industry-Wide Standards: Vol. 3, No. 49, Dec. 5, 1960, p. 12.
[65] Ceramic Industry, Study Ceramics in Space: Vol. 75, No. 3, September 1960, p. 54.
[66] South African Mining and Engineering Journal (Johannesburg), Aluminum Oxide Abrasive: Vol. 71, No. 3536, pt. 2, Nov. 11, 1960, p. 1219.
[67] U.S. Embassy, Paris, France, State Department Dispatch 800: Dec. 9, 1960, p. 1.
[68] Steel, Metal Abrasive Producers Put Accent on Performance: Vol. 146, No. 5, Feb. 1, 1960, pp. 88–90.
[69] Neustadt, David E., Selecting Abrasives for Economical Cleaning: Foundry, vol. 88, No. 5, May 1960, pp. 278, 281, 283.
[70] Steel, Mechanical Descaler Saves $75 a Day: Vol. 146, No. 9, Feb. 29, 1960, p. 85.
[71] Iron Age, Shot and Grit: Vol. 185, No. 9, Mar. 3, 1960, pp. 104–105.

with abrasive applications included finely ground and calcined clays, lime, talc, ground feldspar, river silt, slate flour, and whiting.

Cerium oxide was used to polish spectacle lenses, precision optical parts, television tubes, camera and instrument lenses, cut-glass and glass specialities, marble and granite, and semiprecious stones. Its acceptance was increasing because of its rapid polishing rate, ease of handling, and cleanliness, and the brilliance of the polish achieved. It was used also for removing scratches from plate glass for mirrors and automobile windows.[72] A trend towards lower prices should stimulate the use of cerium oxide in the glass industry.

Glass polishing with cerium oxide apparently involved both chemical and physical processes, the chemical aspect possibly playing the more significant role.[73] In fast and durable glass polishing without scratches, the cerium oxide particles must be of uniform size with no contaminants present.[74]

In chemical mixtures used for highway snow and ice control, abrasives were included to provide skid protection. A satisfactory mixture for most storm conditions was one part abrasive to two parts chemical, by weight.[75]

A mixture of ground walnut shells and a special abrasive material proved effective for cleaning porcelain insulators.[76]

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[72] Hampel, Clifford A., Cerium in the Glass Industry: Glass Ind., vol. 41, No. 2, February 1960, pp. 82–86, 109–112, 113.

[73] Duncan, L. K., Cerium Oxide for Glass Polishing: Glass Ind., vol. 41, No. 7, July 1960, pp. 387–391, 412–414.

[74] Ceramic Industry, CeO as Polishing Medium: Vol. 74, No. 5, May 1960, p. 7.

[75] Highway Research Board, Snow and Ice Control With Chemicals and Abrasives: Bull. 252, 1960, 30 pp.

[76] Ceramic Industry, How Blast Cleaning Porcelain Insulators Cuts Man Hours: Vol. 74, No. 5, May 1960, pp. 74–76.

Aluminum

By R. August Heindl,[1] Clarke I. Wampler,[2] and Mary E. Trought[2]

PRODUCTION of primary aluminum in the United States in 1960 reached a new high and was 3 percent greater than in 1959. For the first time, annual production exceeded 2 million tons and its value exceeded $1 billion. The 1960 output was 2.8 times that of 1950 and corresponded to an average increase of nearly 11 percent compounded annually. World output of 5 million short tons was an increase of 11 percent over 1959 and 3.1 times greater than in 1950.

TABLE 1.—Salient aluminum statistics

(Thousand short tons and thousand dollars)

	1951–55 (average)	1956	1957	1958	1959	1960
United States:						
Primary production	1,211	1,679	1,648	1,566	[1] 1,954	2,014
Value	$484,517	$805,782	$836,944	$773,610	[1] $955,190	$1,030,007
Price: Ingot, average cents per pound	21.0	26.0	27.5	26.9	26.9	[2] 26.0
Secondary recovery [3]	319	340	362	290	360	329
Imports for consumption (crude and semicrude)	231	265	258	293	[1] 302	196
Exports (crude and semicrude)	25	68	63	82	164	384
Consumption, apparent	1,735	2,128	2,137	2,092	[1] 2,488	2,015
World: Production	2,730	3,720	3,725	[1] 3,875	[1] 4,500	5,010

[1] Revised figure.
[2] The former price of pig is now applied to ingot. The use of the term "pig" was discontinued in August 1960.
[3] The 1951–53 data are recoverable aluminum-alloy content; data for subsequent years are recoverable aluminum content.

LEGISLATION AND GOVERNMENT PROGRAMS

Two companies shipped aluminum to the Government under supply contracts negotiated during 1950–52. The rate of shipments continued to drop sharply, as the quantity shipped in 1960 was 51 percent of that in 1959 and only 11 percent of the 1957 and 1958 shipments.

Under the defense materials system effective since July 1953, aluminum supply in the United States, above the quantity set aside for defense and atomic energy requirements and the national stockpile, was available for civilian consumption. A total set-aside of 54,000

[1] Assistant chief, Branch of Nonferrous Metals, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

tons a quarter or 216,000 tons annually was announced by the U.S. Department of Commerce, Business and Defense Services Administration. This was unchanged from the 1959 total.

In May, Subcommittee 3 of the Select Committee on Small Business of the House of Representatives, under the chairmanship of Congressman Sidney R. Yates, held hearings on problems of small business in the aluminum industry.[3] Testimony was taken on the following subjects: (1) The extension of the "molten metal" contracts between the automobile producers and two aluminum companies, Reynolds Metals Co. and Aluminum Company of America; (2) the acceleration of mergers and acquisitions by integrated producers; (3) the existence of possible price squeeze and discrimination against the small non-integrated users of primary metal by the integrated producers-suppliers of the basic metal; and (4) the effect of the increase in the export of aluminum scrap and its impact on the secondary aluminum market.

Included in the subcommittee's report were the recommendations that: (1) The Department of Commerce reevaluate the problems related to the increase in the export of aluminum scrap and consider whether controls are necessary and (2) the Department of Justice and the Federal Trade Commission continue to probe the pricing of molten metal, pricing policy in general, mergers, and acquisitions in the industry. These agencies should also conduct an industrywide cost study.[4]

The supplemental list of commodities on which the U.S. Government proposed to bargain reciprocal import concessions under the General Agreement on Tariffs and Trade (GATT) at Geneva, Switzerland, in 1961, included crude aluminum. The U.S. primary producers indicated they would oppose any reduction in the tariff, and hearings were scheduled for early 1961 by the Tariff Commission.

TABLE 2.—Shipments of aluminum to the Government under aluminum supply contracts

(Short tons)

Year	Alcoa [1]	Kaiser [1]	Reynolds [2]	Harvey [3]	Total
1957	104,998	116,804	102,509		324,311
1958	97,497	95,272	130,359		323,128
1959			45,320	27,915	73,235
1960			[4] 34	36,968	37,002
Total	202,495	212,076	278,222	64,883	757,676

[1] Contract expired in 1958.
[2] Contract expired in 1959.
[3] Contract to expire by 1963.
[4] Shipment in December 1960 with respect to tenders made prior to 1960.

[3] Subcommittee 3 on Problems of Small Business in the Aluminum Industry to the Select Committee on Small Business, Report: House of Representatives, 86th. Cong., 2d sess., Washington, D.C., May 1960, 216 pp.
Modern Metals, The Aluminum Hearings: Pt. 1, vol. 16, No. 5, June 1960, pp. 32, 34, 36, 38, 40, 43, 44, 46, 48; pt. 2, No. 6, July 1960, pp. 44, 46, 48, 50, 52, 54, 56, 58, 60; pt. 3, No. 7, August 1960, pp. 62, 64, 66, 70, 72, 74, 76, 78, 79.

[4] Subcommittee 3 on Foreign Trade, Foreign Aid, and Basic Metals to the Select Committee on Small Business, Report: House of Representatives, 68th. Cong., 2d sess., Washington, D.C., Dec. 22, 1960, 28 pp.

DOMESTIC PRODUCTION

PRIMARY

Domestic primary aluminum production was a record 2,014,000 tons—60,000 tons above production in 1959, the previous record year. However, shipments of 1,866,000 tons were 6 percent below those of 1959. Production rates were highest during the second and third quarters. During the year the industry operated at an average of 82 percent of installed capacity, with the highest rate, 85 percent, attained during the April–July period.

TABLE 3.—Production and shipments of primary aluminum in the United States [1]

(Short tons)

Quarter	1959		1960	
	Production	Shipments	Production	Shipments
First	456,005	442,914	491,536	488,190
Second	486,393	556,958	515,815	460,789
Third	[2] 521,309	[2] 500,856	513,419	457,555
Fourth	[2] 490,405	487,832	493,728	459,717
Total	[2] 1,954,112	[2] 1,988,560	2,014,498	1,866,251

[1] Quarterly production and shipments adjusted to final annual totals.
[2] Revised figure.

New facilities were activated, and plans for new or expanded primary production facilities were announced. In March, Reynolds Metals Co. (Reynolds) activated the second of three 33,300-ton-annual-capacity potlines at its new St. Lawrence plant near Massena, N.Y. Aluminum Company of America (Alcoa), in March, started a new 20,000-ton line at Point Comfort, Tex., and, in June, started the first of five potlines, each to have an annual capacity of 35,000 tons, at its Evansville, Ind., plant. Activation of this line was timed to fulfill an agreement to supply a General Motors Corp. (G.M.) foundry at Bedford, Ind. It was reported that G.M. would buy from Alcoa up to 50 percent of the aluminum and aluminum alloy requirements of its Bedford foundry, but not to exceed 36,000 tons a year. The metal was shipped molten in covered flasks a distance of 115 miles.[5] Power for the Evansville plant was being supplied by a new 375,000-kilowatt coal-fired steam generating plant.

Harvey Aluminum, Inc., announced plans to increase the capacity of its reduction plant at The Dalles, Oreg., by 25 percent or 15,000 tons a year. As a result of an agreement reached with Bonneville Power Administration, United Pacific Aluminum Corp. was expected to build a two-potline plant near Longview, Wash., with an annual capacity of 40,000 tons. Power for the first 20,000-ton line was to be available in January 1962 and for the second line in December 1963.

[5] American Metal Market, Alcoa Begins Operations at Warrick Plant: Vol. 67, No. 104, June 1, 1960, pp. 1, 10.

TABLE 4.—Actual and planned primary aluminum production capacity in the United States

(Short tons per year)

Company and plant	Capacity		
	Actual end of 1960	Being built in 1960	Total, actual and planned
Aluminum Company of America:			
Alcoa, Tenn	157,100		157,100
Badin, N.C	47,150		47,150
Massena, N.Y	118,000	32,000	150,000
Point Comfort, Tex	140,000		140,000
Rockdale, Tex	150,000		150,000
Vancouver, Wash	97,500		97,500
Wenatchee, Wash	108,500		108,500
Evansville, Ind	35,000	140,000	175,000
Total	853,250	172,000	1,025,250
Reynolds Metals Co.:			
Arkadelphia, Ark	55,000		55,000
Jones Mills, Ark	109,000		109,000
Listerhill, Ala	190,000		190,000
Longview, Wash	60,500		60,500
San Patricio, Tex	95,000		95,000
Troutdale, Oreg	91,500		91,500
Massena, N.Y	[1] 100,000		100,000
Total	701,000		701,000
Kaiser Aluminum & Chemical Corp.:			
Chalmette, La	247,500		247,500
Mead, Wash	176,000		176,000
Tacoma, Wash	41,000		41,000
Ravenswood, W. Va	145,000		145,000
Total	609,500		609,500
Anaconda Aluminum Co.:			
Columbia Falls, Mont	65,000		65,000
Harvey Aluminum, Inc.:			
The Dalles, Oreg	60,000	15,000	75,000
Ormet Corp.:			
Clarington, Ohio	180,000		180,000
Grand total	2,468,750	187,000	2,655,750

[1] At end of 1960 the plant was complete, but only 2 potlines of 33,300 tons each were operating.

Domestic primary aluminum capacity at the beginning of the year was 2,402,750 tons, increased to 2,468,750 tons by yearend, and upon completion of new facilities was to total 2,655,750 tons.

U.S. capacity to produce superpurity aluminum (99.99 percent or higher) was increased during the year. Kaiser Aluminum & Chemical Corp. (Kaiser) with the addition of six new refining cells at its Mead plant, each capable of producing 180 tons of the high-purity metal a year, raised its capacity to 1,505 tons a year. Consolidated Aluminum Corp., formerly Aluminum Foils, Inc., Jackson, Tenn., increased its capacity to produce superpure aluminum to 1,800 tons. Total U.S. capacity at yearend was 3,575 tons.

Alcoa, through negotiations with Aluminium Ltd., cancelled a substantial portion of its obligation, originally contracted in 1953, to buy aluminum from the latter company. Under the new agreement Alcoa paid approximately $9.5 million to cancel acceptance of 59,000 tons of metal. Alcoa's remaining obligation under the 1953 agreement was about $8.3 million as of December 31, 1960.

Kaiser completed a plant in Gary, Ind., to calcine petroleum coke for use in making carbon electrodes for its reduction plants.

Reynolds announced plans to construct a silicon metal production plant at Listerhill, Ala. The plant, designed to permit future expansion, was to have the capacity to produce 5,000 tons of silicon a year. The new facility was to meet the silicon requirements of the Listerhill reduction plant and a portion of that needed by other Reynolds plants.[6]

Harvey Aluminum, Inc. (Harvey), in order to develop into a fully integrated producer of primary aluminum and of a complete range of fabricated products, for the first time issued stock for public sale. The company was adding billet casting, wire rod, and related facilities at The Dalles plant. It also planned to build an alumina plant and an aluminum rolling mill.

Alcoa announced plans to expand and modernize its two sheet mills at Davenport, Iowa, and Alcoa, Tenn., at a cost of $18 million. During the year the company installed a 44-inch four-stand tandem cold sheet mill at Alcoa, Tenn., a 14,000-ton extrusion press at Lafayette, Ind., and a 5,200-ton extrusion press at Vernon, Calif.

Kaiser installed facilities at the Trentwood, Wash., rolling mill to produce aluminum-can stock and was expanding its capacity for casting aluminum billet at Chalmette, La. A casting machine for producing aluminum deoxidizing shot for use in the steel industry was installed at its Mead, Wash., plant.

Reynolds completed the $67 million expansion of its sheet and plate plant at Sheffield, Ala.

The aluminum industry's interest in expanding its activities in foreign countries continued at a high level. A British affiliate of Alcoa acquired a foil manufacturing company and a rigid foil container company in the United Kingdom. Alcoa and Imperial Chemical Industries, Ltd., each acquired a 50-percent share of a group of United Kingdom companies, the Associated Light Metal Industries. One of these companies was the second largest secondary smelter in the United Kingdom. Alcoa's Japanese affiliate, Furukawa Aluminum Co., Ltd., expanded its operations and increased its investment in other fabricating operations.

Early in 1960, Kaiser entered into an agreement with Delta Metal Co., Ltd., a United Kingdom company, to acquire one-half interest in James Booth Aluminium, Ltd. Kaiser activity in India, Ghana, Australia, and New Zealand is discussed in the World Review section of this chapter. Reduction and fabrication facilities in Spain, in which Kaiser had interests, were being expanded. Kaiser was also associated with a company building a fabricating plant in Argentina.

During the year, Reynolds T.I. Aluminium Ltd. of the United Kingdom, owned 49 percent by Reynolds, acquired the foil division of Venesta Ltd. with plants in the United Kingdom and India. Associates of Reynolds International, Inc., a subsidiary of Reynolds, expanded manufacturing operations in Canada, Venezuela, and Colombia. Reynolds also was planning a reduction plant in Venezuela

[6] Modern Metals, Reynolds To Build Silicon Metal Plant: Vol. 16, No. 2, March 1960, p. 104.

and was to participate in building a reduction plant and an alumina plant in Greece.

Three U.S. metal companies, Bridgeport Brass Co., Cerro Corp., and Scovill Manufacturing Co., joined with Aluminium, Ltd., of Canada in planning a new 100,000-ton hot rolling mill to meet the companies' needs for coil stock for rerolling in their respective sheet mills. The new mill was to be erected at Oswego, N.Y., at a cost of about $30 million. Production was to start in 1963.

SECONDARY

In 1960, aluminum recovered from purchased nonferrous scrap, as reported by consumers to the Bureau of Mines, totaled 329,000 tons. Recovery from new scrap declined 5 percent to 266,000 tons, and recovery from old scrap dropped to 63,000 tons, 20 percent below the preceding year. Recovery of secondary aluminum alloys (all constituents) from 441,000 tons of aluminum scrap reported processed in 1960 totaled 353,000 tons, a decline of 9 percent compared with 1959. An additional 1,350 tons of aluminum was recovered from copper-base, zinc-base, and magnesium-base scrap. The Bureau estimated that full coverage of the industry during 1960 would show a total scrap consumption of 523,000 tons and secondary ingot production of 329,000 tons. Calculated aluminum recovery based on full coverage would total 407,000 tons, and metallic aluminum alloy recovery would total 438,000 tons. The value of 329,260 tons of aluminum recovered from processed scrap was $171.2 million, computed from the average primary aluminum price of 26 cents per pound.

Shipments of aluminum alloys by secondary smelters in 1960 totaled 280,000 tons, a decline of 17 percent from the 1959 shipments but an increase of 16 percent over the 1958 shipments. In comparison with 1959, shipments of Al–Si–Cu–Ni alloys were down 7,548 tons or 33 percent; No. 319 and variations were down 6,744 tons or 16 percent; and AXS 679 and variations were off 18,346 tons or 14 percent. Contrary to the trend, pure aluminum, 97 percent minimum, and Al-Zn alloys increased over 1959.

The data obtained through a Bureau of Mines canvass are combined with data made available to the Bureau by the Aluminum Smelters Research Institute which covers the operations of its members. The combined coverage is estimated to represent about 85 percent of the secondary aluminum industry.

In June, Aluminium, Ltd., announced that it had withdrawn its proposal to purchase the assets of Apex Smelting Co. of Chicago, because of indicated objections on the part of the U.S. Department of Justice.

Three new facilities were completed. Apex Smelting Co. announced the completion of a modern scrap handling facility at its Chicago plant. The installation included automatic recording scales and conveyors to move the scrap from incoming trucks to machines for sorting and reducing the material to clean solids. Aaron Ferer & Sons, Inc., Los Angeles, Calif., announced the opening of a modern secondary aluminum smelter and nonferrous scrap facility. The new plant had an annual capacity of 25,000 tons of secondary ingot. United States Reduction Co. announced plans for the construction of a scrap preparation plant at Russellville, Ala. The plant was to supply the company's smelters at East Chicago, Ind., and Toledo, Ohio. It was further planned to construct a new smelter at the Russellville site when ingot demand justified such expansion.

TABLE 5.—Aluminum recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

Kind of scrap	1959	1960	Form of recovery	1959	1960
New scrap:					
Aluminum-base	[1] 281,315	[2] 266,141	As metal	16,079	16,684
Copper-base	52	32	Aluminum alloys	[3] 338,940	308,318
Zinc-base	[3] 354	130	In brass and bronze	166	158
Magnesium-base	200	289	In zinc-base alloys	2,279	1,880
			In magnesium alloys	329	228
Total	[3] 281,921	266,592	In chemical compounds	2,134	1,992
			Total	[3] 359,927	329,260
Old scrap:					
Aluminum-base	[1] 76,911	[2] 61,769			
Copper-base	136	104			
Zinc-base	[3] 579	530			
Magnesium-base	380	265			
Total	[3] 78,006	62,668			
Grand total	[3] 359,927	329,260			

[1] Aluminum alloys recovered from aluminum-base scrap in 1959, including all constituents, amounted to 299,872 tons from new scrap and 87,063 tons from old scrap; total 386,935 tons.
[2] Aluminum alloys recovered from aluminum-base scrap in 1960, including all constituents, amounted to 283,305 tons from new scrap and 69,784 tons from old scrap; total 353,089 tons.
[3] Revised figure.

TABLE 6.—Stocks and consumption of new and old aluminum scrap in the United States in 1960 [1]

(Short tons, gross weight)

Class of consumer and type of scrap	Stocks, Jan. 1 [2]	Receipts	Consumption			Stocks, Dec. 31
			New scrap	Old scrap	Total	
Secondary smelters: [3]						
New scrap:						
Segregated 2S and 3S sheet and clips, less than 1.0 percent Cu	1,117	17,567	17,644	----------	17,644	1,040
Segregated 51S, 52S, 61S, etc., sheet and clips, less than 1.0 percent Cu	919	16,403	16,815	----------	16,815	507
Segregated sheet and clips, more than 1.0 percent Cu (14S, 17S, 24S, 25S, etc.)	1,552	13,463	13,820	----------	13,820	1,195
Mixed alloy sheet and clips	3,489	44,520	45,949	----------	45,949	2,060
Cast scrap	498	6,190	6,221	----------	6,221	467
Borings and turnings	4,216	80,244	80,875	----------	80,875	3,585
Dross and skimmings	5,450	69,750	70,276	----------	70,276	4,924
Foil (includes both new and old)	255	2,949	3,042	----------	3,042	162
Miscellaneous	849	10,855	10,837	----------	10,837	867
Old scrap:						
Wire and cable	240	1,449	----------	1,427	1,427	262
Pots and pans	445	16,188	----------	15,571	15,571	1,062
Mixed alloy sheet	250	4,811	----------	4,770	4,770	291
Aircraft	456	5,470	----------	5,673	5,673	253
Castings and forgings	920	21,320	----------	21,273	21,273	967
Pistons	148	2,433	----------	2,462	2,462	119
Irony aluminum	1,271	13,179	----------	13,712	13,712	738
Miscellaneous	3,245	22,693	----------	23,522	23,522	2,416
Total	25,320	349,484	265,479	88,410	353,889	20,915
Primary producers:						
New and old scrap:						
Segregated 2S and 3S sheet and clips, less than 1.0 percent Cu	195	9,831	9,717	----------	9,717	309
Segregated 51S, 52S, 61S, etc., sheet and clips, less than 1.0 percent Cu	288	24,354	23,960	----------	23,960	682
Segregated sheet and clips, more than 1.0 percent Cu (14S, 17S, 24S, 25S, etc.)	139	3,559	3,497	----------	3,497	201
Mixed alloy sheet and clips	305	5,285	5,363	----------	5,363	227
Cast scrap	5	374	360	----------	360	19
Borings and turnings	54	776	791	----------	791	39
Dross and skimmings	40	12	52	----------	52	0
Foil (includes both new and old)	31	4,567	4,160	----------	4,160	438
Miscellaneous	576	5,872	6,336	----------	6,336	112
Wire and cable	1	150	----------	130	130	21
Total	1,634	54,780	54,236	130	54,366	2,048

See footnotes at end of table.

TABLE 6.—Stocks and consumption of new and old aluminum scrap in the United States in 1960 [1]—Continued

(Short tons, gross weight)

Class of consumer and type of scrap	Stocks, Jan. 1 [2]	Receipts	Consumption			Stocks, Dec. 31
			New scrap	Old scrap	Total	
Foundries, fabricators, and chemical plants:						
New scrap:						
Segregated 2S and 3S sheet and clips, less than 1.0 percent Cu	1,216	11,829	12,174		12,174	871
Segregated 51S, 52S, 61S, etc., sheet, and clips, less than 1.0 percent Cu	77	2,637	2,395		2,395	319
Segregated sheet and clips, more than 1.0 percent Cu (14S, 17S, 24S, 25S, etc.)	57	1,356	1,399		1,399	14
Mixed alloy sheet and clips	259	5,436	5,060		5,060	635
Cast scrap	563	5,577	6,024		6,024	116
Borings and turnings	4	140	142		142	2
Dross and skimmings	276	174	440		440	10
Foil (includes both new and old)	592	1,563	1,589		1,589	566
Miscellaneous	162	2,250	2,000		2,000	412
Old scrap:						
Wire and cable	0	1		1	1	0
Pots and pans	76	24		100	100	0
Mixed alloy sheet	0	46		46	46	0
Aircraft	5	54		57	57	2
Castings and forgings	75	886		916	916	45
Pistons	1	196		197	197	0
Irony aluminum	0	5		5	5	0
Miscellaneous	5	685		679	679	11
Total	3,368	32,859	31,223	2,001	33,224	3,003
Grand total of all scrap consumed:						
New scrap:						
Segregated 2S and 3S sheet and clips, less than 1.0 percent Cu	2,528	39,227	39,535		39,535	2,220
Segregated 51S, 52S, 61S, etc., sheet and clips, less than 1.0 percent Cu	1,284	43,394	43,170		43,170	1,508
Segregated sheet and clips, more than 1.0 percent Cu. (14S, 17S, 24S, 25S, etc.)	1,748	18,378	18,716		18,716	1,410
Mixed alloy sheet and clips	4,053	55,241	56,372		56,372	2,922
Cast scrap	1,066	12,141	12,605		12,605	602
Borings and turnings	4,274	81,160	81,808		81,808	3,626
Dross and skimmings	5,766	69,936	70,768		70,768	4,934
Foil (includes both new and old)	878	9,079	8,791		8,791	1,166
Miscellaneous	1,587	18,977	19,173		19,173	1,391
Old scrap:						
Wire and cable	241	1,600		1,558	1,558	283
Pots and pans	521	16,212		15,671	15,671	1,062
Mixed alloy sheet	250	4,857		4,816	4,816	291
Aircraft	461	5,524		5,730	5,730	255
Castings and forgings	995	22,206		22,189	22,189	1,012
Pistons	149	2,629		2,659	2,659	119
Irony aluminum	1,271	13,184		13,717	13,717	738
Miscellaneous	3,250	23,378		24,201	24,201	2,427
Total	30,322	437,123	350,938	90,541	441,479	25,966

[1] Includes imported scrap.
[2] Revised figure.
[3] Excludes secondary smelters owned by primary aluminum companies.

TABLE 7.—Production and shipments of secondary aluminum alloys by independent smelters [1]

(Short tons) [2]

Product	1959		1960	
	Production [3]	Shipments [4]	Production [3]	Shipments [4]
Pure aluminum (Al minimum, 97.0 percent)	16,079	16,336	16,684	16,488
Aluminum-silicon (maximum Cu, 0.6 percent)	28,566	28,169	23,947	23,903
Aluminum-silicon (Cu, 0.6 to 2 percent)	9,904	9,580	5,706	6,011
No. 12 and variations	5,844	5,818	4,011	3,862
Aluminum-copper (maximum Si, 1.5 percent)	1,649	1,659	1,000	1,117
No. 319 and variations	43,877	43,263	36,683	36,519
AXS 679 and variations	129,835	128,914	111,735	110,568
Aluminum-silicon-copper-nickel	23,101	22,860	15,348	15,312
Deoxidizing and other destructive uses	33,617	32,245	29,098	29,527
Aluminum-base hardeners	9,847	9,873	9,333	9,147
Aluminum-magnesium	2,944	2,794	1,993	2,032
Aluminum-zinc	6,803	6,683	9,545	9,362
Miscellaneous	28,444	27,827	16,881	16,494
Total	340,510	336,021	281,964	280,342

[1] Includes companies and military establishments producing aluminum "remelt" or "scrap pig."
[2] Gross weight, including copper, silicon, and other alloying elements, at independent secondary smelters; total secondary aluminum and aluminum alloy ingot contained 15,024 tons primary aluminum in 1959 and 14,105 tons in 1960.
[3] No allowance was made for consumption by producing plants.
[4] No allowance was made for receipts by producing plants.

CONSUMPTION AND USES

The total apparent consumption of aluminum decreased 19 percent to 2,015,000 short tons. Primary aluminum sold by producers and secondary aluminum recovered from old and new scrap decreased 6 and 9 percent, respectively.

Net shipments of aluminum wrought products and castings decreased 9 percent to 1,900,000 tons in 1960. Compared with 1959, shipments of extruded shapes decreased 13 percent; rolled structural shapes, 12 percent; and sand castings, 9 percent. Wrought products continued to represent 80 percent of all shipments.

The Aluminum Association survey compared percentage distribution of all mill wrought and foundry castings shipments, exclusive of die castings, to consuming industries as reported by its members. In the last quarter of 1960, 20.6 percent of the shipments went to the building products industry, 16.4 percent to transportation, 12 percent to containers and packaging, and approximately 9 percent each to consumer durable goods and electrical. Over 17 percent went to distributors and jobbers.[7]

[7] American Metal Market (Aluminum End Use), Building Products Out in Front: Vol. 68, No. 107, June 6, 1961, p. 10.

TABLE 8.—Apparent consumption of aluminum in the United States

(Short tons)

Year	Primary sold or used by producers [1]	Imports (net) [2]	Recovery from old scrap [3]	Recovery from new scrap [3]	Total apparent consumption
1951–55 (average)	1,210,825	205,220	72,631	246,115	1,734,791
1956	1,591,478	196,277	71,673	268,095	2,127,523
1957	1,579,063	195,644	72,459	289,360	2,136,526
1958	1,590,978	211,619	64,127	225,428	2,092,152
1959	[4] 1,988,560	[4] 139,828	[4] 78,006	[4] 281,921	[4] 2,488,315
1960	1,866,251	−180,057	62,668	266,592	2,015,454

[1] Includes shipments to the Government: 1957, 324,311 tons; 1958, 323,128 tons; 1959, 73,235 tons; 1960, 37,002 tons.
[2] Crude and semicrude. Includes ingot equivalent of scrap imports and exports (weight × 0.9).
[3] The 1951–53 data are recoverable aluminum-alloy content; data for subsequent years are recoverable aluminum content.
[4] Revised figure.

The following distribution for wrought products was obtained from the figures published by the Bureau of the Census:

	Percent 1959	Percent 1960
Plate, sheet, and foil:		
Non-heat-treatable	37.9	39.5
Heat-treatable	6.8	6.0
Foil	7.5	8.2
Rolled rod, bar, and wire:		
Rod, bar, etc.[1]	3.7	3.1
Bare wire, conductor and nonconductor	1.9	1.8
Bare cable (including steel-reinforced)	5.8	6.0
Wire and cable, insulated or covered	1.8	2.0
Extruded shapes:		
Alloys other than 2000 and 7000 series	27.5	26.6
Alloys in 2000 and 7000 series	1.4	1.3
Tubing:		
Drawn	2.2	2.0
Welded, non-heat-treatable	.9	[2] .8
Powder, flake, and paste:		
Atomized	.3	.4
Flaked	.2	.2
Paste	.5	.5
Forgings (including impact extrusions)	1.6	1.6
	100.0	100.0

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

TABLE 9.—Net shipments[1] of aluminum wrought and cast products by producers

(Short tons)

	1959	1960
Wrought products:		
Plate, sheet, and foil	[2] 884,259	818,628
Rolled structural shapes, rod, bar, and wire	[2] 223,324	195,893
Extruded shapes, rod, bar, tube blooms, and tubing	[2] 541,078	468,079
Powder, flake, and paste	17,442	16,411
Forgings	[2] 26,923	25,027
Total	[2] 1,693,026	1,524,038
Castings:		
Sand	70,994	64,925
Permanent mold	137,428	128,882
Die	184,050	181,676
Other	(3)	(3)
Total	393,200	376,026
Grand total	[2] 2,086,226	1,900,064

[1] Net shipments are total shipments less shipments to other metal mills for further fabrication.
[2] Revised figure.
[3] Figure withheld because estimates did not meet publication standards of the Bureau of the Census because of the associated standard error.

Source: Bureau of the Census.

The use of aluminum in 1961 automobiles showed a sharp increase above the consumption in the 1960 models. On the basis of an industrywide survey it was reported that the 1960 models used an average of 54.4 pounds of aluminum per car and that the 1961 models would contain an average of 62.8 pounds per car. Cars having aluminum engines, the Rambler, Corvair, F-85, and Special, contained from 106 to 135 pounds each.[8]

A number of articles were published in which the design and casting of aluminum engines was discussed. One of the cars had shell-molded gray iron cylinders, and the other three used centrifugally cast iron alloy cylinder liners. These latter were machined on their outer surfaces with rough corrugated surfaces. They were then inserted in the mold and the aluminum cast around them. Usually, casting-alloy 356 containing 7 percent silicon was used. One company used castings produced in permanent molds, and the other had a die casting operation.[9]

Aluminum trim applications in the automotive industry continued to increase, and aluminum was also becoming widely used in components for car air conditioners. Research was continuing on the development of alloys and fabrication techniques for producing aluminum bumpers.[10]

[8] Darby, H. K., Engine Blocks Boost Aluminum's Stake in Autos: Modern Metals, vol. 16, No. 10, November 1960, pp. 72, 74, 76, 77.
Steel, Alcoa Predicts Rising Use of Aluminum for Cars: Vol. 148, No. 3, Jan. 16, 1961, p. 52.
[9] Foundry, Diecasting and Permanent Molds: Vol. 88, No. 7, July 1960, pp. 164, 167, 168, 170.
Light Metals, The All-Aluminum Engine: Vol. 23, No. 270, November 1960, pp. 298–301.
Road & Track, The B-O-P 3.4-Liter Aluminum V-8: November 1960, pp. 22–35.
Precision Metal Molding, Aluminum in the Automobile Engine—1899 to 1960: March 1960, pp. 35–40.
[10] Rannells, Karl, Aluminum Producers Eye Auto Bumpers as Next Major Market: Am. Metal Market, vol. 67, No. 244, Dec. 22, 1960, pp. 1, 6.

Aluminum usage continued to expand in other transportation areas. Nearly 47 percent of the truck trailers produced in 1960 were aluminum, up from 39 percent in 1958. Thirty percent of the tankers were constructed of aluminum.[11] Development of applications in the railroad industry included refrigerator car floors, boxcar liners, doors, roofs, and cross members for freight cars. Other applications, advantages of using aluminum, and potential tonnages were discussed.[12]

It was estimated that in 1959, 20 million pounds of aluminum was consumed in the manufacture of 120,000 aluminum pleasure boats. Although this represented a continued growth, it appeared that plastic-Fiberglas boats were becoming more popular than the metal boats. The outlook for the two materials was compared.[13]

General Electric Company's Extra High Voltage (EHV) power line was being constructed to test the possibility of transmitting power at 500,000 and 750,000 volts. Most of the substation structurals and a number of the transmission towers being tested were fabricated of aluminum. The aluminum conductor was 2.32 inches in diameter with three times the active cross-sectional area of conductors used to transmit 220,000-volt power.[14]

In order to evaluate properly the potential applications of EC (electrical conductor) grade aluminum, data were published on the metal's elevated temperature properties. Included were fatigue, tensile, and creep data at temperatures up to 800° F.[15]

The aluminum industry continued to expand its markets in the packaging and container industry. It was estimated that over 60 percent of the 1.2 billion 6-ounce cans used for packing the 1960–61 Florida orange juice concentrate would be either all-aluminum or aluminum-body cans. Alcoa and Kaiser both announced the development of cans with tabs which are pulled for easy opening. One was all aluminum, and the other had a foil-paper laminated body and aluminum ends.[16]

Aluminum drill pipe was sold by Reynolds to an oil company for operational testing. It was reported that the new drill stem successsfully drilled wells in depths ranging to 10,400 feet. Reynolds collaborated with two oil companies in developing aluminum pellets, called Frac-Shot, used in fracturing congested geological masses to free oil or gas.[17]

It was estimated that more than 1,000 tons of aluminum would be consumed in the 600-foot-diameter radio telescope being built at the U.S. Naval Radio Research Station near Sugar Grove, W. Va. Alumi-

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[11] American Metal Market, Use for Truck Trailers Rising: Vol. 68, No. 42, Mar. 3, 1961, p. 8.

[12] Darby, H. K., How Aluminum Will Serve the Railroad Revolution: Modern Metals, vol. 16, No. 6, July 1960, pp. 76–78, 80, 82, 84, 86–89.

[13] Modern Metals, Aluminum vs. Plastics in Pleasure Boats: Vol. 16, No. 3, April 1960, pp. 30, 32, 34, 36, 38.

[14] American Metal Market, General Electric Energizes EHV Line; Aluminum Dominant: Vol. 67, No. 235, Dec. 9, 1960, p. 6.

[15] Carlson, C. L., EC Aluminum—Its Properties at Elevated Temperatures: Materials in Design Eng., vol. 51, No. 4, April 1960, pp. 117–119.

[16] Iron Age, Industry Tears the Lid Off Cans: Vol. 186, No. 10, Sept. 8, 1960, pp. 64–65.
Modern Metals, Deep Drawing Cans From Pre-Coated Sheet: Vol. 16, No. 10, November 1960, pp. 38, 40.
Church, George J., Clash Over Cans—Steel Makers Step Up Drive To Curb Gains of Aluminum Containers: Wall Street Jour., vol. 156, No. 102, Nov. 23, 1960, pp. 1, 6.

[17] American Metal Market, Tiny Aluminum Pellets Used in Preparing Oil and Gas Wells: Vol. 67, No. 171, Sept. 5, 1960, p. 6.

num structural items were to be used, and the reflecting surface was to be an expanded aluminum mesh developed especially for radio, radar, and telemetry reception.[18]

STOCKS

Primary aluminum inventories at reduction plants totaled 111,300 tons on January 1, 1960, and except for February and March increased each month thereafter. In July month-end stocks exceeded the previous high of 195,000 tons, reported in May 1957, and set a new record of 259,500 tons on December 31, 1960. December stocks were more than double the opening stocks for the year and were 33 percent above the stocks for May 1957. Based on December's production rate, 1960 closing stocks were equivalent to 49 days' output. In addition to the primary aluminum stocks reported, reduction plants also had inventories of ingot and aluminum in process.

There was little change in the inventories of secondary aluminum during 1960. Yearend stocks were 23,300 tons, only 800 tons more than those reported on December 31, 1959. Stocks were highest in August, when they were about 9 percent above the monthly average of 23,400 tons. Aluminum-base scrap inventories decreased 14 percent or 4,400 tons from the beginning of the year. The 26,000 tons of scrap held by consumers in December 1960 represented a 27-day supply based on the December consumption rate.

PRICES

There was no increase in the base price of primary aluminum in 1960. Effective August 2 the aluminum industry dropped the term "pig" and sold primary metal as "unalloyed ingot," 99.5 percent guaranteed minimum, at 26 cents per pound. Previously aluminum pig sold at 26 cents per pound in 50-pound units and ingot sold at 28.1 cents per pound in 30-pound units. In recent years there was no chemical difference between the two, and sale of the higher priced ingot was reported to be almost insignificant.

In November the price of superpurity aluminum ingot was increased 2 cents a pound to 47.5 cents.

During the year secondary smelters reduced the prices of most alloys 2 cents per pound. The changes, which were gradual, occurred from February through June and also in October. The American Metal Market listed the following closing market prices for December 30, 1960: Alloy 195, 25.75 to 26.75 cents per pound; No. 12, 22.75 to 23.25 cents per pound; and No. 380 (1 percent Zn), 23 to 24 cents per pound. All these prices were 2 cents per pound less than prices at the end of 1959. No. 355 alloy at 24.50 to 25 was off 3.25 cents.

Decreases in scrap prices occurred periodically during the year, and by the end of the year most classes were down 2 to 2.5 cents per pound. Closing market prices on December 30, 1960, according to the American Metal Market were: 2S, 3S, 51S, and 52S clips, 15.5

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[18] American Metal Market, Aluminum for Big Ear: Vol. 68, No. 3, Jan. 5, 1961, p. 10. Electronic News, 2 Million Lbs. of Aluminum Set for Navy Radio-Telescope: Vol. 5, No. 216, Aug. 15, 1960, p. 43.

to 16 cents per pound; 75S clips, 11.5 to 12 cents per pound; and aluminum borings and turnings, 13 to 14 cents per pound. Compared to prices quoted on December 31, 1959, these scrap prices decreased 2½ to 3 cents, 1½ to 2 cents, and 2 cents per pound, respectively.

FOREIGN TRADE [19]

Exports.—In 1960, for the first time since 1947, the United States became a net exporter of aluminum. Exports of ingots, slabs, and crude metal totaled 285,000 tons, up from 121,000 tons in the previous year. During the same period, imports of crude metal dropped 85,000 tons to 155,000 tons. Exports of crude, scrap, and semifabricated metal totaled 384,000 tons, and imports of such metal were 196,000 tons, resulting in a net export balance of 188,000 tons. This contrasted with a net import balance of 138,000 tons in 1959.

Over 41 percent of the crude primary metal exported went to the United Kingdom, and 27 percent was exported to West Germany. Largest scrap exports were to West Germany, 36 percent; Italy, 29 percent; and Japan, 20 percent.

Imports.—Major import sources of crude metal were Canada, 67 percent; Norway, 20 percent; and France, 7 percent. More than 3,000 tons was imported from Africa. Major sources of semifabri-

TABLE 10.—U.S. imports for consumption of aluminum, by classes

Class	1959		1960	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Crude and semicrude:				
Metal and alloys, crude	[1] 239,976	$111,259	154,706	$75,808
Circles and disks [2]	} [1] 50,628	} [1] 34,869	4,509	3,139
Plates, sheets, etc., n.e.s. [2]			26,131	19,052
Rods and bars [2]			6,037	3,681
Scrap	10,919	3,299	5,042	1,598
Total	[1] 301,523	[1] 149,427	196,425	103,278
Manufactures:				
Foil less than 0.006 inch thick	4,529	5,923	4,830	6,118
Folding rules	(3)	(4)	(3)	(4)
Leaf (5½ by 5½ inches)	(5)	13	(5)	14
Powder and powdered foil (aluminum bronze)	65	62	66	62
Powder in leaf (5½ by 5½ inches)	(6)	6		
Table, kitchen, hospital utensils, etc	2,990	4,526	3,128	4,753
Other manufactures	(7)	3,831	(7)	12,014
Total	(7)	14,361	(7)	22,961
Grand total	(7)	[4] 163,788	(7)	126,239

[1] Revised figure.
[2] Not separately classified prior to Jan. 1, 1960.
[3] Number: 1959, 300; 1960, 1,584; equivalent weight not recorded.
[4] Less than $1,000.
[5] Leaves: 1959, 5,865,141; 1960, 3,702,448.
[6] Leaves: 84,833.
[7] Quantity not recorded.

Source: Bureau of the Census.

[19] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 11.—U.S. imports for consumption of aluminum, by classes and countries

(Short tons)

Country	1959			1960		
	Metal and alloys, crude	Plates, sheets, bars, etc.	Scrap	Metal and alloys, crude	Plates, sheets, bars, etc.	Scrap
North America:						
Canada	[1] 166,797	5,436	9,090	104,070	7,647	4,403
Other			264			46
Total	[1] 166,797	5,436	9,354	104,070	7,647	4,449
Europe:						
Austria	9,517	[1] 2,052		3,364	1,518	
Belgium-Luxembourg		[1] 14,299	28	24	7,805	3
France	12,335	[1] 4,446	1,019	10,221	3,818	205
Germany, West	1,705	[1] 4,325	56	110	2,000	
Italy	7,153	[1] 5,636	17	1,109	3,613	
Norway	32,568	417		31,430	567	
Spain		234		891	912	
Sweden	100	947	245		1,091	28
United Kingdom	95	3,741	155	6	1,181	25
Yugoslavia	70	[1] 1,545		340	1,540	
Other	253	[1] 1,666	21	1	652	332
Total	63,796	[1] 39,308	1,541	47,496	24,697	593
Asia:						
Japan	(2)	5,779			4,204	
Other		85			129	
Total	(2)	5,864			4,333	
Africa	9,383			3,140		
Oceania		20	24			
Grand total: Short tons	[1] 239,976	[1] 50,628	10,919	154,706	36,677	5,042
Value, thousands	$111,259	[1] $34,869	$3,299	$75,808	$25,872	$1,598

[1] Revised figure.
[2] Less than 1 ton.

Source: Bureau of the Census.

TABLE 12.—U.S. exports of aluminum, by classes

Class	1959		1960	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Crude and semicrude:				
Ingots, slabs, and crude	[1] 121,305	[1] $53,619	284,979	$128,199
Scrap	[1] 32.164	[1] 10,384	79,513	26,905
Plates, sheets, bars, etc	9,015	9,977	18,098	16,266
Castings and forgings	1,216	2,842	1,190	2,849
Semifabricated forms, n.e.c	120	155	149	195
Total	163,820	76,977	383,929	174,414
Manufactures:				
Foil and leaf	567	852	1,318	1,787
Powders and pastes (aluminum and aluminum bronze) (aluminum content)	415	503	338	424
Cooking, kitchen, and hospital utensils	1,162	2,873	1,030	2,573
Sash sections, frames (door and window)	1,849	2,590	1,376	2,175
Venetian blinds and parts	1,312	1,656	1,504	1,852
Wire and cable	5,308	2,690	2,641	1,895
Total	10,613	11,164	8,207	10,706
Grand total	174,433	88,141	392,136	185,120

[1] Revised figure.

Source: Bureau of the Census.

cated metal were Belgium-Luxembourg, Canada, Japan, France, and Italy. Eighty-seven percent of the scrap imports were from Canada.

Tariff.—Suspension of the 1½-cent-per-pound duty on scrap was continued in 1960. There was no export quota for aluminum scrap.

TABLE 13.—U.S. exports of aluminum, by classes and countries

(Short tons)

Destination	1959			1960		
	Ingots, slabs, and crude	Plates, sheets, bars, etc.[1]	Scrap	Ingots, slabs, and crude	Plates, sheets, bars, etc.[1]	Scrap
North America:						
Canada	714	4,523	437	681	5,230	893
Cuba	87	965	4	100	251	----------
Mexico	6,189	140	7	5,231	159	16
Other	4	886	40	176	655	61
Total	6,994	6,514	488	6,188	6,295	970
South America:						
Argentina	2,573	11	----------	6,228	68	314
Brazil	37	109	----------	943	115	----------
Colombia	2,771	147	----------	2,919	340	----------
Venezuela	324	1,224	1	668	729	(2)
Other	236	221	----------	343	127	----------
Total	5,941	1,712	1	11,101	1,379	314
Europe:						
Belgium-Luxembourg	279	59	51	6,147	153	523
France	3,929	289	57	10,522	405	----------
Germany, West	[3] 18,824	9	14,024	75,650	368	28,736
Italy	1,497	161	5,242	6,512	156	22,758
Netherlands	4,219	37	495	8,239	141	334
Switzerland	4,988	5	[3] 34	8,620	63	91
United Kingdom	55,066	291	3,324	118,109	6,233	9,073
Other	6,759	509	51	11,172	1,071	399
Total	[3] 95,561	1,360	[3] 23,278	244,971	8,590	61,914
Asia:						
India	69	15	----------	915	954	1
Japan	5,459	20	8,341	8,774	216	16,152
Philippines	3,241	113	5	3,185	205	----------
Other	2,162	299	51	2,748	353	69
Total	10,931	447	8,397	15,622	1,728	16,222
Africa	151	142	----------	707	498	84
Oceania	1,727	176	----------	6,390	947	9
Grand total: Short tons	[3] 121,305	10,351	[3] 32,164	284,979	19,437	79,513
Value, thousands	[3] $53,619	$12,974	[3] $10,384	$128,199	$19,310	$26,905

[1] Includes plates, sheets, bars, extrusions, castings, forgings, and unclassified "semifabricated forms."
[2] Less than 1 ton.
[3] Revised figure.

Source: Bureau of the Census.

WORLD REVIEW

World production of aluminum was estimated at 5 million short tons, 11 percent above 1959. All major producing countries showed increases. Free world countries producing more than 100,000 tons of metal and showing increases of more than 10 percent over 1959 were: France, 36 percent; Japan, 33 percent; Canada, 28 percent; Norway, 13 percent; and West Germany, 12 percent. Production in the free world, 4 million tons, was 80 percent of world output.

The 1960 production, which was 3.1 times as great as that of 1950, corresponded to a 12 percent increase compounded annually over the decade. The upward trend had been continuous since 1947.

TABLE 14.—Changes in world aluminum productive capacity [1]

(Short tons)

A. FREE WORLD

Country, company, and plant location	Annual capacity 1960
North America:	
Total United States	2,468,750
Total North America	3,346,750
South America:	
Brazil: Aluminio Minas Gerais, S.A.[2]	(3)
Europe:	
Austria: Salzburger Aluminium G.m.b.H.—Lend	11,000
Total	85,000
France:	
Pechiney, Compagnie de Produits Chimiques et Électro-Metallurgiques—Noguères (Hautes-Pyrénées)	61,700
Société d'Électro-Chimie, d'Électro-Metallurgie et des Aciéries Électriques d'Ugine:	
Lannemezan (Hautes-Pyrénées)	38,600
Les Clavaux (Isère) [4]	----------
Total	274,100
Norway:	
A/S Aardal og Sunndal Verk—Aardal	72,800
A/S Norsk Aluminium Co—Hoyanger	15,400
A/S Mosjøen Aluminium—Mosjøen	35,300
Total	208,000
Spain:	
Aluminio de Galicia, S.A.—La Coruna [5]	7,700
Aluminio Espanol, S.A.—Sabinanigo (Huesca) [5]	(3)
Total	34,600
Total Europe	1,007,900
Asia:	
Japan:	
Showa Denko K.K.:	
Kitikata	37,500
Omachi	13,300
Nippon Keikinzoku K.K.—Niigata	31,900
Sumitomo Kagaku K.K.:	
Kikumoto	29,800
Nagoya	13,000
Total	168,500
Total Asia	199,200
Australia: Aluminium Production Corp. Ltd.—Bell Bay [6]	(3)
Total free world	4,638,550

B. SOVIET BLOC

U.S.S.R.: Stalingrad	220,500
Total	935,500
Poland: Skawina Aluminium Works	50,000
Total Soviet bloc	1,233,600
Total world	5,872,150

[1] Changes to up-date table 14—Producers of aluminum, in the Aluminum Chapter of the 1959 Minerals Yearbook.
[2] Formerly Eletro-Quimica Brasileira, S.A.
[3] No change.
[4] Plant no longer produces aluminum ingot.
[5] Jointly owned by Kaiser, Pechiney, and Spanish interests, with the latter holding the majority ownership.
[6] Comalco Industries Pty., Ltd., ⅔ and the Tasmanian Government ⅓ ownership.

TABLE 15.—World production of aluminum by countries [1]

(Short tons)

Country [2]	1951-55 (average)	1956	1957	1958	1959	1960
North America:						
Canada	533,148	620,321	556,715	634,102	593,630	761,357
United States	1,210,502	1,678,954	1,647,709	1,565,557	1,954,112	2,014,498
Total	1,743,650	2,299,275	2,204,424	2,199,659	2,547,742	2,775,855
South America: Brazil	1,282	6,920	9,794	13,102	19,950	[3] 30,900
Europe:						
Austria	46,688	65,490	62,125	62,716	72,271	74,924
Czechoslovakia	[4] 15,616	23,400	18,400	29,100	[3] 38,600	[3] 44,000
France	123,154	165,125	176,290	186,415	190,695	259,263
Germany:						
East	15,894	37,800	[3] 38,100	[3] 37,500	[3] 38,600	[3] 44,000
West	120,773	162,439	169,576	150,759	166,631	186,221
Hungary	31,577	38,375	27,650	43,560	50,400	54,564
Italy	60,950	70,225	72,981	70,603	82,658	92,206
Norway	63,404	101,349	105,430	133,777	160,881	182,304
Poland	[5] 14,110	24,000	22,443	24,738	25,143	28,640
Rumania [3]	[6] 6,200	8,800	11,000	11,200	11,000	11,000
Spain	4,389	14,283	16,721	17,769	24,959	32,268
Sweden (includes alloys)	9,991	13,734	14,958	15,113	17,086	[3] 19,000
Switzerland	30,605	33,180	34,238	34,723	37,886	43,795
U.S.S.R.[3]	334,000	500,000	550,000	605,000	690,000	745,000
United Kingdom	31,964	30,892	32,933	29,517	27,381	32,390
Yugoslavia	5,110	16,162	19,989	23,899	21,214	27,635
Total [3]	915,000	1,305,000	1,375,000	1,475,000	1,655,000	1,880,000
Asia:						
China (Manchuria) [3]	[5] 7,200	11,000	22,000	29,800	77,600	88,100
India	5,208	7,281	8,718	9,167	19,131	20,123
Japan	51,957	72,754	74,934	93,231	110,385	146,864
Taiwan	5,704	9,655	9,104	9,455	8,251	9,106
Total [2 3]	70,100	100,700	114,800	141,700	215,400	264,200
Africa: Cameroun, Republic of	-----	-----	8,300	35,121	46,644	[3] 47,000
Oceania: Australia	[6] 1,398	10,240	11,899	12,196	14,392	13,054
World total (estimate) [1 2]	2,730,000	3,720,000	3,725,000	3,875,000	4,500,000	5,010,000

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] In addition to countries listed, North Korea may have produced a negligible quantity of aluminum.
[3] Estimate.
[4] Average for 1953-55.
[5] Average for 1954-55.
[6] One year only as 1955 was the first year of production reported.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

NORTH AMERICA

Canada.—Aluminum Company of Canada, Ltd. (Alcan), operated at an average production rate of 85 percent of capacity during the year. Work was resumed toward completion of buildings at the Kitimat, British Columbia, plant where construction was suspended in 1957. The buildings were eventually to house smelter potlines of about 80,000-tons capacity.

Aluminium Laboratories, Ltd., announced that after many years' work a basically new process for producing aluminum was developed. A pilot plant of 6,000 to 8,000 short tons was being built at Arvida, Quebec, and was scheduled for completion in 1962. This development is discussed further in the section on technology of this chapter.

Canadian British Aluminium Co., Ltd., reported that, owing to technical operating difficulties, 1960 production was approximately 3,500 tons below the plant's rated capacity of 90,000 tons a year. It also was announced that Canadian British was to terminate, effective December 31, 1961, its contract to obtain alumina from Alcan. A new alumina supply contract was negotiated with Reynolds Metals Co.

SOUTH AMERICA

Argentina.—Pechiney, Compagnie de Produits Chimiques et Electro-Metallurgiques, the French company, was reported to be negotiating with the Argentine Government for the establishment of a 27,500-short-ton aluminum plant. Kaiser also was interested in the project.[20]

Kaiser Aluminum International and Guillermo Decker, S.A., a manufacturer of nonferrous products in South America, organized a new company, Industrias Manufactureras del Aluminio, S.A. The company was to build a plant to manufacture mill produces for the building, consumer durables, container, and transportation industries. The plant, which was to cost $7 million, was to be at Abasto, 25 miles from Buenos Aires.

Brazil.—Aluminio Minas Gerais, S.A., a subsidiary of Aluminium, Ltd., formerly called Eletro-Quimica Brasileira, S.A., began work on a new extension to its Saramenha plant in Ouro Preto, which would increase its annual capacity from 9,700 to 14,000 short tons by the end of 1961. It was planned to expand the plant by an additional 5,000 tons a year as demand increased.

Companhia Nacional de Aluminios planned a 22,000-ton-per-year plant at Pocos de Caldas to be completed in 1963. The company was formed by Aluminum Company of America, 45 percent interest; Byington interests (Brazilian), 35 percent interest; and M. A. Hanna Co., 20 percent interest. It was estimated that the initial investment would range between $39 and $41 million.[21]

Surinam.—The Brokopondo hydroelectric and smelting plant project of Suriname Aluminum Co. continued on schedule, and the 45-mile road from Paranam to Affobakka was completed and opened to traffic. Work on the dam at Affobakka was started in August.

Venezuela.—Reynolds Metals Co. concluded an agreement with the Venezuelan Government for the formation of Aluminio del Caroni, S.A., to build and operate a 25,000-ton-per-year plant, costing $30 million, in the Caroni region in southeastern Venezuela. The company was to be financed jointly by Reynolds and a government-owned company. Bauxite was to be imported, and power would be obtained from the Caroni hydroelectric plant.[22]

EUROPE

Members of the European Economic Community (E.E.C.) and the European Free Trade Association (E.F.T.A.) reportedly agreed on tariffs for aluminum and aluminum semifabricated products. The six members of E.E.C., West Germany, France, Italy, Belgium, Luxembourg, and the Netherlands, set the tariff on unwrought aluminum entering the Community at 10 percent ad valorem and at 15 percent

[20] Rice, Walter L., Aluminum Production Hits Record High But Is Still 12 Percent Below Capacity: Min. World, Apr. 25, 1961, pp. 68–69.
[21] Bureau of Mines, Mineral Trade Notes: Vol. 51, No. 5, November 1960, p. 5.
[22] Metal Bulletin (London), Caroni Plant Decision: No. 4558, Dec. 30, 1960, p. 23.

on semifabricated aluminum. E.F.T.A. members, other than Portugal—Austria, Norway, Sweden, Switzerland, United Kingdom, and Denmark—permitted each country to set its own tariff on imports from nonmember countries. Both the E.E.C. and E.F.T.A. provided for elimination of tariffs over a 10- to 13-year period on aluminum imports from other members of each organization.[23]

Data were reported on the 1959 consumption of aluminum by end uses in 10 countries of the Organisation for European Economic Cooperation. Between 1958 and 1959, consumption in these countries increased 14 percent from 1.02 million tons to 1.17 million tons. The major consuming countries showed the following increases: United Kingdom, 16 percent; West Germany, 16 percent; France, 10 percent; and Italy, 15 percent. During 1959, the industries consuming the largest quantities of aluminum were: Transportation, 28 percent; and electrical engineering, 13 percent. Packaging, machinery and equipment, building and construction, and home and office appliances each accounted for approximately 10 percent of the total consumption.

TABLE 16.—Aluminum consumption by end-uses—1959 [1]

(Short tons)

	West Germany	France	Italy	United Kingdom	All other [2]	Total
Transportation	84,105	74,277	50,706	109,065	13,944	332,097
Machinery and equipment	40,234	19,546	8,818	24,008	19,977	112,583
Electrical engineering	45,635	33,263	8,818	35,218	30,511	153,445
Building and construction	20,944	13,230	12,566	25,368	39,076	111,184
Packaging	39,132	19,533	11,023	30,654	19,520	119,862
Home and office appliances	15,101	22,420	11,023	44,155	13,972	106,671
All other [3]	74,957	34,665	17,086	71,933	33,120	231,761
Total	320,108	216,934	120,040	340,401	170,120	1,167,603

[1] Organisation for European Economic Cooperation, Non-Ferrous Metals Statistics, November 1960, pp. 141-146.
[2] Includes Netherlands, Sweden, Austria, Norway, Belgium, and Switzerland.
[3] Includes chemical, food, and agricultural appliances; powder, iron, steel, and other metal-producing industries; metal industries not elsewhere specified; and miscellaneous.

Austria.—Salzburger Aluminium G.m.b.H. announced that it would expand annual capacity of its Lend plant to 11,000 tons by replacing old reduction cells.

France.—As a result of the opening of two plants in the Lacq area, aluminum production of 259,000 tons was an increase of 36 percent over the record high of 1959. The Noguères plant of Pechiney, with a capacity of 61,700 short tons, and the new Lannemezan plant of Ugine, with a capacity of 27,000 short tons a year, began operating during the year. Pechiney began expanding the Noguères plant and when completed in 1961, the plant was to have a capacity of 92,600 tons, Ugine closed its Les Clavaux plant at the end of 1959.

The new plant at Lannemezan had 144 cells which operated at 70,000 amperes. Soderberg vertical-pin anodes were used, and the

[23] Mining Journal (London), vol. 254, No. 6496, Feb. 19, 1960, p. 214.
Mining Engineering, Foreign Aluminum News: Vol. 12, No. 10, October 1960, p. 1066.
Light Metals (London), Aluminum and the European Free Trade Association: Vol. 23, No. 261, February 1960, p. 48.
Gregory, Richard T., Trade Group Rivalry Seen Sparking W. European Economy: Am. Metal Market, vol. 67, No. 139, July 21, 1960, p. 9.

coke and pitch for the anodes were imported from West Germany. The plant had an operating force of 350 employees.[24]

A 5,000-ton pilot plant was built by Pechiney and Ugine at Noguères for the production of aluminum through thermal reduction. This development is discussed further in the section on technology of this chapter.

An article describing the role of Lacq gas in the development of the aluminum industry stated that during the past 10 years production of aluminum had increased almost fourfold.[25]

French aluminum prices increased 4.9 percent on July 18. Price controls for primary ingots and calcined alumina were lifted by the Government on July 29.

Exports of 76,000 short tons of aluminum were more than double those of 1959. The chief importing countries were Belgium with 36,000 tons; the United States, 15,000 tons; Argentina, 3,000 tons; West Germany, 1,700 tons; and Italy, 800 tons.

Germany, West.—Vereinigte Aluminium-Werke A.G. began constructing a 44,000-ton-per-year reduction plant at Norf, 10 kilometers from the Erftwerk plant. The plant, to cost approximately US$33 million, was scheduled for completion in 1963. The plans provided for an additional 22,000-ton expansion if needed.[26] Power was to be supplied from the Frimmersdorf plant, which was being expanded to meet the added requirement of the reduction plant.

The duty-free import quota for primary aluminum was 57,300 short tons in 1960.

Greece.—The establishment of a US$75 million aluminum complex in Greece was agreed upon by the Government and American, French, and Greek companies. Pechiney was to have a 50-percent interest in the enterprise; Stavros Niarchos, 21 percent; Reynolds International Inc., 17 percent; and the Industrial Development Corp. of Greece, 12 percent. The project, scheduled for completion during the first half of 1964, was to include a 110,000-ton-per-year alumina plant, a 57,900-ton-a-year aluminum plant, and two ancillary hydroelectric plants on the Akheloos river with a combined capacity of 150,000 kilowatts. The power was to be supplied at $0.0036 a kilowatt-hour for the period commencing from the repayment of the corporation's debts or at the latest from the 16th year of operation. Prior to this time, the rate was to vary from $0.003 to $0.0036.

Norway.—Despite power shortages, aluminum output increased 13 percent over the record high of 1959. A/S Aardal og Sunndal Verk announced plans for a new 110,000-ton-per-year aluminum plant to be built within 3 years. Work continued on the company's expansion plans already underway, and the first of the new cells was to go into production in the fall of 1961. This expansion was to raise the plant's capacity from 69,600 tons to 110,000 tons a year. Capacity of the Mosjøen plant was increased 7,800 tons, to 35,300 tons, during the

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[24] Journal du Four Électrique et des Industries Electro-Chimiques (Paris), L'Usine d'Aluminium de Lannemezan (France): Vol. 65, No. 6, November–December 1960, pp. 263–266.

[25] Baudart, G. A., Le Rôle du Gaz de Lacq dans les Récents Développements de l'Industrie de l'Aluminium en France: Rev. de l'Aluminium (Paris), No. 283, January 1961, pp. 55–59.

[26] American Metal Market, Lack of Hydro Power No Barrier as Germany Builds New Smelter: Vol. 67, No. 237, Dec. 13, 1960, p. 4.

year. A/B Svenska Metallverken of Sweden announced its interest in building an aluminum plant at Trondheim.

The historical background of the Norwegian aluminum industry was discussed, and the two Government-owned plants, one at Aardal and the other at Sunndalsora, were described in detail.[27]

Poland.—The two-stage expansion of the Skawina works was completed by the end of 1960. The annual capacity, which was 25,000 tons at the beginning of the year, was increased to 36,000 tons in October and further expanded to 50,000 annual tons in December.[28]

Spain.—Aluminum production reached a new high of 32,000 short tons. Previously, Spain had imported 22,000 to 33,000 tons of aluminum a year, in 1960 about 20,000 tons was exported.

The La Coruna plant of Aluminio de Galicia, S. A., with an annual capacity of 7,700 short tons, was completed in the spring and was to be enlarged to 8,250 tons by 1962.[29]

ASIA

India.—Madras Aluminium Co. was registered to build an integrated aluminum plant in Mettur, Salem district, Madras. The plant was to have an annual capacity of 11,000 short tons, 8,800 of which was to be used to fabricate products and the remainder to produce ingots. Bauxite from the Shevroy deposits was to be used. Montecatini, Soc. Generale per l'Industria Mineraria e Chimica, of Italy was to contribute part of the capital and the machinery.[30]

Construction of the Hindustan Aluminium Corp., Ltd. plant at Pipri, in the Mirzapur district of Uttar Pradesh, was begun, and completion was scheduled for 1962. The plant was within 2 miles of the Rihand dam and power station and near the Amarkantak bauxite deposits in the Vindhaya mountains in Madhya Pradesh and in the Lohandaga area of Bihar State. The company was jointly owned by Kaiser, the Birla interest of India, and the general investing Indian public. Kaiser's interest was approximately 27 percent.

The Hirakud smelter of Indian Aluminium Co., Ltd., the capacity of which was being doubled to 22,400 short tons a year, was to be further expanded to 30,000 tons by April 1962.

In March, for the first time, the Indian Government levied an excise duty of approximately 10 percent on aluminum production. On the basis of recommendations by the Indian Tariff Commission, the protective duty of 35 percent ad valorem was continued on all forms of aluminum imports until December 31, 1964.

Japan.—Production of primary aluminum continued its upward trend and was 33 percent more than that of 1959. The three producing companies had the following plans for expansion, Nippon Keikinzoku K.K., in addition to expanding its plant capacity at Kambara by 24,000 short tons a year, was to build a new 55,000-ton-a-year

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[27] Metal Industry (London), Aluminium in Norway: Vol. 97, No. 5, July 29, 1960, pp. 83–86.

[28] Metal Bulletin (London), Skawina Expansion: No. 4525, Sept. 2, 1960, p. 24.

[29] Metal Industry (London), Aluminium in Spain: Vol. 98, No. 3, Jan. 20, 1961, p. 55.

[30] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 2, February 1960, p. 3.
Journal of Mines, Metals and Fuels (Calcutta), Madras Aluminium Project: Vol. 8, No. 10, October 1960, p. 31.

plant at Shimizu in central Japan; Showa Denko K.K. planned to build a new 66,000-ton-a-year plant in Goi, near Tokyo; and Sumitomo Kagaku K.K. planned to build a 66,000-ton-a-year plant at Sakai near Osaka. Mitsubishi Chemical Industries, Ltd., a producer during World War II, outlined plans for building a new reduction facility at Naoyetsu, northern Japan.[31]

AFRICA

Angola.—Official approval was granted Aluminio Portugues (Angola), S.A.R.L., to establish an aluminum plant at Dondo. The plant, with an initial capacity of 27,500 short tons, was expected to begin operating in late 1962.

Ghana.—Under an agreement signed between Kaiser and the Ghanian Government in November, Volta Aluminium Co., Ltd., (Valco) was to raise $178 million to build an aluminum smelter. The Government was to supply power for the smelter from a $168 million dam to be built on the Volta River. The agreement also called for the production of about 202,000 short tons of aluminum annually before 1966. It was further announced that the Government would not increase the company's rate of taxation for 30 years and that the company would benefit from a tax-free 10-year period.

In December, Aluminum, Ltd., decided not to participate in Valco. The remaining participants were Kaiser, Alcoa, Olin Mathieson Chemical Corp., and Reynolds.

OCEANIA

Australia.—Consolidated Zinc Corp., Ltd., bought British Aluminium's share in the jointly owned Commonwealth Aluminium Corp. Pty., Ltd., thus dissolving their partnership formed to develop Australian bauxite resources. Subsequently, Kaiser joined with Consolidated Zinc as an equal partner in Comalco Industries Pty., Ltd., to undertake the development of an integrated aluminum industry in Australia and New Zealand. The project, scheduled for completion in 1966, included (1) development of the Weipa bauxite deposits on Cape York peninsula in Queensland; (2) construction of an alumina plant at Weipa with an annual capacity of 403,200 short tons; (3) expansion of the Bell Bay aluminum plant in Tasmania from 13,400 to at least 31,400 short tons a year; (4) development of hydroelectric power with an initial output of 280,000 kilowatts, using waters of Lakes Te Anau and Manapouri in New Zealand; (5) construction of a new reduction plant having an annual capacity of 134,400 short tons at Bluff, South Island, New Zealand; and (6) establishment of fabricating facilities in Australia. The Bell Bay smelter, which had been owned jointly by the Federal and Tasmanian Governments, was sold to a company owned jointly by Consolidated Zinc (two-thirds) and the Tasmanian Government (one-third). Consolidated Zinc's share

[31] American Metal Market, Mitsubishi Outlines Plans for New Aluminum Smelter: Vol. 67, No. 248, Dec. 29, 1960, p. 6.

in the new company, Aluminum Production Corp., Ltd., subsequently came under the control of Comalco Industries.[32]

A survey by the Australian Department of Trade pointed out that estimated consumption of primary aluminum in 1965 could rise to 52,500 short tons, nearly double that of 1957–58.[33]

TECHNOLOGY

In an article on technological advances in aluminum reduction it was anticipated that consumption of electrical energy per pound of aluminum would, during the 1960 decade, approach 6.8 kilowatt-hours. From 1940 to 1950 energy consumption was approximately 7.7 kilowatt-hours per pound and from 1950 to 1960, it was 7.3 kilowatt-hours per pound. It was noted that decreases in cell voltages resulting in part from use of larger cells and decreases in current losses through use of larger and welded bus bars have contributed significantly to lower energy requirements.[34]

Data from the 1958 Census of Manufactures show that from 1947 to 1958 manpower requirements in the production of aluminum decreased from 28.0 to 17.7 man-hours per ton.

TABLE 17.—Productivity in the aluminum industry

Year	Production workers [1]		Production (thousand short tons)	Man-hours per ton produced
	Number	Thousand man-hours		
1947	7,336	16,014	572	28.0
1949	7,314	16,769	603	27.8
1950	8,869	18,215	719	25.3
1951	10,133	21,991	837	26.3
1952	11,735	24,923	937	26.6
1953	16,726	34,183	1,252	27.3
1954	16,982	35,335	1,461	24.2
1955	16,382	33,886	1,566	21.6
1956	17,046	34,752	1,679	20.7
1957	16,327	33,430	1,648	20.3
1958	13,428	27,738	1,566	17.7

[1] U.S. Bureau of the Census, U.S. Census of Manufactures, 1958, Smelting and Refining of Nonferrous Metals and Alloys; Industry report MC58(2)-33C, U.S. Government Printing Office, Washington, D.C. The figures for 1949-53 and 1955-57 represent estimates derived from a representative sample of manufacturing establishments canvassed in the Annual Survey of Manufacturers.

In the United States, improvements in the design of both Soderberg and prebaked anode cells since World War II had resulted in increased cell sizes. Also, there had been improvements through mechanization of anode adjustment, mechanization of Soderberg anode stud changing, and the use of mechanical crust breakers in the alumina

[32] American Metal Market, Australian Partnership Dissolved: Vol. 67, No. 181, Sept. 20, 1960, pp. 1, 6.
Metal Bulletin (London), Bell Bay Changes Hands: No. 4525, Sept. 2, 1960, p. 24.
Light Metals (London), vol. 23, No. 269, October 1960, p. 260; No. 271, December 1960, p. 320.

[33] Department of Trade (Melbourne), Industry Study Series, The Australian Aluminium Industry: May 1960, 30 pp.

[34] Ginsberg, Hans, Concerning Chemical Technology of Aluminum: Ztschr. Erzbergbau u. Metallhuettenw. [Per. for Ore Min. and Metal Smelting], vol. 13, No. 1, January 1960, pp. 1–6.

feeding operation. However, development of larger cells resulted in shorter cell life and increased problems from electromagnetic effects, and, as a result of a smaller area-to-volume ratio, intensified the problem of removing heat from the cell. Two methods proposed for solving these problems were modification of the electrolyte to permit use of higher current density and lower operating temperatures and use of new materials of construction for cell lining.[35]

One refractory that showed promise for use in the reduction cell was silicon-nitride-bonded silicon carbide, which has good thermal conductivity and low electrical conductivity coupled with a high resistance to attack by molten aluminum and cryolite. Titanium diboride resists attack by the cell electrolyte but has electrical conductivity comparable to mild steel and was being evaluated for use in reduction cells as cathode lead-ins.[36] Research also resulted in the development of new high-alumina refractories designed specifically for use in aluminum melting furnaces, especially where contamination of the melt must be minimized.[37]

Results of basic studies of the properties of the electrolyte in the reduction cell were reported. Haupin stated that the so-called "metal mist" in the electrolyte forms in the presence of moisture and consists of hydrogen bubbles containing a small partial pressure of aluminum monofluoride, sodium, and sodium tetrafluoroaluminate.[38] A reaction mechanism was proposed for the solution of alumina in cryolite,[39] and liquids curves were determined, by means of cooling curves, for cryolite-alumina-aluminum fluoride and for the cryolite-rich part of melts containing cryolite, alumina, calcium fluoride, and aluminum fluoride.[40]

In addition to research on recovery of aluminum by the electrolytic method, results of studies of other methods of recovering the metal were reported. Information developed by the Federal Bureau of Mines indicated that clay and similar aluminum silicates can be smelted successfully in a three-phase arc furnace when the major part of the reductant comprises wood chips. It was found that aluminum-silicon alloys containing as much as 55 percent aluminum could be produced by smelting natural aluminum silicates. Maintenance of the proper carbon balance in the furnace charge was found to be extremely important in the smelting operation.[41]

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[35] Lewis, Robert A., Trends in Aluminum Cell Design: Chem. Eng. Prog., vol. 56, No. 5, May 1960, pp. 78–82.

[36] Steel, Space Age Material Solves Mundane Problems Too: Vol. 147, No. 23, Dec. 5, 1960, p. 108.

Modern Metals, New Refractory May Reduce Aluminum Production Costs: Vol. 16, No. 8, September 1960, pp. 40, 42.

Chemical Week, Cost Bonus Backs Refractory's Opening Bid: Vol. 87, No. 6, Aug. 6, 1960, p. 73–74.

[37] Industrial Heating, Kaiser Low-Silica Aluminum Melting Refractory: Vol. 27, No. 8, August 1960, p. 1699.

Industrial Heating, Phosphate, and Ceramic Bonded High Alumina Refractories Developed for Aluminum Melting Furnaces: Vol. 27, No. 8, August 1960, pp. 1694, 1696.

[38] Haupin, Warren E., Metal Mists and Aluminum Losses in the Hall Process: Jour. Electrochem. Soc., vol. 107, No. 3, March 1960, pp. 232–236.

[39] Foster, Perry A., Jr., Frank, William B., The Structure of Cryolite-Alumina Melts: Jour. Electrochem. Soc., vol. 107, No. 12, December 1960, pp. 997–1001.

[40] Fenerty, Anne, and Hollingshed, E. A., Liquidus Curves for Aluminum Cell Electrolyte: Jour. Electrochem. Soc., vol. 107, No. 12, December 1960, pp. 993–997.

[41] Fursman, Oliver C., and Banning, Lloyd H., Experimental Smelting of Aluminum Silicates To Produce Aluminum-Silicon Alloys: Bureau of Mines Rept. of Investigations 5575, 1960, 23 pp.

Production of aluminum-silicon alloys by thermal reduction was discontinued in West Germany at the end of World War II and had not been resumed. However, the process had been reevaluated. Its advantages and disadvantages were enumerated and the basic reactions investigated.[42]

Two major factors in the world aluminum industry, Aluminum Ltd. of Canada and Pechiney of France, announced plans to construct experimental plants for producing aluminum by nonelectrolytic methods.

Aluminium, Ltd., planned a plant with a capacity of 6,000 to 8,000 tons of aluminum a year and costing approximately $4 million. The process to be used was not described, but the company said that bauxite would be the source of aluminum and that the unit energy requirement would not be reduced appreciably from that of the conventional process. However, substantial savings were expected in other elements of production cost and in the capital investment required per unit of capacity. Based on patents assigned to Aluminium Laboratories, Ltd., it appeared that the subhalide process was to be used.[43] In this process crude aluminum metal is treated, at approximately 1,000° C., with $AlCl_3$ to produce gaseous AlCl. The temperature is then reduced to 700° C. with the result that the AlCl decomposes to aluminum metal and $AlCl_3$ which is recycled.

The experimental plant to be built by the two French producers, Pechiney and Ugine was to have an annual capacity of 5,000 tons. It was reported that a two-stage carbothermic process for reducing aluminum oxides was to be tested. In the first stage aluminum oxide is produced by carbothermic reduction of bauxite. In the second stage the oxide is reduced to a mixture of aluminum and aluminum carbide in an electric furnace in the presence of carbon. The metal-carbide mixture is then separated, and the aluminum carbide is recycled.[44] A patent also was issued to Pechiney on the production of aluminum by decomposing aluminum nitride.[45]

The properties and specifications of electrode pitch, used as a binder in the preparation of carbon anodes, were discussed. Modification of pitch properties and details of laboratory work on thermal treatment were given. Design of plants for thermal treatment of pitch also was reviewed.[46]

An extensive series of articles, based on information supplied by Aluminium Laboratories, Ltd., discussed the welding of aluminum in considerable detail. The two most widely used methods of welding aluminum, metal-inert-gas (MIG) method or tungsten-inert-gas (TIG), method were described in detail, and their advantages, disad-

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[42] Schmitt, H., and Wittner, H., Concerning the Thermal Manufacture of Aluminum-Silicon Alloys With High Aluminum Content: Ztschr. Erzbergbau u. Metallhuettenw. [Per. for Ore Min. and Metal Smelting], vol. 13, No. 10, October 1960, pp. 471–477.

[43] Johnston, Alan H., and Southam, Frederick William (assigned to Aluminium Laboratories, Ltd., Montreal, Canada), Recovery of Aluminum in Subhalide Distillation: U.S. Patent 2,914,398, Nov. 24, 1959.

Johnston, Alan H., Bohmer, Hans Otto, Phillips, Norman W. F., and Southam, Frederick William (assigned to Aluminium Laboratories, Ltd., Montreal, Canada), Conversion Process for Aluminum Subhalide Distillation: U.S. Patent 2,937,082, May 17, 1960.

[44] Mercier, Jean (assigned to Pechiney, Paris, France), Reduction of Alumina: U.S. Patent 2,974,032, Mar. 7, 1961.

[45] Assigned to Pechiney Compagnie De Products Chimiques et Electrometal-lurgiques, Improvements in or Relating to the Production of Aluminium: British Patent 842,726, July 27, 1960.

[46] Thomas, B. E. A., Electrode Pitch: Gas World, Apr. 2, 1960, pp. 51–66.

vantages, and equipment costs were compared. Information on resistance, oxy-gas, and metal-arc welding methods as well as on torch, furnace, and dip brazing operations also was presented. Two articles in the series reviewed pre- and post-weld operations and supervision and safety, quality control including inspection and testing of welded joints, and weld faults and possible corrective measures. The final paper of the series described the detrimental effect of the heat of welding on the mechanical properties of the alloys welded. It was pointed out that as welding equipment, processes, techniques, alloys, design and joint efficiency improve, this detrimental effect is reduced. Selection of alloys and methods of compensating for loss of strength through design were covered.[47]

Experimental and recently developed welding processes were described. Methods in which aluminum specifically was mentioned were electron-beam, high-frequency, resistance, ultrasonic, percussion, forge, and friction welding. Most of these methods were reported to be potentially useful in welding dissimilar metals.[48]

Casting aluminum was the subject of a number of articles. Six of the most widely used continuous processes were summarized, and the advantages and disadvantages of each were enumerated.[49] A recently developed method of continuous horizontal casting of aluminum, the Ugine Venthon process, was described. Horizontal casting is based on either the solidification of the metal in a mobile-walled mold to eliminate relative movement between the mold wall and the metal, or solidification in a fixed-wall mold through which the metal is drawn as it freezes. The Ugine Venthon process, first developed for casting aluminum bus bars, uses the latter method.[50]

In the production of aluminum castings, gating and risering are closely interdependent processes. The size, shape, and location of gates often are dictated by risering, and gating must be considered when the risering is selected. Methods and principles underlying gating and risering design with the objective of producing sound high-quality aluminum castings were discussed.[51]

The low-pressure casting process, a technique intermediate between die casting and permanent-mold casting, was used in the new aluminum foundry of the Chevrolet Motor Division of General Motors Corp. near Massena, N.Y., to cast cylinder heads, crankcase halves, and rear engine housings. In this process, the metal is displaced upward under differential air pressure from a holding furnace beneath

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[47] Modern Metals, Welding Aluminum, Pt. 1, General Welding Processes: Vol. 16, No. 4, May 1960, pp. 78, 80, 82; Pt. 2, The Tungsten-Inert-Gas Process, No. 5, June 1960, pp. 50, 52–54, 56, 60; Pt. 3, The Metal-Inert Gas Process, No. 6, July 1960, pp. 62, 64, 66, 68, 70, 72; Pt. 4, A Comparison-MIG vs. TIG, No. 7, August 1960, pp. 46, 48, 50; Pt. 5, Resistance Welding, No. 8, September 1960, pp. 70–72, 74, 78, 80–82; Pt. 6, Oxy-Gas and Metal Arc Welding, No. 9, October 1960, pp. 66, 68, 72, 74; Pt. 7, Torch, Furnace and Dip Brazing, No. 10, November 1960, pp. 62–64, 66, 67, 70; Pt. 8, Pre- and Post-Weld Operations, No. 11, December 1960, pp. 38, 40, 42, 44; Pt. 9, Weldor Supervision and Safety, No. 12, January 1961, pp. 72–74, 78, 80; Pt. 10, Quality Control, vol. 17, No. 10, February 1961, pp. 58–63; Pt. 11, Mechanical Properties of Welds, No. 20, March 1961, pp. 32–37.

[48] Merriam, Jack C., The New Welding Processes: Materials in Design Engineering, vol. 51, No. 1, January 1960, pp. 105–120.

[49] Fear, G. C., Continuous Casting of Aluminum: Jour. Metals, vol. 12, No. 1, January 1960, pp. 37–41.

[50] Angleys, P., Ugine Venthon Process: Jour. Metals, vol. 12, No. 1, January 1960, p. 42.

[51] Taylor, Howard F., Flemings, Merton C., and Piwonka, Thomas S., Risering—Aluminum Castings: Foundry, vol. 88, No. 5, May 1960, pp. 216–217, 219, 222, 224, 226.

Flemings, Merton C., and Taylor, Howard F., Gating—Aluminum Castings: Foundry, vol. 88, No. 4, April 1960, pp. 72–78.

the die assembly instead of being poured from a ladle. Advantages claimed for the process were high-density structure, high yield due to elimination of large gates and risers, high productivity, low equipment costs, and clean castings.[52]

An integrated casting plant was described. To increase efficiency of continuous melting furnaces, automatic pouring and turntable-mounted molds were utilized.[53] In the diecasting plant, extensive use was made of continuous melting furnaces, unit dies, and conveyors for moving the castings.[54]

The removal of hydrogen and entrapped oxides from molten aluminum by the use of special equipment for flushing with nitrogen or the use of nitrogen-chlorine mixtures was described. It was reported that a 90-percent nitrogen, 10-percent chlorine mixture gave the most satisfactory results.[55] The use of carbon dioxide in hardening molds and cores was discussed. In this operation sodium silicate is used as the binder for the sand. Carbon dioxide then reacts with sodium silicate to form sodium carbonate and silica.[56]

Data were reported on both low-temperature (cryogenic) and high-temperature properties of aluminum alloys. Maintenance of strength at low temperatures, nonsparking, and good corrosion resistance are properties which make aluminum useful in the generation, transportation, and storage of liquified gases. Results of low-temperature tear tests, impact tests, and tensile tests of several aluminum alloys were tabulated.[57]

The elevated-temperature tensile and creep-rupture properties were tabulated for 36 commercially established aluminum wrought and casting alloys which would normally be used at elevated temperatures.[58]

Information on the corrosion of aluminum, including basic research, atmospheric and aqueous corrosion by acidic or basic media, and methods of protecting aluminum, was included in review articles which contained extensive bibliographies.[59] Studies also were reported on attempts to improve or refine methods for determining the susceptibility of aluminum-zinc alloys to corrosion. Electrochemical processes for accelerating intergranular corrosion were discussed.[60]

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[52] Barton, H. K., Low Pressure Die-Casting: Metal Ind., vol. 97, No. 19, Nov. 4, 1960, p. 375–379.

Light Metal Age, 'Hot Metal' Plants Use Advanced Methods: Vol. 18, Nos. 7 and 8, August 1960, pp. 8–12.

[53] Miske, Jack C., Permanent Mold Castings: Foundry, vol. 88, No. 1, January 1960, pp. 66–71.

[54] Miske, Jack C., Diecasting Production: Foundry, vol. 88, No. 2, February 1960, pp. 84–87.

[55] Gottschalk, Roy F., Degassing and Cleaning Aluminum With Nitrogen and Nitrogen-Chlorine Mixtures: Metal Prog. vol. 78, No. 3, September 1960, p. 97–99.

[56] Modern Metals, How Gases Aid Castings: Vol. 16, No. 3, April 1960, pp. 50, 52, 54, 56.

[57] Johnson, E. W., Aluminum Alloys—Tough and Ductile Down to −423° F. (−250° C.): Chem. Eng., vol. 67, No. 16, Aug. 8, 1960, pp. 133–136.

Light Metal Age, Aluminum in Cryogenics: Vol. 18, Nos. 1 and 2, February 1960, pp. 6–12, 14–17.

[58] Voorhees, Howard R., and Freeman, James W., High-Purity Aluminum: Report on the Elevated-Temperature Properties of Aluminum and Magnesium Alloys, STP No. 291, 1960, pp. 9–224.

[59] Porter, F. C., Aluminium 1959: Corrosion Prevention and Control, vol. 7, No. 1, January 1960, pp. 33–44.

Porter, F. C., Aluminium and Corrosion: Corrosion Prevention and Control, vol. 8, No. 1, January 1961, pp. 37–43.

[60] Ketcham, Sara J., and Beck, Walter, Detecting Intergranular Corrosion Susceptibility in Aluminum Alloys: Corrosion, vol. 16, No. 1, January 1960, pp. 125–128.

Numerous articles described the preparation, properties, and utilization of aluminum alloys in such applications as sidings for homes, containers, automobile engines, and chemical-process equipment.[61] The full potential of hypereutectic aluminum-silicon alloys had not been realized, but it appeared that such alloys, containing 15 to 30 percent silicon, could have broad application in the production of automobile engine blocks. Information was published on the effects of grain-refiners such as sodium, phosphorus, and magnesium or aluminum alloys.[62]

Published information on fabrication of aluminum shapes included articles on bending, roll forming, and explosive forming.[63]

The literature on aluminum research and technology in 1960 was reviewed. Major sections were on melting and casting, working, joining, properties, corrosion and protection, and applications.[64]

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[61] Murphy, Frank B., Aluminum Alloys: Ind. and Eng. Chem., vol. 52, No. 11, November 1960, pp. 953–958.
Metal Progress, Progress in Aluminum Alloys: Vol. 78, No. 4, October 1960, pp. 137–142.
Horst, Jr., R. L., Selecting Aluminum Alloys for Process Equipment: Mat. Des. Eng., vol. 51, No. 5, May 1960, pp. 51, 130–135.
Materials in Design Engineering, Aluminum and Its Alloys: Vol. 52, No. 6, Mid-November 1960, pp. 100–109.

[62] Bates, A. P., Hypereutectic Aluminium-Silicon Alloys: Metallurgia, vol. 61, No. 364, February 1960, pp. 70–78.
Schneider, K., Aluminum Casting Alloys—Properties Improvement by Grain Refining: Modern Castings, vol. 37, No. 4, April 1960, pp. 176–181.

[63] Modern Metals, How To Bend Aluminum: Vol. 16, No. 8, September 1960, pp. 44, 46, 48, 52.
Iron Age, Explosive Forms Aluminum Door: Vol. 186, No. 12, Sept. 22, 1960, pp. 100–101.
Modern Metals, Bending Aluminum—Strip, Plate, Shapes, Tubes: Vol. 16, No. 10, November 1960, pp. 42, 44, 46.

[64] Elliott, E., Aluminium and Its Alloys in 1960: Metallurgia, vol. 63, No. 376, pt. 1, February 1961, pp. 65–70; No. 377, pt. 2, March 1961, pp. 105–114.

Antimony

By G. Richards Gwinn [1] and Edith E. den Hartog [2]

INCREASES in primary and secondary smelter production, in imports, exports, and stocks, and relatively steady mine production, and industrial consumption characterized the domestic antimony industry in 1960. Prices were steady.

Antimony remained on the list of commodities that could be obtained for the supplemental stockpile through the Commodity Credit Corporation (CCC), and 2,158 short tons of antimony was received by barter transactions.

DOMESTIC PRODUCTION

MINE PRODUCTION

Domestic mines produced 635 tons, recovered almost entirely in the form of impure cathode metal as a byproduct of processing silver-lead ores by the Sunshine Mining Co., Shoshone County, Idaho.

SMELTER PRODUCTION

Primary.—Smelter production of 10,000 tons of primary antimony represented an increase of 14 percent over the 1959 total. The increase was attributed largely to a relatively high output of antimony oxide during the year. Antimony ores and concentrates, 7 percent from domestic mines, 83 percent from foreign sources, and 10 percent

TABLE 1.—Salient antimony statistics

(Short tons)

	1951-55 (average)	1956	1957	1958	1959	1960
United States:						
Production:						
Primary:						
Mine	1,481	590	709	705	[1] 678	635
Smelter [2]	11,764	11,855	11,400	8,557	8,748	9,954
Secondary	23,090	24,106	22,565	19,515	20,043	20,104
Imports, general (antimony content)	13,456	13,577	15,265	9,878	13,273	14,515
Exports	122	65	68	86	174	906
Consumption [3]	17,733	16,006	12,389	11,880	13,317	13,267
Price: New York, average cents per pound	37.34	34.97	35.09	31.76	31.30	31.30
World: Production	55,000	59,000	56,000	51,000	59,000	61,000

[1] Corrected figure.
[2] Includes primary content of antimonial lead produced at primary lead smelters.
[3] Includes primary content of antimonial lead produced at primary lead smelters and antimony content of alloys imported.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

TABLE 2.—Production and shipment of antimony (concentrates and metal) in the United States

(Short tons)

Year	Gross weight of antimony-bearing concentrate produced	Contained antimony, percent	Antimony produced	Antimony shipped
1951–55 (average)	5,023	29.5	1,481	(1)
1956	3,714	16.9	590	1,732
1957	3,022	23.5	709	253
1958	4,309	16.4	705	382
1959	4,671	14.5	678	146
1960	4,256	14.9	635	1,086

[1] Data not available.

as byproduct antimony recovered from domestic lead ores supplied 75 percent of the total source materials for smelter output. Intermediate smelter products, derived from both foreign and domestic concentrates, furnished the remaining 25 percent of the source materials.

Byproduct antimony recovered from domestic lead ores totaled 456 tons, 10 percent of the domestic smelter output. Companies that reported primary antimony production were American Smelting and Refining Company, Foote Mineral Co., Harshaw Chemical Co., Hummel Chemical Co., McGean Chemical Co., National Lead Co., and Sunshine Mining Co.

Secondary.—The recovery of 20,104 short tons of secondary antimony was comparable to that reported in 1959, 20,043 tons. All secondary antimony was recovered from antimony-bearing lead and tin scrap largely by secondary smelters. Secondary metallic antimony was not produced in the United States. Primary and secondary lead smelters recovered 19,200 short tons of antimony from scrap; manufacturers and foundries reclaimed the remaining 900 tons. Battery-plate scrap supplied 11,700 tons; type-metal scrap, 3,200 tons; drosses, 2,700 tons; bearing metals, 1,300 tons; and antimonial lead scrap, 1,000 tons. Most of the antimony recovered from battery-plate scrap was used to produce antimonial lead.

Secondary lead smelters required 1,924 tons of primary metallic antimony, in addition to scrap, in making lead and tin alloys.

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	
1951–55 (average)	2,549	5,835	103	895	2,382	11,764
1956	4,291	4,731	129	639	2,065	11,855
1957	4,658	4,210	107	510	1,915	11,400
1958	2,833	3,825	84	319	1,496	8,557
1959	2,667	4,411	70	430	1,170	8,748
1960	3,665	5,188	60	385	656	9,954

TABLE 4.—Secondary antimony produced in the United States

(Short tons, antimony content)

Kind of scrap	1959	1960	Form of recovery	1959	1960
New scrap:			In antimonial lead [1]	12,343	12,594
Lead-base	2,589	2,590	In other lead alloys	7,659	7,483
Tin-base	66	67	In tin-base alloys	41	27
Total	2,655	2,657	Total	20,043	20,104
			Value (millions)	$12.5	$12.6
Old scrap:					
Lead-base	17,358	17,405			
Tin-base	30	42			
Total	17,388	17,447			
Grand total	20,043	20,104			

[1] Includes 754 tons of antimony recovered in antimonial lead from secondary sources at primary plants in 1959 and 919 tons in 1960.

CONSUMPTION AND USES

Industrial consumption of primary antimony was 13,300 tons, approximately equal to the 1959 total. Consumption declined slightly through the first three quarters of the year, and then turned upward during the fourth quarter. Almost all uses contributed to the decrease. Antimonial lead was the leading consuming outlet for metallic antimony. Bearings, type metals, and pipe also utilized substantial quantities of metallic antimony. The use of antimony oxide by the booming plastics industry in such products as plastic insulated wire, floor coverings, and flame proofing agents furnished a substantial quantity of the total consumption of antimony oxide. It was reported that the increased requirements for antimony oxide reduced the quantities of ore available for the output of metallic antimony.

TABLE 5.—Byproduct antimonial lead produced at primary lead refineries, in the United States

(Short tons)

Year	Antimonial lead produced at primary lead refineries					
	Gross weight	Antimony content				
		From domestic ores [1]	From foreign ores [2]	From scrap	Total	
					Quantity	Percent
1951–55 (average)	61,960	1,632	750	1,702	4,084	6.6
1956	66,826	1,320	745	1,283	3,348	5.0
1957	67,786	1,300	615	1,149	3,064	4.5
1958	50,246	811	685	1,307	2,803	5.6
1959	37,487	676	494	754	1,924	5.1
1960	30,230	456	200	919	1,575	5.2

[1] Includes primary residues and small quantity of antimony ore.
[2] Includes foreign base bullion and small quantities of foreign antimony ore.

TABLE 6.—Industrial consumption of primary antimony in the United States

(Short tons, antimony content)

Year	Class of material consumed						Total
	Ore and concentrate	Metal [1]	Oxide	Sulfide	Residues	Byproduct antimonial lead	
1951-55 (average)	1,628	5,692	7,015	120	896	2,382	17,733
1956	1,149	5,198	6,843	112	639	2,065	16,006
1957	677	4,055	5,129	103	510	1,915	12,389
1958	515	4,179	5,283	88	319	1,496	11,880
1959	270	5,420	5,948	79	430	1,170	13,317
1960	226	5,888	6,033	78	386	656	13,267

[1] Includes antimony in imported alloys.

TABLE 7.—Industrial consumption of primary antimony in the United States, by class of material produced

(Short tons, antimony content)

Product	1951-55 (average)	1956	1957	1958	1959	1960
Metal products:						
Ammunition	4	14	12	(1)	(1)	(1)
Antimonial lead [2]	7,015	5,494	4,233	3,698	4,141	4,394
Bearing metal and bearings	1,015	1,077	944	644	886	803
Cable covering	100	190	183	208	157	146
Castings	75	57	106	82	84	72
Collapsible tubes and foil	36	12	20	37	33	17
Sheet and pipe	163	300	258	273	202	202
Solder	149	144	90	100	113	130
Type metal [2]	1,193	1,050	607	877	883	580
Other	104	137	153	147	130	148
Total [2]	9,854	8,475	6,606	6,066	6,629	6,492
Nonmetal products:						
Ammunition primers	23	13	14	10	11	11
Fireworks	33	37	37	33	28	33
Flameproofing chemicals and compounds	1,961	1,082	760	758	1,033	1,177
Ceramics and glass	1,760	2,188	1,611	1,570	1,727	1,640
Matches	21	18	26	18	19	17
Pigments	1,459	1,471	1,085	1,047	1,167	1,282
Plastics	665	976	748	841	1,034	1,013
Rubber products	46	156	284	265	217	238
Other	1,911	1,590	1,218	1,272	1,452	1,364
Total	7,879	7,531	5,783	5,814	6,688	6,775
Grand total	17,733	16,006	12,389	11,880	13,317	13,267

[1] Included with "Other" to avoid disclosing individual company confidential data.
[2] Includes antimony content of imported antimonial lead consumed.

STOCKS

Industrial stocks at yearend of 7,200 tons were slightly above those of the preceding year.

Government stocks of antimony metal on December 31, 1960, included 818 tons in the CCC inventory, 8,820 tons in the supplemental stockpile, and quantities that may not be disclosed in the strategic stockpile.

TABLE 8.—Industry stocks of primary antimony in the United States, December 31

(Short tons, antimony content)

Stocks	1956	1957	1958	1959	1960
Ore and concentrate	2,474	2,337	3,052	2,884	2,356
Metal	2,236	1,300	1,232	1,422	1,346
Oxide	2,638	2,510	1,889	1,659	2,187
Sulfide	159	160	143	115	94
Residues and slags	598	746	565	685	938
Antimonial lead [1]	314	329	371	373	242
Total	8,419	7,382	7,252	7,138	7,163

[1] Inventories from primary sources at primary lead smelters only.

PRICES

The quoted price of RMM brand antimony metal continued unchanged throughout 1960 at 29.10 cents, per pound, in bulk, f.o.b., Laredo, Tex., and 31.30 cents, per pound, in cases, New York, N.Y. Quoted prices for foreign metal, oxide, and ores, however, increased in 1960.

TABLE 9.—Antimony price ranges in 1960

Type of antimony:		Price
Domestic metal [1]	cents per pound	29.00–31.30
Foreign metal [2]	do	24.00–27.25
Antimony trioxide [3]	do	24.00–28.00
Antimony ore,[3] 50–55 percent	dollars per short-ton unit	2.25– 2.80
Antimony ore, minimum 60 percent	do	2.50– 3.50
Antimony ore, minimum 65 percent	do	3.30– 3.65

[1] RMM brand, f.o.b., Laredo, Tex.
[2] Duty-paid delivery, New York.
[3] Quoted in E&MJ Metal and Mineral Markets.

FOREIGN TRADE [3]

Imports.—General imports of contained antimony of 14,500 tons represented an increase of 9 percent over the 13,300 tons received in 1959. All classes of imports except needle or liquated antimony contributed to the increase. Most of the ores and concentrates were supplied by Mexico, Bolivia, and the Union of South Africa. Yugoslavia, the United Kingdom, Belgium-Luxembourg, and France, of the European countries; and Mexico, in the Western Hemisphere, were the major suppliers of metal. About 25 percent of the metal imports represented Government acquisitions from the United Kingdom and Yugoslavia on barter contracts executed by the CCC. A smaller percentage of the ore and concentrate imports also was obtained through barter contracts.

Exports.—Antimony exports in 1960 of 906 tons, chiefly to Belgium-Luxembourg and Japan, were unusually high compared with 174 tons exported in 1959. Antimony ores and concentrates comprised the bulk of the material exported and, for the most part, represented reexports of foreign concentrates.

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 10.—U.S. imports[1] of antimony, by countries

Year and country	Antimony ore			Needle or liquated antimony		Antimony metal		Antimony oxide	
	Short tons (gross weight)	Antimony content		Short tons (gross weight)	Value (thousands)	Short tons	Value (thousands)	Short tons (gross weight)	Value (thousands)
		Short tons	Value (thousands)						
1951-55 (average)	18,273	7,941	$2,595	27	$14	2,933	$1,746	1,757	$946
1956	17,424	6,572	1,762	46	23	4,693	2,424	1,489	640
1957	21,374	8,198	1,973	38	17	5,052	2,413	1,893	[2] 790
1958	8,203	3,427	643	136	58	4,355	1,900	1,634	643
1959:									
North America:									
Canada						(3)	4		
Guatemala	143	97	21						
Mexico	7,732	2,018	232			660	436		
Total	7,875	2,115	253			660	440		
South America:									
Bolivia [4]	1,931	1,221	302						
Chile [4]	556	359	63						
Peru [4]						191	70		
Uruguay	336	118	12						
Total	2,823	1,698	377			191	70		
Europe:									
Belgium-Luxembourg				47	20	813	340	356	152
France						28	11		
Germany, West								192	78
Italy						66	32		
Netherlands								55	22
United Kingdom	112	73	4	45	20	815	343	1,453	573
Yugoslavia				71	34	1,822	787		
Total	112	73	4	163	74	3,544	1,513	2,056	825
Asia: Turkey	441	229	38						
Africa: Union of South Africa	4,056	2,351	564						
Grand total	15,307	6,466	1,236	163	74	4,395	2,023	2,056	825
1960:									
North America:									
Canada						(3)	15		
Guatemala	174	119	22						
Mexico	10,221	2,699	346			603	395		
Nicaragua	12	6	1						
Total	10,407	2,824	369			603	410		
South America:									
Bolivia [4]	1,528	974	216						
Chile [4]	269	177	34						
Peru [4]	99	57	14			90	31		
Total	1,896	1,208	264			90	31		
Europe:									
Belgium-Luxembourg				2	1	492	222	329	139
France						205	93	268	112
Germany, West						6	2	92	36
Netherlands								112	46
United Kingdom				22	10	1,868	795	1,567	639
Yugoslavia						2,140	928		
Total				24	11	4,711	2,040	2,368	972
Asia: Japan						(3)	(5)		

TABLE 10.—U.S. imports[1] of antimony, by countries—Con.

Year and country	Antimony ore: Short tons (gross weight)	Antimony ore: Antimony content: Short tons	Antimony ore: Antimony content: Value (thousands)	Needle or liquated antimony: Short tons (gross weight)	Needle or liquated antimony: Value (thousands)	Antimony metal: Short tons	Antimony metal: Value (thousands)	Antimony oxide: Short tons (gross weight)	Antimony oxide: Value (thousands)
1960—Continued									
Africa:									
Algeria	--------	--------	--------	--------	--------	33	14	--------	--------
Mozambique	224	132	29	--------	--------	--------	--------	--------	--------
Union of South Africa	3,879	2,291	552	--------	--------	--------	--------	--------	--------
Total	4,103	2,423	581	--------	--------	33	14	--------	--------
Grand total	16,406	6,455	1,214	24	11	5,437	2,495	2,368	972

[1] Data are general imports, that is, include antimony imported for immediate consumption plus materia entering the country under bond. Table does not include antimony contained in lead-silver ores.
[2] Data known to be not comparable with other years.
[3] Less than 1 ton.
[4] Imports shown from Chile probably were mined in Bolivia or Peru and shipped from a port in Chile.
[5] Less than $1,000.

Source: Bureau of the Census.

TABLE 11.—U.S. imports for consumption of antimony[1]

Year	Antimony ore: Short tons (gross weight)	Antimony ore: Antimony content: Short tons	Antimony ore: Antimony content: Value (thousands)	Needle or liquated antimony: Short tons (gross weight)	Needle or liquated antimony: Value (thousands)	Antimony metal: Short tons	Antimony metal: Value (thousands)	Type metal and antimonial lead[2] (short tons)	Antimony oxide: Short tons (gross weight)	Antimony oxide: Value (thousands)
1951–55 (average)	18,197	7,893	$2,592	27	$14	2,949	$1,753	1,089	1,756	$946
1956	17,424	6,572	1,762	46	23	4,321	2,245	1,044	1,479	636
1957	21,374	8,198	1,973	38	17	5,412	2,587	417	1,893	[3] 790
1958	8,203	3,427	643	136	58	4,282	1,871	645	1,634	643
1959	15,307	6,466	1,236	177	79	4,422	2,039	592	2,056	825
1960	16,406	6,455	1,214	24	11	5,437	2,495	641	2,368	972

[1] Does not include antimony contained in lead-silver ore.
[2] Estimated antimony content; for gross weight and value, see Lead chapter of this volume.
[3] Known to be not comparable with other years.

Source: Bureau of the Census.

WORLD REVIEW

Bolivia.—Production of antimony ores and concentrates in 1960 was reported in terms of exports as production figures were not available. The Unificada, S.A. a privately owned mine, was by far the largest producer. Beginning in September, domestic production of relatively small quantities of antimonial lead, type metal, and impure lead-silver-antimony bullion was begun.

Canada.—Production of 761 short tons of antimony in Canada represented a slight decline from the 1959 output. All antimony pro-

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duced was recovered as a byproduct of the processing of lead and silver ores by the Consolidated Mining & Smelting Co. of Canada, Ltd., at Trail, British Columbia. Domestic production was not adequate for Canadian demands, and imports were necessary.

TABLE 12.—World production of antimony (content of ore except as indicated) by countries [1] [2]

(Short tons)

Country [1]	1951–55 (average)	1956	1957	1958	1959	1960
North America:						
Canada [3]	1,384	1,070	680	430	829	761
Guatemala (U.S. imports)	----------	----------	13	47	97	119
Mexico [4]	5,300	5,022	5,734	3,029	3,621	4,662
United States	1,481	590	709	705	678	635
Total	8,165	6,682	7,136	4,211	5,225	6,177
South America:						
Argentina	35	2	7	11	----------	----------
Bolivia (exports) [4]	8,373	5,635	7,026	5,818	6,065	[5] 5,500
Peru [4]	948	1,068	920	964	793	833
Total	9,356	6,705	7,953	6,793	6,858	6,333
Europe:						
Austria	488	489	430	514	631	[5] 660
Czechoslovakia [6]	1,800	1,800	1,800	1,800	1,800	[5] 1,800
France	325	258	----------	42	----------	----------
Greece	330	----------	----------	----------	----------	----------
Italy	537	309	224	188	231	[5] 300
Portugal	37	----------	11	7	7	[5] 7
Spain	212	250	220	220	180	[5] 220
U.S.S.R. [6]	5,500	5,500	5,500	6,600	6,600	[5] 6,600
Yugoslavia (metal)	1,571	1,767	1,950	1,835	2,514	2,657
Total [1] [5]	10,800	10,400	10,100	11,200	12,000	12,200
Asia:						
Burma [4]	115	90	70	90	240	[5] 220
China [5]	10,600	14,300	15,400	16,500	16,500	19,000
Iran [7]	132	44	[5] 110	160	[5] 160	[5] 185
Japan	295	619	474	298	340	[5] 280
Ryukyu Islands	[8] 22	12	6	----------	26	159
Thailand	61	41	2	----------	10	[5] 10
Turkey	1,626	1,063	1,232	[9] 1,687	[9] 1,380	[5] [9] 1,650
Total [5]	12,850	16,200	17,300	18,700	18,700	21,500
Africa:						
Algeria	1,831	2,641	1,547	1,106	1,135	785
Morocco	913	330	360	203	252	310
Rhodesia and Nyasaland, Federation of:						
Southern Rhodesia	100	72	83	151	104	98
Union of South Africa	10,721	15,689	11,021	7,904	13,619	13,567
Total	13,565	18,732	13,011	9,364	15,110	14,760
Oceania: Australia	291	322	543	775	703	[5] 220
World total (estimate) [1]	55,000	59,000	56,000	51,000	59,000	61,000

[1] Antimony is also produced in Hungary, but production data are not available; no estimate for Hungary is included in the world total.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Antimony content of smelter products exclusively from mixed ores.
[4] Includes antimony content of smelter products derived from mixed ores.
[5] Estimate.
[6] Estimate according to the annual issues of Minerais et Metaux (France), except 1960.
[7] Year ended March 20 of year following that stated.
[8] One year only, as 1955 was first year of commercial production.
[9] Exports.

Compiled by Augusta W. Jann, Division of Foreign Activities.

China.—China was again the world's leading producer of antimony. Production came mostly from Hunan and Kwangsi Provinces. Food shortages and other economic difficulties hampered production, but output was estimated as at least comparable to that of 1959.

Mexico.—Production of antimony, more than half of which was recovered as ore and the remainder as a byproduct of lead refining, increased 29 percent over the 1959 output. Domestic consumption remained at a relatively low level, and most of the output was exported, chiefly to the United States.

Union of South Africa.—Consolidated Murchison (Transvaal) Goldfields & Development Co., Ltd., was the sole antimony producer in the Union of South Africa. Antimony was recovered from an antimony-gold ore in which the antimony occurred in poorly defined lenses in a country rock of quartz-carbonate-schist. Sales of concentrate remained steady throughout the year, and the United Kingdom provided the major market.

TECHNOLOGY

At Reno, Nev., the Federal Bureau of Mines completed a study on the effect of adding antimony to titanium metal. The resulting titanium-antimony alloys had adequate ductility and higher yield strengths than unalloyed titanium.[4] An improved method of growing single crystals of aluminum antimonide for use in semiconductors capable of operating at high ambient temperatures [5] and the measurement of the segregation coefficients of impurity elements in aluminum antimonide ingots were reported.[6] The effect of a magnetic field on the thermal conductivity of indium antimonide was described. The method of measurement, the apparatus utilized, and the behavior under various temperature ranges were reported.[7]

The semiconductor characteristics of cadmium-antimony alloys of differing compositions also were described.[8] The development of a new gold-antimony alloy with improved properties for transistor use was reported.[9] Intensive laboratory studies were in progress on the development of a silver-antimony-tellurium alloy, which seemed to give promise as the most efficient thermoelectric device for use in semiconductors.[10]

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[4] Ramsdell, J. D., and Lenz, W. H., Effect of Antimony on Tensile Properties of Titanium: Bureau of Mines Rept. of Investigations 5586, 1960, 11 pp.

[5] Allred, W. P., Mefferd, W. L., and Williardson, R. K., The Preparation and Properties of Aluminum Antimonide: Jour. Electrochem. Soc., vol. 107, No. 2, February 1960, pp. 117–122.

[6] Hazelby, D., and Parmee, J. L., Measurement of the Segregation Coefficients of Impurity Elements in Aluminum Antimonide: Jour. Electrochem. Soc., vol. 107, No. 2, February 1960, pp. 144–145.

[7] Amirkhanova, D. K., and Bashirov, R. I., The Effect of a Magnetic Field on the Thermal Conductivity of Indium Antimonide: Fizika Tverdogo Tela, vol. 2, No. 7, 1960, pp. 1597–1607.

[8] Journal of the Institute of Metals (London), Semi-Conductor Characteristics of Cadmium-Antimony Alloys: Vol. 27, No. 10, June 1960, p. 632.

[9] Steel, New Alloy for Transistors: Vol. 146, No. 7, February 1960, p. 123.

[10] American Metal Market, Silver-Antimony-Tellurium Seen Best "Cooling" Alloy: Vol. 67, No. 170, Sept. 2, 1960, p. 5.

Arsenic

By H. M. Callaway [1] and Gertrude N. Greenspoon [2]

PRODUCTION of white arsenic in the United States increased markedly in 1960, reflecting the general upturn in output of copper, the metal with which arsenic is most commonly associated. The volume of shipments from producer warehouses increased considerably but lagged sufficiently behind production to cause a slight rise in stocks. Imports decreased under the restraining influence of adequate domestic supply.

TABLE 1.—Salient white arsenic statistics

	1951-55 (average)	1956	1957	1958	1959	1960
United States:						
Production....short tons..	13,337	12,201	10,493	11,508	5,189	(1)
Shipments....do....	11,621	18,876	12,785	10,931	7,239	(1)
Imports for consumption....do....	7,158	6,422	10,135	9,524	19,386	12,825
Stocks Dec. 31: Producer....do....	10,190	4,827	2,535	3,112	1,058	(1)
Consumption, apparent [2]....do....	18,779	25,298	22,920	20,455	26,625	(1)
Price: Refined, carlots [3] cents per pound..	6	5½	5½	5½	4–5	4–5
World: Production....short tons..	46,000	[4] 49,000	[4] 45,000	[4] 41,000	47,000	62,000

[1] Figure withheld to avoid disclosing individual company confidential data.
[2] Producers' shipments, plus imports, minus exports; no exports were reported by producers, 1951–60.
[3] E&MJ Metal and Mineral Markets.
[4] Revised figure.

DOMESTIC PRODUCTION

All strikes that began at arsenic-producing copper plants in mid-1959 were settled by early 1960, and the general acceleration of copper production in 1960 led to increased output of white arsenic. The entire production was a byproduct of smelting copper and lead ores that contained arsenic as an impurity. Only two plants produced arsenic during the year: The Anaconda, Mont., smelter of The Anaconda Company and the Tacoma, Wash., smelter of American Smelting and Refining Company. The Midvale, Utah, smelter of United States Smelting, Refining and Mining Co., which in former years had produced white arsenic from the processing of lead ores, was dismantled and sold in 1959.

Excepting small quantities of laboratory ultrapure arsenic for semiconductor use, no arsenic metal was produced in 1960.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

TABLE 2.—Salient white arsenic statistics, 1910–60

Year	United States						World production (short tons)
	Production (short tons)	Shipments (short tons)	Imports [1] (short tons)	Exports [2] (short tons)	Apparent consumption (short tons)	Price, (cents per pound) [3]	
1910	1,497	[4]	1,348	----------	2,845	2¼–3¼	9,000
1911	3,132	[4]	1,921	----------	5,053	3	12,000
1912	3,141	[4]	3,103	----------	6,244	3½	12,000
1913	2,513	[4]	1,519	----------	4,032	4⅜	9,000
1914	4,670	[4]	1,594	----------	6,264	3¾	11,000
1915	5,498	[4]	1,400	----------	6,898	3½–4½	13,000
1916	5,986	[4]	1,071	----------	7,057	3⅞–8¼	14,000
1917	6,151	6,151	1,178	----------	7,329	8–20	17,000
1918	6,323	6,323	1,847	----------	8,170	9–15	21,000
1919	6,029	6,029	4,389	----------	10,418	8–12	20,000
1920	11,502	11,502	3,740	----------	15,242	10¼–18	24,000
1921	6,158	4,786	1,669	----------	6,455	5¾–9½	14,000
1922	9,350	10,027	1,081	----------	11,108	6–15½	21,000
1923	14,902	14,271	10,152	[4]	24,423	9–15½	35,000
1924	20,177	14,453	8,877	[4]	23,330	13½–6½	36,000
1925	12,119	12,317	9,316	[4]	21,633	6¼–3½	35,000
1926	6,759	11,805	7,703	[4]	19,508	3–3½	31,000
1927	11,730	11,560	12,517	[4]	24,077	3½–4	35,000
1928	14,163	11,767	11,153	[4]	22,920	4	34,000
1929	16,605	14,546	13,157	[4]	27,703	4	35,000
1930	17,057	17,425	10,471	[4]	27,896	4	40,000
1931	17,137	13,777	7,791	1,400	20,168	4	39,000
1932	12,704	12,483	6,882	2,000	17,365	4	39,000
1933	10,650	11,797	10,583	2,000	20,380	4	40,000
1934	13,096	15,623	14,110	2,700	27,033	3½–4	56,000
1935	14,237	12,670	15,075	800	26,945	3½	61,000
1936	15,379	15,581	17,586	1,000	32,167	3½	61,000
1937	16,814	17,636	19,256	2,200	34,692	3½–3	62,000
1938	16,685	13,160	14,238	2,300	25,098	3	76,000
1939	22,341	22,439	14,674	3,200	33,913	3	62,000
1940	24,983	23,339	9,929	1,639	31,629	3–3½	59,000
1941	32,481	34,784	10,292	1,616	[5] 43,460	3–4	66,000
1942	28,681	31,038	16,350	305	[5] 47,083	4	69,000
1943	31,202	32,423	16,112	1,975	[5] 46,560	4	73,000
1944	36,094	34,472	9,965	2,401	[5] 42,036	4	75,000
1945	24,349	24,810	13,149	858	37,101	4	61,000
1946	10,211	12,039	13,821	[6] 1,000	24,860	4–6	46,000
1947	18,755	18,188	13,940	[6] 1,000	31,128	6	62,000
1948	18,639	14,965	9,336	----------	24,301	6–6¼	60,000
1949	12,795	10,181	4,696	----------	14,877	6–5½	39,000
1950	13,273	17,330	14,774	----------	32,104	5½–6½	52,000
1951	16,190	14,351	14,518	----------	28,869	6½	69,000
1952	15,673	9,244	4,483	----------	13,727	6½–5½	54,000
1953	10,873	11,315	4,717	----------	16,032	5½	30,000
1954	13,167	11,523	4,848	----------	16,371	5½	38,000
1955	10,780	11,673	7,222	----------	18,895	5½	45,000
1956	12,201	18,876	6,422	----------	25,298	5½	49,000
1957	10,493	12,785	10,135	----------	22,920	5½	45,000
1958	11,508	10,931	9,524	----------	20,455	5½	41,000
1959	5,189	7,239	19,386	----------	26,625	4–5	47,000
1960	[7]	[7]	12,825	----------	[7]	4–5	62,000

[1] General imports 1910–33; thereafter imports for consumption.
[2] Data for 1943–45 reported by U.S. Department of Commerce; data for all other years reported by producers to Bureau of Mines.
[3] Refined white arsenic, carlots, quoted by Oil, Paint and Drug Reporter through 1947; thereafter, by E&MJ Metal and Mineral Markets.
[4] Data not available.
[5] Consumption based on allocation data of the War Production Board was 40,442 tons in 1941; 41,520 in 1942; 51,083 in 1943; and 43,500 in 1944.
[6] Estimated.
[7] Figure withheld to avoid disclosing individual company confidential data.

CONSUMPTION AND USES

Most of the output of white arsenic in 1960 was used in manufacturing lead and calcium arsenate insecticides. Arsenic compounds were also used in weedkillers, glass manufacture, cattle and sheepdips, dyestuffs, wood preservatives, and hide-tanning compounds. Small quantities of ultrapure arsenic metal were used in semiconductor products.

TABLE 3.—Production and shipments of white arsenic in the United States

Year	Crude			Refined			Total		
	Production (short tons) [1]	Shipments		Production (short tons)	Shipments		Production (short tons)	Shipments	
		Short tons	Value		Short tons	Value		Short tons	Value
1951–55 (average)	12,695	11,020	$605,178	642	601	$52,290	13,337	11,621	$657,468
1956	11,423	18,048	685,145	778	828	69,524	12,201	18,876	754,669
1957	9,814	11,980	475,629	679	805	54,721	10,493	12,785	530,350
1958	11,121	10,544	421,777	387	387	37,884	11,508	10,931	459,661
1959	4,897	6,922	293,940	292	317	27,315	5,189	7,239	321,255
1960	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)

[1] Excludes crude consumed in making refined.
[2] Figure withheld to avoid disclosing individual company confidential data.

TABLE 4.—Production of arsenical insecticides and consumption of arsenic wood preservatives in the United States

(Short tons)

Year	Production of insecticides [1]		Consumption of wood preservatives [2]		
	Lead arsenate (acid and basic)	Calcium arsenate (70 percent $Ca_3(AsO_4)_2$)	Wolman salts (25 percent sodium arsenate)	Other	Total
1951–55 (average)	8,429	6,232	920	336	1,256
1956	5,878	13,553	1,005	768	1,773
1957	5,960	9,739	1,068	1,167	2,235
1958	7,469	5,216	1,082	1,167	2,249
1959	6,452	3,212	1,357	1,274	2,631
1960	(3)	(3)	[4] 1,144	[4] 1,022	[4] 2,166

[1] Bureau of the Census, U.S. Department of Commerce.
[2] Forest Service, U.S. Department of Agriculture.
[3] Data not available.
[4] Preliminary figures.

STOCKS

At the beginning of 1960, producers' stocks of white arsenic totaled 1,100 tons. However, increased sales during the year failed to distribute the total new supply, and stocks at yearend were somewhat higher than those inventoried at the end of 1959.

PRICES

White arsenic was quoted at 4 to 5 cents per pound (powdered, in barrels, carlots, delivered) throughout 1960. Prices had remained at that level since May 1959, when producers lowered their prices from 5½ cents. According to the Oil, Paint and Drug Reporter, lead arsenate (carload lots packed in 3-pound bags) was quoted at 30½ cents throughout the year.

The London price in 1960 for white arsenic, per long ton, 98-percent minimum purity, was £40 to £45 (equivalent to 5.00 to 5.63 cents per pound). Arsenic metal on the London market sold for £400 per long ton (50 cents per pound).

FOREIGN TRADE [3]

Imports.—The increased quantity of arsenic from domestic producers caused decreased imports in 1960. Imports of white arsenic dropped 34 percent to 12,800 tons. Mexico continued to be the principal supplier. As in former years, France was a significant exporter to the United States. Sweden, which in 1959 made large shipments, supplied only small quantities of arsenic to U.S. consumers in 1960.

Of the 72 tons of arsenic metal imported, almost all came from Sweden. About 7,000 pounds of arsenic metal, possibly of semicondutor grade, was imported from Canada and the United Kingdom. Other significant imports were 105 tons of sodium arsenate and 15 tons of arsenic sulfide.

TABLE 5.—U.S. imports for consumption of white arsenic (As_2O_3 content), by countries

Country	1951-55 (average)		1956		1957	
	Short tons	Value	Short tons	Value	Short tons	Value
North America:						
Canada	486	$40,252	540	$49,387	1,508	$119,427
Mexico	6,035	683,709	5,831	691,354	6,851	604,932
Total	6,521	723,961	6,371	740,741	8,359	724,359
South America: Peru	12	1,294				
Europe:						
France	439	54,703	12	927	981	34,770
Sweden	131	14,946	33	2,954	779	34,317
Other countries [1]	(2)	(2)	6	575	16	989
Total	570	69,649	51	4,456	1,776	70,076
Asia: Japan	55	7,836				
Grand total	7,158	802,740	6,422	745,197	10,135	794,435

Country	1958		1959		1960	
	Short tons	Value	Short tons	Value	Short tons	Value
North America:						
Canada	800	$63,353	607	$49,116	503	$40,249
Mexico	6,052	541,795	12,528	962,894	9,857	856,327
Total	6,852	605,148	13,135	1,012,010	10,360	896,576
Europe:						
France	1,201	49,532	3,504	153,336	2,252	129,724
Sweden	1,471	64,932	2,746	176,043	213	19,357
Other countries [1]			1	122	(2)	382
Total	2,672	114,464	6,251	329,501	2,465	149,463
Grand total	9,524	719,612	19,386	1,341,511	12,825	1,046,039

[1] Includes Poland-Danzig and the United Kingdom.
[2] Negligible.

Source: Bureau of the Census.

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 6.—U.S. imports and exports of arsenicals, by classes

[Pounds]

Class	1951–55 (average)	1956	1957	1958	1959	1960
Imports for consumption:						
White arsenic (As_2O_3 content)	14,315,445	12,843,816	20,270,069	19,048,920	38,771,199	25,649,095
Metallic arsenic	153,681	88,666	136,745	61,660	84,769	145,085
Sulfide	52,407	84,894	42,094	126,354	41,872	30,352
Sheepdip	62,712	70,421	67,763		116,785	
Lead arsenate	34,997					
Arsenic acid	1,120					
Calcium arsenate	357,791	60,000				4,001
Sodium arsenate	134,104	229,616	328,049	173,337	152,769	209,956
Paris green	8,251					
Exports:						
Calcium arsenate	3,743,040	628,020	2,779,954	1,274,000	122,920	289,700
Lead arsenate	594,946	2,563,176	1,216,158	2,099,960	1,398,900	1,888,149

Source: Bureau of the Census.

Exports.—No exports of white arsenic were reported. However, 1.9 million pounds of lead arsenate, valued at approximately $335,000, was exported to 13 countries, mostly in Central and South America. Smaller quantities of calcium arsenate were shipped from the United States to Canada and Peru.

Tariff.—White arsenic, arsenic sulfide, Paris green, and sheepdip (certain varieties contain arsenic) were free of duty. Arsenic acid was subject to a duty of 3 cents per pound, and lead arsenate was subject to a duty of 1.5 cents per pound. The duty of 2.5 cents per pound on metallic arsenic, effective June 30, 1958, continued through 1960. Compounds of arsenic not specified in the Tariff Act were subject to a duty of 12½ percent of their foreign market value.

WORLD REVIEW

World production of white arsenic increased markedly in 1960 to 62,000 tons. This quantity was 32 percent more than the 1959 output and was the largest production recorded since 1951. The increase was attributed to the worldwide higher production levels of other metals, chiefly copper, with which arsenic is mineralogically and metallurgically associated.

Canada.—The Deloro Smelting & Refining Co., Ltd., a producer of refined white arsenic since 1885, closed its plant at Marmora, Ontario, near yearend. The plant recovered arsenic from smelting silver-cobalt concentrate from the Cobalt and Gowganda areas in northern Ontario. Arsenic occurred in the concentrate as arsenides and sulfarsenides of cobalt, iron, and nickel.

Mexico.—Production of white arsenic in Mexico reached a record of 16,500 tons in 1960. Of that quantity, the United States imported 9,800 tons. Presumably, the United States also received arsenic in intermediate smelter products from Mexico in 1960. These were processed, and the arsenic was reported as a component of U.S. production.

TABLE 7.—Free world production of white arsenic, by countries[1] [2]

(Short tons)

Country [1]	1951–55 (average)	1956	1957	1958	1959	1960
North America:						
Canada	822	895	1,849	1,162	789	806
Mexico	5,073	2,913	5,075	3,411	11,536	[3] 16,500
United States	13,337	12,201	10,493	11,508	5,189	(4)
South America:						
Brazil	1,078	819	188	292	366	[3] 330
Peru	24	28	22	369	524	[3] 550
Europe:						
Belgium (exports)	1,526	3,056	2,280	543	3,161	(5)
France	5,235	9,455	7,627	8,400	[6] 9,420	[3] [6] 8,800
Germany, West (exports)	1,107	334	216	205	180	[3] 120
Greece	54	45	11	13	11	[3] 11
Italy	1,510	1,173	1,087	688	1,345	[3] 1,100
Portugal (exports)	1,321	1,660	1,314	1,172	429	[3] 440
Spain	117	----------	----------	285	320	(5)
Sweden	12,550	13,437	12,282	11,194	12,100	[6] 15,114
Asia: Japan	1,626	1,833	1,521	1,429	1,186	[3] 1,200
Africa: Rhodesia and Nyasaland, Federation of: Southern Rhodesia	407	1,084	883	683	528	204
World total (estimate)[1] [2]	46,000	49,000	45,000	41,000	47,000	62,000

[1] Arsenic may be produced in Argentina, Austria, China, Czecholovakia, Finland, East Germany, Hungary, U.S.S.R., and United Kingdom, but information is too meager to estimate production.
[2] This table incorporates a number of revisions of data published in previous Arsenic chapters. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Figure withheld to avoid disclosing individual company confidential data; included in world total.
[5] Data not available; estimate included in world total.
[6] Exports.

Compiled by Augusta W. Jann, Division of Foreign Activities.

Rhodesia and Nyasaland, Federation of.—Johannesburg Consolidated Investment Co., Ltd., began geologic investigations of arsenic, antimony, and gold properties in the Que Que district of Southern Rhodesia.

Sweden.—The entire output of white arsenic in Sweden was produced by Boliden Mining Co., the leading world producer. In 1960, Boliden planned to replace its present Stockholm white arsenic plant with a more efficient refinery of larger capacity.

TECHNOLOGY

A process for removing arsenic and sulfur from cobalt and nickel ores was patented in the United Kingdom and assigned to Metallurgical Resources, Inc.[4] The ore or concentrate is treated with sodium hydroxide or other alkali metal hydroxides; aerated at elevated temperature and pressure to yield soluble sodium arsenate and sulfate; and the resulting solution is reacted with lime to precipitate the arsenate and sulfate of calcium.

Johnson, Matthey & Co., Ltd., London, announced commercial production of arsenic metal in the purity range of 1 part-per-million total impurities.[5] American Smelting and Refining Co., New York, and Consolidated Mining & Smelting Co. of Canada, Ltd., previously reported availability of arsenic metal of about the same purity. Demand for the ultrapure metal resulted from recently developed uses in semiconductors.

[4] Engineering and Mining Journal, vol. 161, No. 9, September 1960, p. 140.
[5] Chemistry and Industry (London), No. 36, Sept. 3, 1960, p. 1139.

Asbestos

By D. O. Kennedy[1] and Victoria M. Roman[2]

THE UNITED STATES consumed 29 percent of the world output of asbestos in 1960 but produced only 6 percent of its requirements. Although domestic output was less than 2 percent of world production, the Nation ranked seventh among world producers.

LEGISLATION AND GOVERNMENT PROGRAMS

In response to invitations sent out late in 1959 for the national stockpile, Arizona producers submitted identical bids, causing all bids to be rejected. Second invitations were sent to the producers in 1960 and bids were accepted from four producers for a total of 500 short tons of Arizona No. 2 fiber. Delays in testing procedures and fiber processing prevented fulfillment of the contracts in 1960.

The Office of Minerals Exploration announced on August 17 the extension of exploration assistance to include nonstrategic varieties of asbestos.

TABLE 1.—Salient asbestos statistics

	1951-55 (average)	1956	1957	1958	1959	1960
United States:						
Production (sales) short tons	50,431	41,312	43,653	43,979	[1] 45,459	45,223
Value thousands	$4,534	$4,742	$4,918	$5,127	[1] $4,391	$4,231
Imports for consumption (unmanufactured) short tons	716,480	689,910	682,732	644,331	713,047	669,495
Value thousands	$59,339	$61,939	$60,104	$58,314	$65,006	$63,345
Exports (unmanufactured)[2] short tons	7,001	2,950	2,893	3,026	4,461	5,525
Value thousands	$1,497	$375	$350	$424	$793	$857
Exports of asbestos products (value)[2] thousands	$12,464	$14,181	$15,223	$13,233	$12,921	$13,703
Consumption, apparent short tons	759,910	728,272	723,492	685,284	[1] 754,045	709,193
World: Production[1] do	1,670,000	1,990,000	2,080,000	2,050,000	2,260,000	2,420,000

[1] Revised figure.
[2] Includes reexports.

DOMESTIC PRODUCTION

Asbestos production in the United States remained the same in 1960; from an estimated 1 million tons of rock, 45,000 tons of fiber was recovered.

Vermont Asbestos Mines Division of Ruberoid Co., at Belvedere Mountain near Hyde Park, Vt., continued to be the only large asbestos producer in the United States. The small quantity of spinning length fiber produced was used in electrolytic cells rather than in textiles.

Six companies reported shipments of asbestos from mines in the Globe district of Arizona in 1960. They were: Jaquays Mining Corp.,

[1] Assistant chief, Branch of Nonmetallic Minerals, Division of Minerals.
[2] Statistical clerk, Division of Minerals.

Kyle Asbestos Mines of Arizona, Le Tourneau Asbestos Corp., Metate Asbestos Corp., Pan American Fiber Corp., and Phillips Asbestos Mines. A mill was erected by Le Tourneau Asbestos Corp. on the outskirts of Globe and plans were announced to treat asbestos fiber with hydrochloric acid to remove lime and dust.[3]

Asbestos Bonding Co. reported production and shipments of chrysotile asbestos from the Phoenix mine in Napa County, Calif. In addition, the following four companies reported mining asbestos for experimental purposes: Coalinga Asbestos Co., Inc., National Mill and Mining Co., Inc., and Union Carbide Nuclear Co. in Fresno County; and Rawhide Asbestos Corp. in Tuolumne County. Jefferson Lake Sulphur Co. acquired ground for a mill site and tailing disposal contiguous to its asbestos deposit near Copperopolis. Interest in California asbestos deposits continued as two companies, Tri-Gem Mining Co., and Mik-Ron Corp. announced plans to mine asbestos ore in San Benito County.

Amphibole asbestos was produced by the Powhatan Mining Co. from mines in Transylvania and Yancey Counties, N.C.

Oregon Asbestos Co. produced a small quantity of chrysotile asbestos from its property in Oregon. Operations started in 1959 continued in 1960.

CONSUMPTION AND USES

Consumption of chrysotile asbestos decreased from 711,000 tons in 1959 to 670,000 tons. As in former years, nearly 97 percent of the chrysotile asbestos consumed was short fiber used principally in asbestos-cement and asbestos-asphalt building materials.

Consumption of crocidolite, as represented by imports, decreased from 26,000 tons in 1959 to 20,000 in 1960.

PRICES

Canadian (Quebec) chrysotile asbestos prices f.o.b. mine, remained unchanged during 1960 as follows:

Grade:	*Per short ton*
Crude No. 1	Can$1, 410–Can$1, 475
Crude No. 2—Crude run of mine and sundry	610– 875
No. 3—Spinning fiber	350– 650
No. 4—Shingle fiber	180– 245
No. 5—Paper fiber	120– 150
No. 6—Waste, stucco, or plaster	86
No. 7—Refuse or shorts	40– 80

Prices of British Columbia chrysotile asbestos, f.o.b. Vancouver, as quoted by Bell Asbestos Mines, Ltd., sales representatives for Cassiar Asbestos Corp., Ltd., were as follows:

Grade:	*Per short ton*
No. 1 crude	Can$1, 522
AAA(C&G 1)	787
AA(C&G 2)	625
A(3K)	470
AC(C&G 3)	325
AK(4K)	220
AS(4T)	181
AX(5D)	142

[3] Mining World, Arizona Asbestos Industry Is Growing Steadily Around Globe: Vol. 22, No. 10, September 1960, pp. 44–45.

Prices of Vermont asbestos f.o.b. Hyde Park or Morrisville, Vt., were unchanged during 1960 as follows:

Grade:	*Per short ton*
Group No. 3—Spinning and filtering	$353–$440
Group No. 4—Shingle fiber	181– 218
Group No. 5—Paper fiber	120– 142
Group No. 6—Waste, stucco, or plaster	86
Group No. 7—Refuse or shorts	41– 75

Asbestos magazine published the following prices, f.o.b. Globe, on Arizona asbestos:

Grade:	*Per short ton*
No. 1 soft	$1,475–$1,800
No. 2 soft	830– 1,050
Group 3—Filtering and spinning	350– 450
Group 4—Plastic and filtration	190– 250
Group 5—Plastic and molding	125– 177
Group 7—Refuse and shorts	60– 100

Market quotations were not available for African and Australian asbestos because purchases and sales are negotiated individually. U.S. Department of Commerce reports showed the following values for imports:

Imports:	*Per short ton* 1959	1960
Amosite	$153.10	$151.83
Crocidolite:		
Australian	205.99	211.40
Union of South Africa	199.13	219.18

FOREIGN TRADE [4]

Imports of amosite increased 16 percent. In contrast, imports of crocidolite decreased 26 percent and chrysotile 6 percent compared with 1959, resulting in a net decrease of 6 percent in total imports.

TABLE 2.—U.S. imports for consumption of asbestos (unmanufactured), by classes and countries

Year and country	Crude (including blue fiber)		Mill fibers		Short fibers		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1959:								
North America: Canada	339	$109,269	149,341	$28,184,066	504,845	$26,681,457	654,525	$54,974,792
South America: Venezuela			90	11,800	26	2,200	116	14,000
Europe:								
Finland	102	3,630			123	3,000	225	6,630
Italy			8	9,525			8	9,525
Portugal	14	1,680					14	1,680
U.S.S.R	3	643					3	643
Yugoslavia	5,646	212,869					5,646	212,869
Africa:								
British East Africa					49	6,450	49	6,450
Rhodesia and Nyasaland, Federation of [1]	4,347	897,760	729	143,317	111	24,542	5,187	1,065,619
Union of South Africa [2]	36,446	6,485,909	1,511	322,986	760	141,860	38,717	6,950,755
Oceania: Australia	8,557	1,762,690					8,557	1,762,690
Total	55,454	9,474,450	151,679	28,671,694	505,914	26,859,509	713,047	65,005,653

See footnotes at end of table.

[4] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 2.—U.S. imports for consumption of asbestos (unmanufactured), by classes and countries—Continued

Year and country	Crude (including blue fiber		Mill fibers		Short fibers		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1960:								
North America:								
Canada	357	$64,989	148,584	$29,055,547	467,860	$24,998,784	616,801	$54,119,320
Guatemala	2	400					2	400
South America: Venezuela	15	2,100			46	6,210	61	8,310
Europe:								
Finland					165	8,250	165	8,250
Italy			[3] 6	[3] 7,785	2	338	8	8,123
Portugal	22	2,800					22	2,800
Yugoslavia	4,578	157,122					4,578	157,122
Africa:								
Rhodesia and Nyasaland, Federation of [1]	1,865	494,055	110	24,209	464	99,476	2,439	617,740
Union of South Africa [2]	36,644	6,771,421	522	90,024	3,627	583,382	40,793	7,444,827
Oceania: Australia	4,626	977,959					4,626	977,959
Total	48,109	8,470,846	149,222	29,177,565	472,164	25,696,440	669,495	63,344,851

[1] All believed to be from Southern Rhodesia.
[2] Includes 1959: 75 tons ($9,066) other chrysotile crude, 2 tons ($787) blue crocidolite, 818 tons ($179,364) spinning fibers, and 446 tons ($92,517) short fibers credited by the Bureau of the Census to the United Kingdom; 8 tons ($6,580) amosite crude credited by the Bureau of the Census to Italy; 294 tons ($53,308) other chrysotile crude, 287 tons ($52,197) blue crocidolite, 73 tons ($10,303) short fibers credited by the Bureau of the Census to Mozambique; and 459 tons ($74,879) blue crocidolite, and 129 tons ($18,002) amosite crude credited by the Bureau of the Census to the Federation of Rhodesia and Nyasaland. 1960: 4 tons ($3,262) blue crocidolite, 484 tons ($91,089) amosite crude, 61 tons ($14,724) spinning fibers, 2 tons ($3,024) paper fibers, 1,085 tons ($251,814) short fibers credited by the Bureau of the Census to United Kingdom; 25 tons ($2,700) blue crocidolite, 121 tons ($11,811) short fibers credited by the Bureau of the Census to Mozambique; and 1,347 tons ($296,643) blue crocidolite, 1,211 tons ($241,275) amosite crude credited by the Bureau of the Census to the Federation of Rhodesia and Nyasaland.
[3] Adjusted by Bureau of Mines to include 4 short tons ($5,490) reported by the Bureau of the Census as short fibers.

Source: Bureau of the Census.

TABLE 3.—U.S. imports for consumption of asbestos, from specified countries, by grades

(Short tons)

Grade	1959			1960		
	Canada	Southern Rhodesia [1]	Union of South Africa	Canada	Southern Rhodesia [1]	Union of South Africa
Chrysotile:						
Crude:						
No. 1	41	35			353	
No. 2	30	20		28	18	
Other	268	4,292	[2] 1,826	329	1,494	2,164
Spinning or textile	20,488	527	[2] 1,173	19,172	110	[2] 219
Shingle	72,679	202	300	88,475		301
Paper	56,174		38	40,937		[2] 2
Short fiber	504,845	111	[2] 760	467,860	464	[2] 3,627
Crocidolite (blue)			[2] 18,006			[2] 14,899
Amosite			[2] 16,614			[2] 19,581
Total	654,525	5,187	38,717	616,801	2,439	40,793

[1] Reported by the Bureau of the Census as Federation of Rhodesia and Nyasaland. Believed to be from Southern Rhodesia.
[2] Includes countries adjusted by Bureau of Mines. See table 2, footnote 2, for explanation.

Source: Bureau of the Census.

Imports of low-iron chrysotile of spinning length from British Columbia increased from 5,988 tons in 1959 to 6,254 tons in 1960. Nearly 97 percent of the chrysotile imported was short fiber of less than spinning length.

The Union of South Africa supplied crocidolite and chrysotile and was the only source of amosite. Imports from Australia consisted solely of crocidolite. Only chrysotile was imported from other countries.

Exports of unmanufactured asbestos increased from 4,461 tons in 1959 to 5,525 tons in 1960.

TABLE 4.—U.S. exports[1] and reexports[2] of asbestos and asbestos products

Product	1959		1960	
	Quantity	Value	Quantity	Value
Exports:				
Unmanufactured:				
Crude and spinning fibers short tons	1,216	$295,549	1,524	$339,996
Nonspinning fibers do	802	200,003	867	150,557
Waste and refuse do	2,299	267,736	3,070	354,054
Total unmanufactured do	4,317	763,288	5,461	844,607
Products:				
Brake lining and blocks—molded, semimolded and woven	(3)	4,673,987	(3)	4,488,132
Clutch facing and lining number	1,427,059	1,139,154	1,461,015	1,149,765
Construction materials, n.e.c. short tons	11,031	2,423,793	9,961	2,237,444
Pipe covering and cement short tons	2,414	1,081,061	3,488	1,906,238
Textiles, yarn, and packing short tons	1,164	2,812,663	1,323	3,128,870
Manufactures, n.e.c.	(4)	771,660	(4)	776,905
Total products		12,902,318		13,687,354
Reexports:				
Unmanufactured:				
Crude and spinning fibers short tons	53	12,570	40	7,290
Nonspinning fibers do	19	3,600	24	4,972
Waste and refuse do	72	13,780		
Total unmanufactured do	144	29,950	64	12,262
Products:				
Brake lining and blocks—molded, semimolded and woven short tons	(3)	18,519	(3)	1,251
Construction materials, n.e.c. short tons			(5)	1,154
Textiles, yarn, and packing short tons			56	13,720
Total products		18,519		16,125

[1] Materials of domestic origin, or foreign material that has been milled, blended, or otherwise processed in the United States.
[2] Material that has been imported and later exported without change.
[3] Values have been summarized; quantities not shown.
[4] Quantity not recorded.
[5] Less than 1 ton.

Source: Bureau of the Census.

WORLD REVIEW

NORTH AMERICA

Canada.—With the opening of a pilot plant in the St. Malo Industrial center of Quebec by the Quebec Department of Mines,[5] facilities for processing asbestos ore samples in quantities up to carload lots were made available to mine operators. Problems confronting Canada

[5] Northern Miner (Toronto), Quebec Government Opens Pilot Plant for Ore Research: Vol. 46, No. 4, Apr. 21, 1960, p. 18.

as the producer of nearly 50 percent of the world's asbestos supply were discussed.[6]

TABLE 5.—World production of asbestos by countries [1] [2]

(Short tons)

Country [1]	1951-55 (average)	1956	1957	1958	1959	1960
North America:						
Canada (sales) [3]	960,336	1,014,249	1,046,086	925,331	1,050,429	1,118,456
United States (sold or used by producers	50,431	41,312	43,653	43,979	45,459	45,223
Total	1,010,767	1,055,561	1,089,739	969,310	1,095,888	1,163,679
South America:						
Argentina	422	238	319	285	[4] 275	[4] 275
Bolivia (exports)	341	62	121	----------	168	66
Brazil	2,038	3,739	2,654	3,816	2,075	1,577
Venezuela	681	5,041	8,390	9,152	5,095	4,333
Total	3,482	9,080	11,484	13,253	7,613	6,251
Europe:						
Bulgaria	948	1,100	1,100	1,100	[4] 1,100	[4] 1,100
Finland [5]	12,620	8,282	10,031	7,977	9,420	10,534
France	11,295	13,357	16,008	20,503	23,096	27,558
Greece	14	6	9	----------	----------	----------
Italy	27,647	39,446	40,361	39,921	48	56,654
Portugal	144	35	64	98	49,770	[4] 45
Spain	51	----------	----------	----------	19	----------
U.S.S.R. [4]	322,000	500,000	500,000	550,000	600,000	660,000
Yugoslavia	3,295	4,165	6,128	5,960	4,748	5,970
Total [4]	380,000	570,000	575,000	625,000	690,000	760,000
Asia:						
China [4]	12,000	26,000	33,000	66,000	88,000	88,000
Cyprus	16,736	15,375	15,028	16,494	14,424	[6] 17,167
India	871	1,378	1,925	1,302	1,464	1,886
Japan	5,638	9,914	13,192	11,187	13,633	17,073
Korea, Republic of	60	54	96	22	88	740
Taiwan	126	118	268	47	150	485
Turkey	79	634	99	839	411	238
Total [4]	36,000	54,000	64,000	96,000	118,000	126,000
Africa:						
Bechuanaland	711	1,356	1,582	1,734	1,410	1,849
Kenya	270	170	109	120	43	117
Morocco: Southern zone	626	379	132	110	----------	----------
Mozambique	99	202	152	198	37	----------
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	87,091	118,973	132,124	127,115	119,699	133,963
Swaziland	32,518	29,875	30,727	25,261	24,807	32,026
Union of South Africa	112,975	136,520	157,474	175,644	182,405	175,867
United Arab Republic (Egypt Region)	332	----------	22	485	502	[4] 550
Total	234,622	287,475	322,322	330,667	328,903	344,372
Oceania:						
Australia	4,850	9,709	14,670	15,570	17,856	[4] 15,400
New Zealand	369	368	230	454	640	[4] 600
Total	5,219	10,077	14,900	16,024	18,496	[4] 16,000
World total (estimate) [1] [2]	1,670,000	1,990,000	2,080,000	2,050,000	2,260,000	2,420,000

[1] Asbestos also is produced in Czechoslovakia, Eritrea, Iran, North Korea, Rumania and Uganda. No estimates for these countries are included in the total, as production is believed to be negligible.
[2] This table incorporates some revisions. Data do not add to totals shown because of rounding where estimated figures are included in the detail.
[3] Exclusive of sand, gravel and stone (waste rock only), production of which is reported as follows: 1951–55 (average) 29,042 tons; 1956, 45,427 tons; 1957, 13,652 tons; 1958, 18,450 tons; 1959, 29,532 tons; 1960, 51,625.
[4] Estimate.
[5] Includes asbestos flour.
[6] Exports.

Compiled by Helen L. Hunt, Division of Foreign Activities.

[6] Mulvihill, R. P., Canadian Asbestos for World Markets: Foreign Trade (Ottawa), vol. 114, No. 6, Sept. 10, 1960, pp. 22–23.

During the year 33.2 million tons of rock was mined and 1.1 million tons of fiber was recovered from 15.3 million tons of ore milled.

Descriptions of mining operations at the Jeffrey mine of the Canadian Johns-Manville Co., Ltd., at Asbestos, Quebec, were published.[7]

TABLE 6.—Canada: Sales of asbestos by grades

Grades	1959			1960		
	Short tons	Value		Short tons	Value	
		Totals (thousands)	Average per ton		Totals (thousands)	Average per ton
Crude No. 1, 2, and other	432	$491	$1,137	330	$341	$1,034
Milled group:						
3	30,375	13,338	439	32,190	14,272	443
4	238,185	44,210	186	294,092	54,757	186
5	135,459	17,409	129	156,901	19,709	126
6	166,346	13,838	83	179,361	14,763	82
7	465,052	20,256	44	445,509	18,794	42
8	14,580	303	21	10,073	208	21
Total, all grades	1,050,429	109,845	105	1,118,456	122,844	110
Waste rock	29,532	29	1	51,625	46	1

Source: Dominion Bureau of Statistics.

Asbestos recovery from the Black Lake mine of the United Asbestos Corp. increased to 5.15 percent in the first half of the year, compared with 4 percent in the same period in 1959, and production nearly doubled.

Exploration at the Munro mine of the Canadian Johns-Manville Co., Ltd., revealed new ore bodies between the two main ore zones, below the main 637-foot haulage level, and in an extension of the west stoping section. Since conversion to underground mining, the ore recovered was reported to be considerably higher grade than that obtained from open pit operations. Changes were made in the mill to improve the quality of fiber produced; an improved type of screening was provided, and installation of a new type of dryer was planned.[8]

Increased sales reported by the Cassiar Asbestos Corp., Ltd., in British Columbia were due largely to stronger demand for cement-grade product, with sales holding steady for the spinning grades. A reserve of 5 million tons of asbestos ore was reported by the company to have been developed at its Clinton Creek property. Expansion of the Cassiar mills to a daily capacity of 1,500 tons of ore was completed in January.

Development of the Baie Verte property of Advocate Mines, Ltd., Northern Newfoundland, was planned. Fiber from the deposit was reported to be grade 4 chrysotile, of good quality, for use in asbestos-cement products.[9] Drilling by the Murray Mining Corp., Ltd., at its Ungava deposit on Hudson Strait, 30 miles south of Deception Bay,

[7] Guimond, R., The World's Largest Asbestos Mine: Precambrian-Mining in Canada (Winnipeg), vol. 33, No. 6, June 1960, pp. 16–19, 22–25.
Jarman, H. G., Asbestos in Canada: Min. Mag. (London), vol. 102, No. 2, February 1960, pp. 95–98.

[8] Northern Miner (Toronto), Johns-Manville Finds New Ore at Munro Mine: Vol. 46, No. 27, Sept. 29, 1960, pp. 1, 5.

[9] Skillings Mining Review, Asbestos Orebody in Newfoundland Under Development: Vol. 49, No. 31, Oct. 29, 1960, p. 11.

Northern Quebec, indicated nearly 4 million tons of asbestos ore. Testing by the Quebec Department of Mines indicated about 12 percent fiber in the ore, mainly in groups four and five, equal or better in quality to that in Southern Quebec. Central Asbestos Mines completed test drilling of its new property in Coleraine Township and shipped the core to Quebec for mill tests. In Northern Ontario, drilling at the property of Normalloy Explorations, Ltd., indicated a large zone of asbestos-bearing rock containing mainly short-fiber asbestos of the type used in molded products. Young-Davidson Mines planned to drill claims 7 miles northeast of Munro mine in Ontario. Four asbestos occurrences in the Prince George area of British Columbia were reported by the Geological Survey of Canada.[10]

Guatemala.—Asbestos de Guatemala announced plans to develop asbestos deposits near El Rancho, El Progresso, and Pozo de Agua, all in the Sierra de Chuacus. Mill tests of a 700-pound sample were made at Globe, Ariz., and results were reported to be satisfactory.

SOUTH AMERICA

Argentina.—Large deposits of asbestos were reported in the province of La Rioja by a West German company.

Brazil.—S. A. Mineracão de Amianto operated its chrysotile asbestos mine at Djalma Dutra (Pocões) in the State of Bahia at a somewhat lower level of production than in 1959.

Venezuela.—The entire production of asbestos in 1959 came from the Tinaquillo mines of Amianto de Venezuela Co., in the State of Cojedes.

EUROPE

Greece.—Kennecott Copper Corp. completed legal requirements necessary for a mining company in Greece, and exercised its option to purchase the asbestos property it had explored in the Kozani area.

Italy.—According to preliminary figures, 1959 imports of asbestos totaled 15,574 tons, valued at US $3,062,000; exports totaled 10,568 tons, valued at US $969,000.

U.S.S.R.—An extensive deposit of asbestos was discovered in Aktyubinskaya Oblast. Development plans for the Bazhenovo chrysotile asbestos deposit, northeast of Sverdlovsk, were discussed in a Russian publication.[11]

Yugoslavia.—Preparations were under way to develop the Picelj mine in the mountains of Kopaonik, where reserves sufficient for 20 years were reported.

ASIA

Cyprus.—Asbestos exports in 1959 were shipped from the port of Limassol mainly to Denmark, Sweden, United Kingdom, Thailand, and Czechoslovakia. Cyprus Asbestos Mines, Ltd. produced from

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[10] Canadian Mining Journal, Asbestos Discoveries Pinpointed by G.S.C.: Vol. 82, No. 4, April 1961, p. 156.

[11] Karchevskaya, Ye.P. [Prospects of Developing the Bazhenovo Asbestos Mine]: Min. Jour. (Moscow), No. 7, 1959, pp. 47–50.

deposits on Troodos Mountain near Amiandos, 1,443,000 tons of rock in 1959 and 1,409,000 tons in 1958.

Japan.—Imports from Canada supplied Japan's requirements for high quality asbestos. Reserves of chrysotile asbestos in Japan were estimated to be about 39 million tons, averaging 1.1 percent fiber.[12]

North Borneo.—Newly discovered asbestos deposits were investigated.

AFRICA

Bechuanaland.—Workings were expanded and operations further mechanized in Bangwaketse Territory deposits.

Morocco.—Imports in 1959, primarily from Canada and the Union of South Africa, totaled 1,034 tons.

Rhodesia and Nyasaland, Federation of.—Over 86 percent of the chrysotile asbestos produced in 1959 was exported. Twenty-one companies reported production in 1959 but only six produced spinning grades: Asbestos Refining Co. (Rhod.) (Pvt.), Ltd., Bulawayo; Lanninhurst Asbestos, Ltd., West Nicholson; Rhodesian and General Asbestos Corp. (Pvt.), Ltd., Bulawaya; Rhodesian Monteleo Asbestos, Shabani; Ross McIntyre & Partners (Pvt.), Ltd., Shabani; and Rosey Cross Asbestos (Pvt.), Ltd., Mashaba.[13]

TABLE 7.—Southern Rhodesia: Asbestos production

Year	Short tons	Value (thousands)	Year	Short tons	Value (thousands)
1956	118,973	$23,832	1959	119,699	$20,735
1957	132,124	25,185	1960	133,963	20,888
1958	127,115	24,147			

Sudan.—Areas of ultrabasic rocks in the Qala en Nahl region, Eastern Sudan, were examined for possible asbestos deposits by the Sudan Geological Department.

Swaziland.—A short description of operations at the Havelock asbestos mine in the Barberton area was published.[14]

Union of South Africa.—Plans were revealed for improving operations at the Lalkloof chrysotile mine of the African Asbestos-Cement Corp., Ltd., following appointment of Johannesburg Consolidated Investment Co., Ltd., as technical and administrative advisers. The company increased the development work at its Lalkloof Mine, and rearrangement of the grading plant was planned.[15] Associated Ore and Metal Corp. suspended production temporarily to reduce accumulated stocks and increased its property holdings in the Pietersburg area, northern Transvaal. Msauli Asbestos Mining and Exploration Co. purchased mechanical equipment and began constructing a hydroelectric plant for its operations. Barberton Chrysotile Asbestos, Ltd. drew from the large accumulation of broken ore in the mine, increas-

[12] Geology and Mineral Resources of Japan, Second Edition: Geol. Survey of Japan, Hisamoto-cho, Kawaski-shi, Japan, March 1960, p. 214.
[13] Bureau of Mines, Mineral Trade Notes: Vol. 51, No. 2, August 1960, pp. 9–12.
[14] Canadian Mining Journal, Barberton Area: Vol. 81, No. 8, August 1960, pp. 63–64.
[15] South African Mining and Engineering Journal, African Asbestos-Cement Corporation Limited: Vol. 71, No. 3542, Dec. 23, 1960, pp. 1654–1655.

ing its milling rate and lowering costs. The tonnage of broken ore remaining was estimated to be 700,000 tons.

TABLE 8.—Union of South Africa: Asbestos production by varieties and sources

(Short tons)

Variety and source	1956	1957	1958	1959	1960
Amosite (Transvaal)	50,097	56,798	69,773	71,720	68,630
Chrysotile (Transvaal)	24,336	25,646	27,403	29,326	29,471
Blue (Transvaal)	14,399	15,303	16,670	13,113	11,185
Blue (Cape)	47,688	59,549	61,520	68,024	66,567
Tremolite (Transvaal)		178	278	222	14
Total	136,520	157,474	175,644	182,405	175,867

TABLE 9.—Union of South Africa: Production and exports of asbestos

Year	Production (short tons)			Exports	
	Transvaal	Cape Province	Total	Short tons	Value (thousands)
1956	88,832	47,688	136,520	122,867	$20,432
1957	97,925	59,549	157,474	142,799	25,278
1958	114,124	61,520	175,644	145,796	25,420
1959	114,381	68,024	182,405	151,515	25,971
1960	109,300	66,567	175,867	174,810	28,965

OCEANIA

Australia.—Mining operations of Australian Blue Asbestos, Ltd., in the Hamersley Range in northwest Western Australia were described.[16]

TECHNOLOGY

Research on the synthesis of asbestos continued with publication of two reports on fiber morphology. Electron micrographs were used to study the physical properties of natural inorganic fibers.[17] Bundles of chrysotile fibers embedded in "Araldite" were examined in an electron microscope.[18] Electron micrographs of cross sections of the fibers showed mainly circular-shaped concentric tubes with amorphous-appearing material plugging voids between tubes and within hollow fibers. The authors concluded that the presence of this material would explain the density of massive chrysotile which appeared too high for a tubular morphology.

A patent was issued for a method of forming capillary-like fibers of chrysotile by leaching antigorite with hydrochloric acid to remove from 5 to 75 percent of the magnesium hydroxide.[19]

Reports on the geology and genesis of asbestos deposits discussed conditions leading to chrysotile deposition in the Cassiar Mountains

[16] Bureau of Mines, Mineral Trade Notes: Vol. 52, No. 1, January 1961, pp. 4–8.
[17] Huggins, C. W., Electron Micrographs of Asbestiform Minerals: Bureau of Mines, Rept. of Investigations 5551, 1960, 14 pp.
[18] Maser, M., Rice, R. V., and Klug, H. P., Chrysotile Morphology: Am. Mineral., vol. 45, Nos. 5 and 6, May–June 1960, pp. 680–688.
[19] Kalousek, G. L. (assigned to Owens-Corning Fiberglas Corp.), Synthesis of Asbestos: U.S. Patent 2,926,997, Mar. 1, 1960.

of British Columbia, and the occurence near Lusaka, Northern Rhodesia, of slip-fiber crocidolite asbestos, classified as magnesioriebeckite.[20]

A Czechoslovakian publication discussed the origin of East Asian chrysotile asbestos deposits.[21]

The Baie Verte chrysotile asbestos deposit, Newfoundland, was described as occupying a tabular zone in serpentine under a surface capping of pyroxene-rich peridotite.[22]

Block-caving methods at the King Mine, Quebec, and Munro Mine, Ontario, were described.[23]

Several patents were issued for machines to separate fiber from heavier gangue material.

An improved electrostatic air filter, tested on a pilot plant scale by the Council of Scientific and Industrial Research in South Africa, had collecting efficiencies of 98 and 99 percent for dust and asbestos fibers, respectively. A full-scale unit of similar design was installed at the Kuruman Cape Blue Asbestos plant in Kuruman, Union of South Africa.[24]

The addition of 2 to 3 percent Group 7 asbestos fibers to asphalt paving mixtures was said to considerably improve physical properties of pavements, thereby promising reduced maintenance costs. Tests were conducted in the laboratory and on 18 test strips of highway in various parts of the United States and Canada.[25] The experimental use of short and waste grades of asbestos fiber in asphalt paving gave promise of greater markets and utilization for such products.

A patent was issued for a machine to produce a multi-colored asbestos-cement sheet.[26]

New types of asbestos papers, suitable for temperatures ranging from 300° F. to 500° F., were marketed. A new refractory material containing asbestos and an asbestos cloth were said to withstand temperatures of 3,000° F.

Numerous patents were issued covering the use of asbestos in special heat insulating applications, sealing compounds, and asphalt coatings.

Tests were made in Japan to produce a special cement by mixing abestos calcined at 650° C. with magnesium hydroxide calcined at 800° C.

The qualities of this cement were said to be about the same as magnesium oxychloride cement.

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[20] Gabrielse, H., The Genesis of Chrysotile Asbestos in the Cassiar Asbestos Deposit, Northern British Columbia: Econ. Geol., vol. 55, No. 2, March–April 1960, pp. 327–337.
Drysdall, A. R., and Newton, A. R., Blue Asbestos from Lusaka, Northern Rhodesia, and Its Bearing on the Genesis and Classification of This Type of Asbestos: Am. Mineral., vol. 45, Nos. 1 and 2, January–February 1960, pp. 53–59.

[21] Vejnar, Z., A Contribution to the Problem of the Origin of Some Chrysotile Asbestos Deposits in Eastern Asia: Sbornik Ustredniho Ustavu Geologickeho, Svazek 24–1957, Praha, Czechoslovakia, 1959, 76 pp.

[22] Bichan, W. J., Commercial Chrysotile Deposits, Baie Verte, Notre Dame Bay District, Newfoundland—Preliminary Notes: Econ. Geol., vol. 55, No. 2, March and April 1960, pp. 399–401.

[23] Harris, C. G., and Sluyter, R., Undercutting at the King Mine of Asbestos Corporation, Limited: Can. Min. and Met. Bull. (Montreal), vol. 53, No. 578, June 1960, pp. 392–396.
Parsons, G. W., and Sampson, R. E., Conversion From Open Pit to Underground Mining at the Munro Mine: Can. Min. and Met. Bull. (Montreal), vol. 53, No. 578, June 1960, pp. 397–405.

[24] South African Mining and Engineering Journal (Johannesburg), Passes Stringent Tests—But No Dust: Vol. 71, No. 3527, pt. 2, Sept. 9, 1960, p. 629.

[25] Engineering News-Record, Asbestos-Asphalt Surface Mixes Tested: Vol. 164, No. 16, Apr. 21, 1960, p. 70.

[26] Field, B. H., and Mayo, J. W. (assigned to The Patent and Licensing Corp.), Multi-Colored Asbestos—Cement Product and Process: U.S. Patent 2,929,735, Mar. 22, 1960.

Barite

By Albert E. Schreck [1] and Victoria M. Roman [2]

DOMESTIC output and sales of primary barite during 1960 declined from the quantities produced and sold in 1959. Imports showed a slight increase.

DOMESTIC PRODUCTION

Twelve States reported mine production of barite in 1960, and total domestic production was about 96,000 tons less than in 1959.

Arkansas was again the leading producer, followed by Missouri, Nevada, and Georgia in descending order. Output also was reported from California, Kentucky, Montana, New Mexico, South Carolina, Tennessee, Utah, and Washington. No production was reported from Idaho, but shipments were made from stocks. At yearend, stocks of primary barite at mines had increased 33 percent.

Crushed and ground barite output declined 19 percent in 1960, due to decreased requirements; stocks at processing plants decreased 7 percent.

TABLE 1.—Salient barite and barium-chemical statistics

	1951–55 (average)	1956	1957	1958	1959	1960
United States:						
Primary:						
Mine or plant production short tons	963,714	1,351,913	1,304,542	486,287	867,201	770,968
Sold or used by producers short tons	947,618	1,299,888	1,145,791	605,402	901,815	713,926
Value thousands	$9,104	$13,498	$12,897	[1] $7,507	$10,301	$8,563
Imports for consumption short tons	234,438	589,053	832,626	523,561	639,598	640,513
Value thousands	$1,663	$3,602	$5,864	$3,733	$4,825	$5,000
Consumption [2] short tons	1,161,907	2,035,389	1,670,720	1,195,669	[1] 1,396,239	1,190,021
Ground and crushed sold by producers short tons	946,458	1,503,010	1,467,117	1,026,865	[1] 1,209,907	976,480
Value thousands	$21,281	$41,623	$42,353	$28,352	[1] $30,431	$24,208
Barium chemicals sold by producers short tons	91,664	106,739	89,757	75,372	[1] 98,670	99,100
Value thousands	$12,652	$13,855	$12,254	$10,685	$13,657	$14,152
World: Production short tons	2,250,000	3,000,000	3,700,000	2,800,000	3,000,000	3,100,000

[1] Revised figure.
[2] Includes some witherite.

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.

TABLE 2.—Domestic barite sold or used by producers in the United States

State	1951–55 (average)		1956		1957	
	Short tons	Value	Short tons	Value	Short tons	Value
Arkansas	409,995	$3,783,705	486,254	$4,255,982	477,327	$4,536,827
California	(1)	(1)	(1)	(1)	13,144	182,378
Georgia, South Carolina, Tennessee	91,678	1,192,243	174,139	2,946,839	175,072	2,982,195
Missouri	318,644	3,201,334	381,642	4,461,955	317,350	3,938,486
Nevada	85,663	523,850	178,440	1,066,930	109,663	720,806
Other States [3]	41,638	402,671	79,413	766,266	53,235	536,727
Total	947,618	9,103,803	1,299,888	13,497,972	1,145,791	12,897,419

State	1958		1959		1960	
	Short tons	Value	Short tons	Value	Short tons	Value
Arkansas	182,779	$1,668,039	338,539	$3,096,583	277,851	$2,578,164
California	24,812	271,766	28,143	326,301	16,157	181,019
Georgia, South Carolina, Tennessee	108,511	2,284,561	89,484	1,809,367	119,304	2,347,220
Missouri	199,268	2,666,496	296,093	3,923,651	180,702	2,587,820
Nevada	59,407	[2] 402,936	91,298	622,973	85,711	579,710
Other States [3]	30,625	213,299	58,258	521,985	34,201	289,276
Total	605,402	[2] 7,507,097	901,815	10,300,860	713,926	8,563,209

[1] Included with Other States to avoid disclosing individual company confidential data.
[2] Revised figure.
[3] Includes Arizona (1951–55), Idaho, Kentucky (1959–60), Montana, New Mexico, Utah (1959–60), and Washington (1953–55, 1957–60).

International Minerals & Chemical Corp. constructed a half-million-dollar barite processing plant at Houston, Tex. The automated plant ground domestic and imported barite.[3]

United States Glass & Chemical Corp. continued construction of its barite mill near Dierks, Ark. The mill was scheduled for completion in June 1961 and was to have an annual capacity of 42,000 tons.

Production of most barium compounds, in contrast to other barium products, increased in 1960.

Barium and Chemicals, Inc. purchased a 165,000-square-foot plant at Steubenville, Ohio and planned to increase facilities for the production of high-purity barium compounds.[4]

CONSUMPTION AND USES

The curtailment in oil- and gas-well drilling had a direct effect on the consumption of barite. Primary barite sold or used by producers declined 21 percent in 1960.

[3] Mining World, vol. 22, No. 12, November 1960, p. 61.
[4] Ceramic Age, Purchase Steubenville Plant: Vol. 75, No. 6, June 1960, p. 60.

TABLE 3.—Ground and crushed barite produced and sold by producers in the United States

Year	Plants	Production (short tons)	Sales: Short tons	Sales: Value (thousands)	Year	Plants	Production (short tons)	Sales: Short tons	Sales: Value (thousands)
1951-55 (average)	27	964,403	946,458	$21,281	1958	34	1,014,133	1,026,865	$28,352
1956	30	1,625,879	1,503,010	41,623	1959	33	[1] 1,198,534	[1] 1,209,907	[1] 30,431
1957	33	1,480,585	1,467,117	42,353	1960	35	972,739	976,480	24,208

[1] Revised figure.

Quantities of crude barite used in manufacturing crushed and ground barite were below 1959 levels and sales of crushed and ground barite to consuming industries were off 19 percent. Ground barite sold declined 233,000 short tons, and oil- and gas-well drillers consumed 94 percent of the total. Consumption of ground barite by the other major consuming industries, aggregating only 6 percent, remained about the same as in 1959.

Barium chemical and lithopone manufacturers used approximately 15,000 tons more barite in 1960 than in 1959. Sales of most barium chemicals were slightly above 1959 levels.

Barium ferrite was used in permanent magnets and barium titanate was used in transducers, vibration pickups, and other electronic applications.

A thin film of barium fluoride was the key material used in a light-amplifying device reported to be very sensitive.[5]

TABLE 4.—Crude barite (domestic and imported) used in the manufacture of ground barite and barium chemicals in the United States

(Short tons)

Year	In manufacture of— Ground barite [1]	In manufacture of— Barium chemicals and lithopone [2]	Total	Year	In manufacture of— Ground barite [1]	In manufacture of— Barium chemicals and lithopone [2]	Total
1951-55 (average)	958,981	202,926	1,161,907	1958	1,053,297	142,372	1,195,669
1956	1,839,770	195,619	2,035,389	1959	[3] 1,226,633	169,606	[3] 1,396,239
1957	1,501,415	169,305	1,670,720	1960	1,004,820	185,201	1,190,021

[1] Includes some crushed barite.
[2] Includes some witherite.
[3] Revised figure.

[5] Materials in Design Engineering, Barium Fluoride Film Makes Electrons Visible: Vol. 52, No. 3, September 1960, pp. 186, 188, 190.

TABLE 5.—Ground and crushed barite sold by producers, by consuming industries

Industry	1951–55 (average)		1956		1957	
	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total
Well drilling	857,539	91	1,421,033	95	1,392,394	95
Glass	25,436	2	32,661	2	27,595	2
Paint	24,926	3	20,602	1	16,179	1
Rubber	19,821	2	22,101	2	21,782	1
Undistributed	18,736	2	6,613	(2)	9,167	1
Total	946,458	100	1,503,010	100	1,467,117	100

Industry	1958		1959		1960	
	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total
Well drilling	977,255	95	1,153,560	95	920,283	94
Glass	9,890	1	[1] 12,165	1	15,012	1
Paint	14,641	1	17,046	1	18,273	2
Rubber	18,387	2	19,806	2	17,082	2
Undistributed	6,692	1	7,330	1	5,830	1
Total	1,026,865	100	[1] 1,209,907	100	976,480	100

[1] Revised figure.
[2] Less than 1 percent.

TABLE 6.—Barium chemicals produced and used or sold by producers in the United States

(Short tons)

Chemical and year	Plants	Produced	Used by producers[1] in other barium chemicals[2]	Sold by producers[3]	
				Short tons	Value
Black ash:[4]					
1951–55 (average)	11	132,907	131,172	1,038	78,377
1956	10	131,006	129,969	6,356	524,359
1957	9	112,048	110,900	1,087	79,474
1958	8	93,539	81,861	1,351	126,050
1959	7	104,740	102,040	2,947	289,580
1960	9	116,995	113,466	3,136	298,741
Carbonate (synthetic):					
1951–55 (average)	4	67,301	23,766	44,245	3,945,511
1956	5	82,043	31,022	50,524	4,783,453
1957	6	74,160	31,056	42,937	4,335,469
1958	6	60,534	26,835	35,307	3,753,712
1959	6	[5] 77,048	29,398	47,137	5,099,366
1960	6	77,690	29,392	46,128	5,010,514
Chloride (100 percent $BaCl_2$):					
1951–55 (average)	4	13,736	2,248	11,424	1,621,103
1956	3	11,746	130	11,174	1,706,683
1957	3	9,715	----------	9,373	1,538,809
1958	4	8,428	----------	8,122	1,328,413
1959	4	(6)	(6)	(6)	(6)
1960	3	8,754	----------	9,401	1,535,188
Hydroxide:					
1951–55 (average)	5	13,170	304	12,659	2,606,072
1956	5	16,957	120	16,762	3,051,368
1957	5	12,698	162	12,551	1,915,700
1958	4	9,892	68	10,093	1,853,900
1959	5	14,293	(6)	13,914	2,320,522
1960	5	17,579	----------	14,971	2,336,402
Oxide:					
1951–55 (average)	3	13,094	7,031	5,967	1,459,694
1956	3	19,816	8,117	11,222	1,969,817
1957	3	20,452	5,446	14,159	2,585,193
1958	3	(6)	(6)	(6)	(6)
1959	3	(6)	(6)	(6)	(6)
1960	3	(6)	(7)	(6)	(6)
Sulfate (synthetic):					
1951–55 (average)	6	12,576	73	12,122	1,459,611
1956	6	9,981	192	9,281	1,263,575
1957	4	9,124	----------	8,719	1,281,657
1958	3	6,581	----------	6,628	844,940
1959	4	(6)	----------	(6)	(6)
1960	4	(6)	----------	(6)	(6)
Other barium chemicals:[8]					
1951–55 (average)	(9)	5,754	1,375	4,209	1,481,906
1956	(9)	1,808	190	1,420	555,803
1957	(9)	1,252	137	931	517,224
1958	(9)	18,549	3,213	13,871	2,778,377
1959	(9)	43,860	[5] 7,798	[5] 34,672	5,947,992
1960	(9)	30,690	(7)	25,464	4,971,000
Total:[10]					
1951–55 (average)	----------	----------	----------	91,664	12,652,274
1956	17	----------	----------	106,739	13,855,058
1957	14	----------	----------	89,757	12,253,526
1958	13	----------	----------	75,372	10,685,392
1959	14	----------	----------	[5] 98,670	13,657,460
1960	14	----------	----------	99,100	14,151,845

[1] Of any barium chemical.
[2] Includes purchased material.
[3] Exclusive of purchased material and exclusive of sales by one producer to another.
[4] Black-ash data include lithopone plants.
[5] Revised figure.
[6] Included with "Other barium chemicals" to avoid disclosing individual company confidential data.
[7] Figure withheld to avoid disclosing individual company confidential data.
[8] Includes barium acetate, oxide, nitrate, peroxide, sulfate, and other unspecified compounds. Specific chemicals may not be revealed.
[9] Plants included in above figures.
[10] A plant producing more than 1 product is counted but once in arriving at grand total.

PRICES

The prices of crude and ground barite have remained unchanged since 1957. During 1960, E&MJ Metal and Mineral Markets quoted the following prices on barite, f.o.b. cars:

Georgia:		
Crude, jig and lump	short ton	$18
Beneficiated, in bulk	do	21
Beneficiated, in bags	do	23.50 to $25
Missouri:		
Crude ore, minimum 94 percent $BaSO_4$ less than 1 percent Fe	do	16 to 18
Crude, oil well drilling, minimum 4.3 specific gravity, bulk	do	18
Some restricted sales	do	11.50
Ground, oil well grade	do	26.75
Water ground, and floated, bleached, carload lots, f.o.b. mine or mill	do	45 to 49
Canada:		
Crude, in bulk, f.o.b. shipping point	long ton	11
Ground, in bags	short ton	16.50
Imported:		
Crude, oil well drilling, minimum 4.25 specific gravity, bulk, c.i.f. Gulf Ports	do	16 to 18

TABLE 7.—Price quotations for barium chemicals in 1960

		January	December
Barium carbonate, precipitated, bags, carlots, works	short ton	$111.50	Unchanged.
Smaller lots, works	do	126.50	Do.
Barium chlorate, drums, works	pound	.32-.41	Do.
Barium chloride, anhydrous, bags, carlots, works	short ton	176.00	Do.
Less carlots, works	do	196.00	Do.
Barium dioxide (peroxide), drums, freight equaled	pound	.20	Do.
Barium hydrate, crystals, bags, carlots, truckloads, freight equaled	short ton	208.00	Do.
Less carlots, less truckloads freight equaled	do	218.00	Do.
Barium nitrate, barrels, carlots, truckloads, delivered	pound	.16	Do.
Less carlots, less truckloads, delivered	do	.17	Do.
Barium oxide, ground, drums, carlots, truckloads, freight equaled	short ton	275.00	Do.
Less carlots, less truckloads, freight equaled	do	285.00	Do.
Blanc fixe, direct process, bags, carlots, works	do	145.00	$160.00.[1]
Less carlots, works	do	155.00	$170.00.[1]
New York warehouse	do	195.00	$215.00.[2]
Lithopone, ordinary, bags, carlots, delivered	pound	[3] .08¾ E	Do.
Less carlots, delivered	do	[3] .09⅛ E	Do.
Titanated (high strength), bags, carlots, delivered	do	.11	Do.
Less carlots, delivered	do	.12	Do.

[1] Price changed July 4, 1960.
[2] Price changed to $200.00 per short ton July 4, 1960, and increased to $215.00 September 12, 1960.
[3] E=East.

Source: Oil, Paint and Drug Reporter.

FOREIGN TRADE [6]

Imports.—Imports of crude barite increased slightly over 1959. Mexico, Canada, Peru, and Greece, in descending order, supplied 78 percent of the total.

[6] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

Of the crude barite imported, 99 percent entered the United States through four ports on the Gulf Coast: New Orleans, La., 48 percent; Laredo, Tex., 30 percent; Sabine, Tex., 14 percent; and Galveston, Tex., 7 percent. The remaining 1 percent entered through St. Louis, Mo., El Paso, Tex., and North Carolina.

All witherite imported in 1960 came from the United Kingdom.

Ground barite imports decreased (almost 1,600 tons) to their lowest level since 1948.

TABLE 8.—U.S. imports for consumption of barite, by countries

	1959		1960	
	Short tons	Value	Short tons	Value
Crude barite:				
North America:				
Canada	171,462	$1,457,502	112,833	$977,759
Cuba	1,498	11,500	336	2,850
El Salvador	262	418		
Mexico	194,133	1,090,746	165,864	1,121,877
Total	367,355	2,560,166	279,033	2,102,486
South America:				
Brazil			23,303	216,282
Peru	112,178	1,097,522	112,744	1,131,634
Total	112,178	1,097,522	136,047	1,347,916
Europe:				
Greece	92,994	518,144	104,706	583,345
Italy	8,747	81,224	6,468	60,060
Spain			13,741	108,125
Yugoslavia	58,324	568,081	45,426	348,337
Total	160,065	1,167,449	170,341	1,099,867
Africa: Morocco			55,092	449,238
Grand total	639,598	4,825,137	640,513	4,999,507
Ground barite:				
North America: Canada	1,536	51,211	13	406
Europe:				
Germany, West	60	2,595	33	1,624
Italy	22	1,055		
Total	82	3,650	33	1,624
Africa: Algeria	25	1,070		
Grand total	1,643	55,931	46	2,030

Source: Bureau of the Census.

TABLE 9.—U.S. imports for consumption of barium chemicals

Year	Lithopone		Blanc fixe (precipitated barium sulfate)		Barium chloride		Barium hydroxide	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1951-55 (average)	186	$34,103	548	$44,162	559	[1] $49,678	112	$23,011
1956	143	[1] 19,931	1,026	104,662	1,378	[1] 107,913	22	3,130
1957	57	8,124	1,447	115,627	1,407	[1] 120,080	113	18,905
1958	69	9,307	1,573	103,865	1,376	129,159	161	25,832
1959	73	8,752	1,757	122,067	1,510	134,663	232	35,104
1960	62	7,973	1,629	124,093	1,004	91,843	39	16,172

Year	Barium nitrate		Barium carbonate precipitated		Other barium compounds	
	Short tons	Value	Short tons	Value	Short tons	Value
1951-55 (average)	260	$43,757	1,495	$106,447	562	[1] $117,673
1956	591	[1] 91,177	1,801	130,852	138	29,735
1957	798	120,075	1,543	105,046	61	22,209
1958	701	107,724	322	23,350	38	26,415
1959	596	89,822	1,895	127,734	55	41,823
1960	736	106,818	1,406	104,674	172	132,294

[1] Data known to be not comparable with other years.

Source: Bureau of the Census.

TABLE 10.—U.S. exports of lithopone

Year	Short tons	Value: Total	Value: Average per ton	Year	Short tons	Value: Total	Value: Average per ton
1951-55 (average)	7,858	$1,317,544	$167.67	1958	613	$122,462	$199.77
1956	1,387	239,892	172.96	1959	538	99,578	185.09
1957	991	177,891	179.51	1960	190	35,160	185.05

Source: Bureau of the Census.

TABLE 11.—U.S. imports for consumption of crude, unground witherite

Year	Short tons	Value [1]	Year	Short tons	Value [1]
1951-55 (average)	3,779	$129,106	1958 [2]	2,240	$108,119
1956 [2]	2,934	110,039	1959 [2]	2,552	113,229
1957 [2]	3,029	138,494	1960 [2]	1,344	59,257

[1] Valued at port of shipment.
[2] In addition, crushed or ground witherite was imported as follows: 1957, 8 tons ($533); 1958, 202 tons ($15,610); 1959, less than 1 ton ($478); 1960, 50 tons ($3,246). Class established June 1, 1956; no transactions.

Source: Bureau of the Census.

Barium-chemical imports decreased 1,000 tons despite increased imports of barium nitrate and other unspecified barium chemicals which were not sufficient to offset the decreased lithopone, blanc fixe, barium chloride, barium hydroxide, and barium carbonate imported. West Germany supplied about 84 percent of the barium compounds imported; France, 5 percent; and Italy, 3 percent. The remainder came from the United Kingdom, Netherlands, Belgium-Luxembourg, Switzerland, and Canada.

Exports.—Lithopone exports in 1960 were 65 percent below 1959. Of the total shipped, Canada received 68 percent; Cuba, 17 percent; Guatemala, 11 percent; and Uruguay, Colombia, and Panama, the remainder.

WORLD REVIEW

Output of barite was reported from 35 countries in 1960. Detailed data on barite reserves and resources in many of these nations were lacking; however, available information for 36 countries was assembled during the year and published.[7]

NORTH AMERICA

Mexico.—Examination of Mexico's barite reserves was begun by government geologists. The first area to be surveyed, near Galeana, Nuevo Leon, contained an estimated 150,000 tons of proven reserve. Examinations also were being conducted in the State of Coahuila.[8]

SOUTH AMERICA

Peru.—Two firms, Barmine Co. and Cia. Perforadora de Pozos para Irrigacion, S.A., from mines in the Rimac Valley, accounted for most of Peru's barite output in 1959. Exports in 1959, by country of destination, were as follows: United States, 118,549 short tons; Venezuela, 3,372 tons; Chile, 1,749 tons; and Ecuador, 912 tons.[9]

EUROPE

Bulgaria.—Operating barite mines included one near Stara Zagora, one near Kremikovtsi, and the Kashana deposit in the Pirdop area. Mines at Trun, Divlya, Zverino, and Botevgrad were inactive. A description of the beneficiation methods used at Bulgarian operations was published.[10] In the past large lumps of barite were hand sorted and smaller size barite was beneficiated by gravity methods. This method of beneficiation was supplanted in 1958 when the Stara Zagora and the Negushevo flotation plants were put into operation. At Stara Zagora the ore, after primary and secondary crushing, was reduced in a ball mill to 200-mesh and classified in a spiral classifier. Soda solution was added in the mill to control pulp density. A potash soap was used as both a frother and collector and, sodium silicate (water

[7] Bureau of Mines, Mineral Trade Notes, Barite Reserves and Resources in Foreign Countries: Vol. 51, No. 4, October 1960, pp. 12–22.

[8] World Mining: International News, Latin America, vol. 13, No. 8, July 1960, p. 78.

[9] Bureau of Mines, Mineral Trade Notes: Vol. 51. No. 1, July 1960, pp. 5–6.

[10] Takov, Sim. [Barite and its Beneficiation in Bulgaria]: Minno Delo i Metalurgiya, Vol. 15, No. 6, June 1960, pp. 10–12. Trans. in Selected Economic Trans. on Eastern Europe, No. 275, Feb. 4, 1961.

TABLE 12.—World production of barite, by countries [1] [2]

(Short tons)

Country [1]	1951–55 (average)	1956	1957	1958	1959	1960
North America:						
Canada	191,310	320,835	228,048	195,719	238,967	155,506
Cuba (exports)	981	----------	22,796	9,407	----------	----------
Mexico	61,060	132,956	579,646	397,550	314,933	315,627
United States	963,714	1,351,913	1,304,542	486,287	867,201	770,968
Total	1,217,065	1,805,704	2,135,032	1,088,963	1,421,101	1,242,101
South America:						
Argentina	19,500	19,152	25,264	18,596	[3] 18,700	[3] 18,700
Brazil	8,175	16,197	55,349	68,564	55,997	[3] 56,000
Chile	2,474	476	860	[3] 880	[3] 880	[3] 880
Colombia	6,359	8,378	6,963	14,330	11,023	8,049
Peru	14,858	11,601	95,388	117,943	105,557	120,813
Total	51,366	55,804	183,824	220,313	192,157	204,442
Europe:						
Austria	5,520	3,413	3,902	4,709	4,068	4,845
France	51,459	61,043	84,426	85,980	89,287	99,208
Germany:						
East [3]	25,353	27,600	27,600	27,600	27,600	27,600
West (marketable)	391,371	448,876	472,518	409,105	428,304	517,657
Greece	26,332	28,843	143,549	227,091	[3] 165,000	[3] 165,000
Ireland	4,081	7,729	11,231	11,283	9,369	9,890
Italy	84,526	103,075	124,945	122,976	109,088	128,070
Poland	[4] 11,574	12,346	[3] 12,400	[3] 12,400	[3] 12,400	[3] 12,400
Portugal	514	346	853	1,351	3,760	[3] 3,700
Spain	14,503	8,505	20,287	31,408	28,186	25,984
Sweden	82	----------	----------	----------	----------	----------
U.S.S.R.[3]	110,000	110,000	110,000	130,000	130,000	140,000
United Kingdom [5]	85,704	84,670	87,280	66,139	68,408	56,591
Yugoslavia	75,794	102,870	133,137	103,801	118,267	[3] 136,700
Total [1] [3]	892,000	1,005,000	1,240,000	1,240,000	1,200,000	1,335,000
Asia:						
India	12,615	7,072	14,462	17,536	14,939	14,976
Japan	18,928	20,578	27,514	16,510	21,331	26,345
Korea, Republic of	736	724	8	----------	----------	220
Phillipines	----------	5,045	6,088	64	186	6,198
Turkey	----------	----------	2,111	6,035	2,513	[3] 2,500
Total [1] [3]	45,500	61,000	83,000	95,000	94,000	117,000
Africa:						
Algeria	21,917	32,843	54,261	67,911	[3] 58,400	[3] 55,000
Morocco: Southern zone	8,898	32,622	16,276	47,060	40,574	92,945
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	132	----------	----------	34	241	----------
Swaziland	448	516	351	480	461	200
Union of South Africa	1,899	2,713	3,369	2,721	2,355	1,878
United Arab Republic (Egypt Region)	39	88	294	2,282	2,017	[3] 2,000
Total	33,333	68,782	74,551	120,488	104,048	152,023
Oceania: Australia	6,705	6,730	10,951	7,618	6,960	[3] 11,000
World total (estimate)[1] [2]	2,250,000	3,000,000	3,700,000	2,800,000	3,000,000	3,100,000

[1] Barite is produced in China, Czechoslovakia, and North Korea, but data on production are not available. Estimates by author of chapter included in total.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Average for 1 year only, as 1955 was first year of commercial production.
[5] Includes witherite.

Compiled by Liela S. Price, Division of Foreign Activities.

glass) served as the depressant for quartz and slime. After rougher flotation, the concentrate underwent four-stage cleaning. The rougher tailing passed to a scavenger cell for recovery of additional barite, and the scavenger concentrate was returned to the rougher circuit. The final barite concentrate was filtered on a drum vacuum filter. The process used at the Negushevo plant was essentially the same as that used at Stara Zagora; however, larger quantities of reagents were consumed. Concentrate from Stara Zagora averaged about 94 percent $BaSO_4$ with 81 percent recovery; that from Negushevo averaged about 95 percent $BaSO_4$ with 82.5 percent recovery. Production costs at Stara Zagora were about half those at Negushevo, primarily because of differences in the cost of ore and transportation. Barite ore processed at the latter plant came from underground mines and had to be transported 25 to 30 miles; ore used at the first plant came from open pits near the plant site.

Ireland.—Magnet Cove Barium Corp. and Silvermines Lead and Zinc Co., Ltd., entered an agreement whereby Magnet Cove would develop barite deposits near Ballynoe, Gortshaneroe.[11]

ASIA

Iran.—Magnet Cove Barium Corp. and Iranian partners formed Magcobar Iran to develop barite deposits in Iran and construct a grinding plant.[12]

Japan.—Japan imported barite to supplement its domestic production. China was the principal source until Japan discontinued trade relations in 1958. Of the 7,288 short tons of barite imported in 1957, 6,406 tons came from China and the remainder from the Republic of Korea. In 1958 China supplied 772 tons; Korea, 110 tons; and India, 1,963 tons.

Barite consumption in Japanese fiscal year 1959 (April 1–March 31) was estimated at 29,431 short tons. The manufacture of inorganic chemicals accounted for 19,511 tons; well drilling, 9,700 tons; and concrete, 220 tons.[13]

AFRICA

Morocco.—Exports of barite in short tons from Morocco in 1959, by country of destination, were as follows:[14]

Destination	*Short tons*
United States	16, 654
United Kingdom	7, 327
Netherlands	4, 387
Belgium	4, 306
Venezuela	3, 920
France	2, 996
Tunisia	331
Germany, West	16

[11] Mining World and Engineering Record (London), Silvermines Lead and Zinc Company Limited: Vol. 176, No. 4544, November 1960, p. 416.
[12] World Mining: International News, Asia, vol. 13, No. 7, June 1960, p. 57.
[13] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 3, March 1960, pp. 5–6.
[14] Bureau of Mines, Mineral Trade Notes: Vol. 51, No. 6, December 1960, pp. 4, 5.

TECHNOLOGY

Some 75 barite deposits in nine Arizona counties were examined, and information was collected on their history, ownership, and geology.[15] Many of the deposits were sampled for metallurgical testing, and the preliminary results were included in the report.

A barite occurrence near Eureka, Mont., was reported by the State Bureau of Mines and Geology. The occurrence, on the west flank of the Tobacco River Valley, Lincoln County, contained three barite bands, 5, 12, and 16 inches wide, which were exposed when a logging road was bulldozed in the area.[16]

A flowsheet outlining the flotation of a complex barite, fluorspar, sphalerite ore was published.[17] Ore, after primary crushing, was ground in a rod mill to minus 65-mesh. Zinc flotation reagents were added in the grinding circuit, and the pulp was conditioned. The pulp underwent rougher flotation, and the resulting concentrate was cleaned. The thickened tailing from this step passed to the barite recovery circuit. Here the pulp was conditioned with barium chloride and citric acid, and a frother and collector were added. After rougher flotation the concentrate was cleaned three times. After thickening, the concentrate was filtered and dried in rotary dryers and shipped in bulk or bags. Tailing from the barite circuit passed to another circuit for the recovery of fluorspar.

Research on barium titanates and barium ferrites continued and several papers resulted.[18] The electrical properties of several complex barium niobates were also investigated.[19] The National Bureau of Standards discovered that a series of barium niobates which contained one of several rare-earth elements and iron oxide exhibited both ferroelectric and ferrimagnetic properties.[20] The compounds had potential application in electronics where both properties are desirable. Research on the physical properties of this material continued.

Heat capacities and entropies of barium zirconate and barium sulfide were published.[21]

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[15] Stewart, L. A., and Pfister, A. J., Barite Deposits of Arizona: Bureau of Mines Rept. of Investigations 5651, 1960, 89 pp.

[16] Mines Magazine, Barite Vein Reported Near Eureka, Mont.: Vol. 50, No. 12, December 1960, p. 3.

[17] Deco Trefoil, Flotation of Barite—Fluorspar—Zinc: Vol. 24, No. 2, March–April 1960, pp. 11–12.

[18] De Vries, R. C., Multiple Growth Twinning in $BaTiO_3$ Single Crystals: Am. Mineral, vol. 45, Nos. 7 and 8, July–August 1960, pp. 852–861.

De Vries, R. C., Lowering of Curie Temperature of $BaTiO_3$ by Chemical Reduction: Jour. Am. Ceram. Soc., vol. 43, No. 4, April 1960, p. 226.

Goto, Y., and Takada, T., Phase Diagram of the System $BaO–Fe_2O_3$: Jour. Am. Ceram. Soc., vol. 43, No. 3, March 1960, pp. 150–153.

Robbins, C. R., The Compound $BaTiGe_3O_9$: Jour. Am. Ceram. Soc., vol. 43, No. 11, November 1960, p. 610.

[19] Baxter, P., and Hellicar, N. J., Electrical Properties of Lead-Barium Niobates and Associated Materials: Jour. Am. Ceram. Soc., vol. 43, No. 11, November 1960, pp. 578–583.

Goodman, G., Ferroelectric Behavior in Barium Zirconium Metaniobate: Jour. Am. Ceram. Soc., vol. 43, No. 2, February 1960, pp. 105–113.

[20] Ceramic Age, Separate Properties—Same Material: Vol. 75, No. 2, February 1960, p. 47.

[21] King, E. G., and Weller, W. W., Low-Temperature Heat Capacities and Entropies at 298.15° K. of the Zirconates of Calcium, Strontium and Barium: Bureau of Mines, Rept. of Investigations 5571, 1960, 3 pp.

King, E. G., and Weller, W. W., Low-Temperature Heat Capacities and Entropies at 298.15° K. of Strontium Sulfide and Barium Sulfide: Bureau of Mines, Rept. of Investigations 5590, 1960, 5 pp.

Bauxite

By John W. Stamper,[1] Arden C. Sullivan,[2] and Mary E. Trought [2]

WORLD production of bauxite in 1960 increased for the 10th consecutive year. Jamaica, British Guiana, the U.S.S.R., and the Republic of Guinea each reported gains of over 500,000 long tons. U.S. production, 7 percent of the world output of 27 million tons, rose 18 percent to 2 million tons. U.S. consumption of 8.9 million tons (dry equivalent) increased 3 percent and represented 33 percent of the total bauxite produced. (Aluminum metal is discussed in the Aluminum chapter of this volume.)

TABLE 1.—Salient bauxite statistics

(Thousand long tons and thousand dollars)

	1951-55 (average)	1956	1957	1958	1959	1960
United States:						
Production, crude ore (dry equivalent)	1,776	1,744	1,416	1,311	1,700	1,998
Value	$13,528	$15,109	$12,868	[1] $12,815	$17,725	$21,107
Imports for consumption [2]	4,076	5,670	7,098	7,915	[1] 8,149	8,744
Exports (as shipped)	38	15	61	12	17	29
Consumption (dry equivalent)	5,444	7,751	7,633	7,034	[1] 8,619	8,883
World: Production	14,420	[1] 18,540	[1] 20,150	[1] 21,020	[1] 22,600	27,060

[1] Revised figure.
[2] Includes bauxite imported for Government account. Import figures for Jamaican, Haitian, and Dominican Republic bauxite included were adjusted by Bureau of Mines to dry equivalent. Other imports, which are virtually all dried, are on an as-shipped basis.

DOMESTIC PRODUCTION

Crude bauxite production in the United States was 2 million long tons, dry equivalent, 18 percent higher than in 1959, but shipments from domestic mines and processing plants to consumers on a dry equivalent basis increased only 1 percent. Domestic production was 19 percent of the new supply, compared with 17 percent in 1959.

Bauxite was mined by American Cyanamid Co. in Georgia, and R. E. Wilson Mining Co., D. M. Wilson Bauxite Co., and Harbison-Walker Refractories Co. in Alabama. These companies produced a total of 66,000 tons, dry equivalent, 4 percent less than in 1959. Crude ore was processed at the R. E. Wilson Mining Co. drying plant near Eufaula, Ala., the Harbison-Walker calcining plant in Henry County, Ala., and the American Cyanamid drying plant at Adairsville, Ga.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

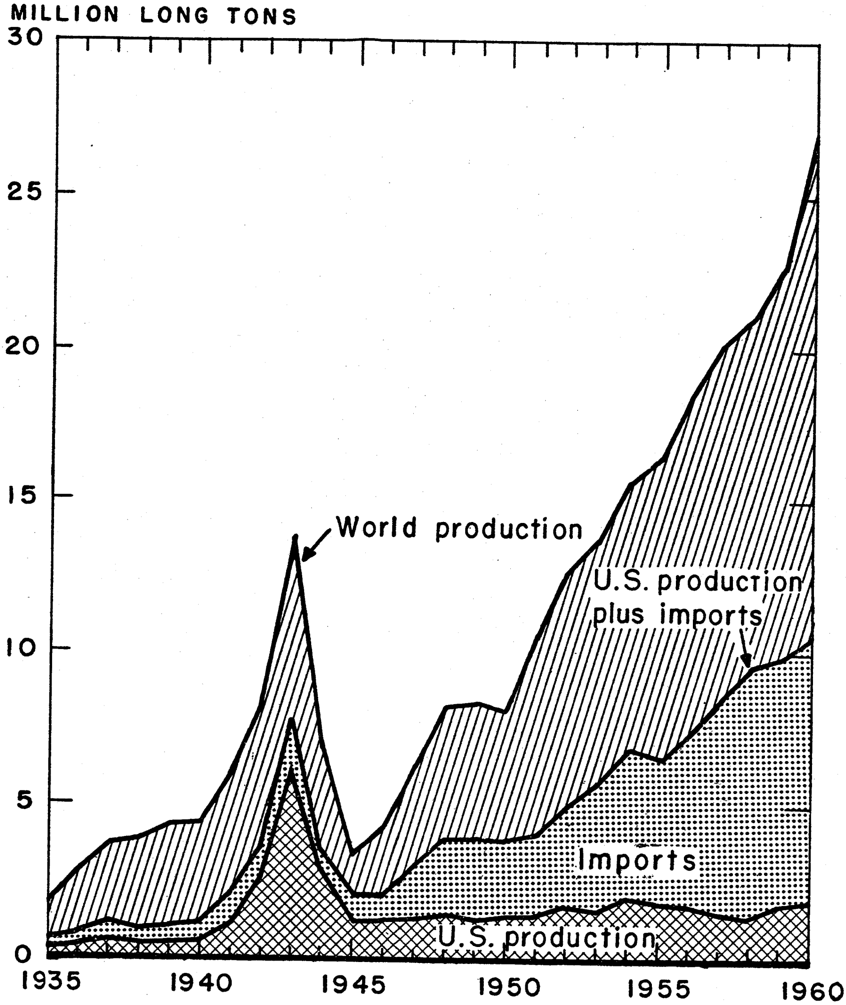

FIGURE 1.—U.S. supply and world production of bauxite, 1935–60.

Arkansas produced 97 percent of the U.S. bauxite output. The two leading producers in Arkansas were Aluminum Company of America (Alcoa) and Reynolds Metals Co.; each shipped ore to its own alumina plant. Three other companies also mined bauxite in Arkansas: American Cyanamid Co., Dickinson McGeorge, Inc., and Stauffer Chemical Co. American Cyanamid Co., Campbell Bauxite Co., Stauffer Chemical Co., and Porocel Corp. operated plants for producing dried, calcined, and activated bauxite. Norton Co. mine and plant were inactive.

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:						
1951-55 (average)	64	52	$430	56	53	$577
1956	94	75	665	74	68	728
1957	77	59	554	67	62	672
1958	67	53	504	61	58	630
1959	89	69	677	63	61	678
1960	82	66	638	49	51	577
Arkansas:						
1951-55 (average)	2,042	1,724	13,098	1,892	1,681	14,241
1956	1,967	1,669	14,444	1,817	1,568	14,644
1957	1,625	1,357	12,314	2,004	1,696	16,476
1958	1,517	1,258	[2] 12,311	1,588	1,348	[2] 14,373
1959	1,940	1,631	17,048	1,827	1,580	17,960
1960	2,327	1,932	20,469	1,876	1,603	18,982
Total United States:						
1951-55 (average)	2,106	1,776	13,528	1,948	1,734	14,818
1956	2,061	1,744	15,109	1,891	1,636	15,372
1957	1,702	1,416	12,868	2,071	1,758	17,148
1958	1,584	1,311	[2] 12,815	1,649	1,406	[2] 15,003
1959	2,029	1,700	17,725	1,890	1,641	18,638
1960	2,409	1,998	21,107	1,925	1,654	19,559

[1] Computed from selling prices and values assigned by producers and estimates of the Bureau of Mines.
[2] Revised figure.

TABLE 3.—Recovery of dried, calcined, and activated bauxite in the United States

(Long tons)

Year	Crude ore treated	Processed bauxite recovered			
		Dried	Calcined or activated	Total	
				As recovered	Dry equivalent
1951-55 (average)	447,650	298,826	48,384	347,210	372,871
1956	181,625	114,685	17,914	132,599	145,166
1957	187,921	128,509	13,093	141,602	147,508
1958	192,921	92,111	44,394	136,505	151,072
1959	215,008	85,833	60,135	145,968	171,187
1960	186,094	46,015	58,373	104,388	147,079

CONSUMPTION AND USES

Domestic consumption of bauxite increased 3 percent. Of the total consumed, 18 percent was from domestic deposits. Jamaican-type ore (from Jamaica, Haiti, or the Dominican Republic) provided an estimated 64 percent of the total consumption. The remainder came from Surinam and British Guiana.

TABLE 4.—Bauxite consumed in the United States, by industries

(Long tons, dry equivalent)

Year and industry	Domestic	Percent	Foreign	Percent	Total	Percent
1959:						
Alumina	1,513,824	90.2	6,513,168	93.8	8,026,992	93.1
Abrasive [1]	913	.1	216,504	3.1	217,417	2.5
Chemical	97,291	5.8	140,200	2.0	237,491	2.8
Refractory	15,175	.9	[2] 66,380	1.0	[2] 81,555	1.0
Other	50,828	3.0	4,510	.1	55,338	.6
Total [1]	1,678,031	100.0	[2] 6,940,762	100.0	[2] 8,618,793	100.0
Percent	19.5		80.5		100.0	
1960:						
Alumina	1,478,324	91.6	6,663,094	91.7	8,141,418	91.6
Abrasive [1]			284,185	3.9	284,185	3.2
Chemical	89,829	5.6	213,687	2.9	303,516	3.4
Refractory	18,684	1.2	75,027	1.0	93,711	1.1
Other	26,377	1.6	34,201	.5	60,578	.7
Total [1]	1,613,214	100.0	7,270,194	100.0	8,883,408	100.0
Percent	18.2		81.8		100.0	

[1] Includes consumption by Canadian abrasives industry.
[2] Revised figure.

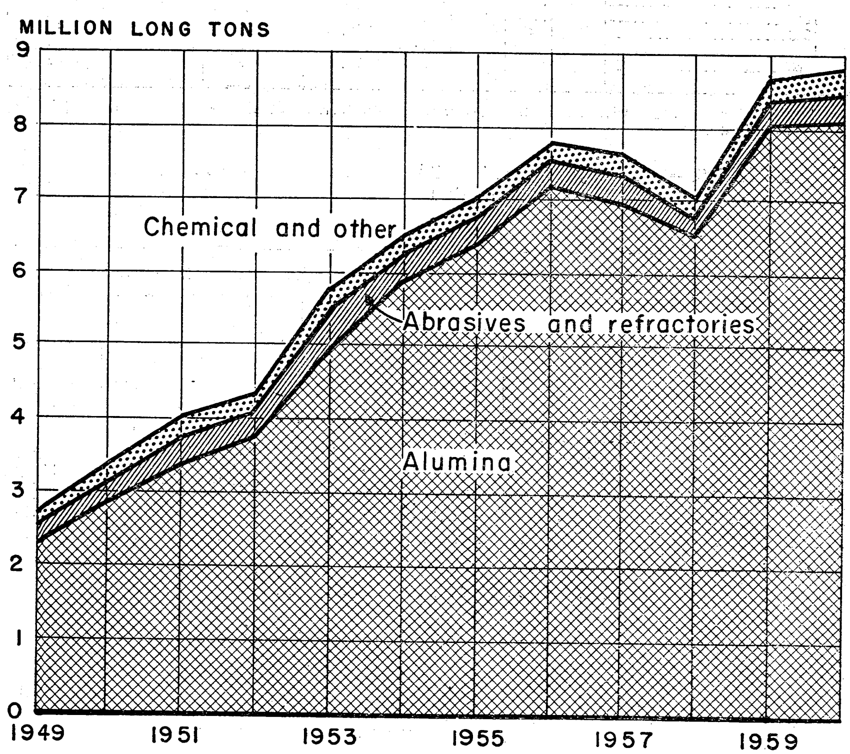

FIGURE 2.—Domestic consumption of bauxite, by uses, 1949–60.

Shipments of domestic ore containing less than 8 percent silica were 4 percent of the total, compared with 13 percent in 1959. The proportion of ore containing 8 to 15 percent silica increased from 54 percent in 1959 to 65 percent, and the proportion of ore containing more than 15 percent silica decreased to 31 percent. Total shipments were about the same as in 1959, the increase in shipments of ore containing 8 to 15 percent silica offsetting the decline in shipment of other types.

TABLE 5.—Bauxite consumed in the United States in 1960, by grades

(Long tons, dry equivalent)

Grade	Domestic origin	Foreign origin	Total	Percent
Crude	1,493,462	1,192	1,494,654	16.8
Dried	44,765	6,930,369	6,975,134	78.6
Calcined	63,774	338,633	402,407	4.5
Activated	11,213	----------	11,213	.1
Total	1,613,214	7,270,194	8,883,408	100.0
Percent	18.2	81.8	100.0	----------

The eight domestic alumina plants operated by the aluminum companies produced 4,026,000 short tons of calcined alumina and aluminum oxide products, about the same as 1959, calculated on the basis of the calcined equivalent. The gross weight of the calcined alumina and aluminum oxide produced was 4,088,000 tons. Of this total, 3,873,000 tons was calcined alumina, 172,000 tons was trihydrate alumina, and the remainder was activated or tabular alumina. Shipments of alumina and aluminum oxide products totaled 4,018,000 tons, of which 3,790,000 tons went to the aluminum industry. The remaining 228,000 tons, valued at $20.4 million, was shipped as commercial trihydrate or as activated, calcined, or tabular alumina for use primarily by the chemical, abrasive, ceramic, and refractory industries.

TABLE 6.—Production and shipments of selected aluminum salts in the United States in 1959

Type of salt	Number of plants producing	Production (short tons)	Shipments and interplant transfers	
			Short tons	Value f.o.b. plant (thousands)
Aluminum sulfate:				
General:				
Commercial (17 percent Al_2O_3)	52	907,098	884,554	$33,055
Municipal (17 percent Al_2O_3)	5	5,066	----------	----------
Iron-free (17 percent Al_2O_3)	12	50,570	27,107	1,976
Sodium aluminate (62.2 percent Al_2O_3)	4	(1)	(1)	(1)
Aluminum chloride:				
Liquid (32° Be′) } Crystal (32° Be′) }	10	23,326	10,179	840
Anhydrous (100 percent $AlCl_3$)	7	29,842	26,636	8,149
Aluminum fluoride, technical	5	57,644	57,359	17,912
Aluminum trihydrate (100 percent $Al_2O_3.3H_2O$)	10	197,072	168,220	10,235
Other aluminum salts	----------	----------	----------	[2] 14,099
Total	----------	----------	----------	86,266

[1] Included with "Other aluminum salts."
[2] Includes cryolite, sodium-aluminum sulfate, sodium-aluminate, potassium-aluminum sulfate, ammonium-aluminum sulfate, aluminum hydroxide (light or litho), and other aluminum compounds.

Source: Data are based upon report Form MA-28E.1, Annual Report on Shipments and Production of Inorganic Chemicals and Gases, Bureau of the Census.

Calcined alumina consumed at the 22 aluminum reduction plants in the United States totaled 3,821,000 short tons, 2 percent more than in 1959. An average of 2.022 long dry tons of bauxite was required to produce 1 short ton of alumina, and an average of 1.897 short tons of alumina was required to produce 1 short ton of aluminum metal. The overall ratio was 3.836 long dry tons of bauxite to 1 short ton of aluminum.

STOCKS

Bauxite stocks in the United States increased 375,000 long dry tons from stocks at the end of 1959. On a dry basis, consumers' inventories decreased 1 percent; those at mines and processing plants increased 65 percent. No withdrawals were made from the Government-held nonstrategic stockpile. Jamaican, Surinam, and refractory grades of bauxite remained on the Group I list of strategic materials for the national stockpile.

During the year 1,059,000 tons of Jamaican-type ore and 987,000 tons of Surinam-type ore were acquired by purchase or barter. This brought the supplementary, Commodity Credit Corp., and Defense Production Act inventories to 5,916,000 tons.

TABLE 7.—Stocks of bauxite in the United States [1]

(Long tons)

Year	Producers and processors		Consumers		Government	Total	
	Crude	Processed [2]	Crude	Processed [2]	Crude	Crude and processed [2]	Dry equivalent
1956	1,143,392	5,812	483,173	1,605,262	2,204,674	5,442,313	4,898,229
1957	739,836	6,313	488,564	2,364,206	2,204,674	5,803,593	5,329,014
1958	644,051	6,806	606,643	2,163,120	2,204,674	5,625,294	5,146,918
1959	741,228	7,341	543,074	1,998,475	2,204,674	5,494,792	5,013,995
1960	1,225,569	10,242	530,646	1,974,890	2,204,674	5,946,021	5,388,767

[1] Excludes strategic stockpile.
[2] Dried, calcined, and activated.

PRICES

No open-market price was in effect for bauxite mined in the United States, as the output was consumed mainly by the producing companies.

The average value of bauxite shipped and delivered to domestic alumina plants was estimated at $16.92 per long ton, dry equivalent, for imported ore.

The price quoted in E&MJ Metal and Mineral Markets for December 29, for imported abrasive-grade ore, crushed and calcined, 86 percent minimum Al_2O_3, f.o.b. port, British Guiana, was $20.45 per long ton, the same as quoted in December 1959. Imported refractory-grade bauxite was quoted at $26.60, the same price as in 1959.

The average value of calcined alumina, as determined from producer reports, was $0.0349 per pound. The value of imported calcined alumina at the port of shipments was comparable.

TABLE 8.—Average value of domestic bauxite in the United States[1]

(Per long ton)

Type	Shipments f.o.b. mines or plants 1959	Shipments f.o.b. mines or plants 1960	Type	Shipments f.o.b. mines or plants 1959	Shipments f.o.b. mines or plants 1960
Crude (undried)	$8.98	$9.51	Calcined	(2)	(2)
Dried	11.17	12.09	Activated	$63.31	$64.18

[1] Calculated from reports to the Bureau of Mines by bauxite producers.
[2] Figure withheld to avoid disclosing individual company confidential data.

TABLE 9.—Average value of U.S. imports and exports of bauxite

(Per long ton)

Type and country	Average value, port of shipment 1959	Average value, port of shipment 1960	Type and country	Average value, port of shipment 1959	Average value, port of shipment 1960
Imports:			Imports—Continued		
Crude and dried:			Calcined: [3]		
British Guiana	[1] $6.95	$6.85	British Guiana	[4] $24.06	$21.59
Dominican Republic [2]	12.73	12.59	Canada		34.85
Greece		4.95	Greece		12.37
Haiti [2]	8.72	8.90	Surinam	[4] 25.00	20.19
Jamaica [2]	9.51	9.48	Average	[4] 24.06	19.13
Surinam	8.04	7.72	Exports:		
Average	9.03	8.93	Bauxite and bauxite concentrate	104.86	88.29

[1] Revised figure.
[2] Dry equivalent tons used for computation.
[3] For refractory use.
[4] Estimated by Bureau of Mines.

Source: Bureau of the Census.

Note: Bauxite is not subject to an ad valorem rate of duty and the average values reported may be arbitrary for accountancy between allied firms, etc. Consequently the data do not necessarily reflect market values in the country of origin.

TABLE 10.—Market quotations on alumina and aluminum compounds

Compound	Dec. 28, 1959	Dec. 26, 1960
Alumina, calcined, bags, carlots, works ... pound	$0.05	$0.0535
Aluminum hydrate, heavy, bags, carlots, freight equalized ... do	.035	.0370
Aluminum sulfate, commercial, ground, bulk, carlots, works, freight equalized ... ton	40.00	40.00
Aluminum sulfate, iron-free, bags, carlots, works, freight equalized ... 100 pounds	3.80	3.80

Source: Oil, Paint and Drug Reporter.

FOREIGN TRADE [3]

Imports.—Imports of bauxite, including ores acquired by the U.S. Government, rose to 8.7 million long tons on a dry weight basis, 7 percent above 1959. Imports from Jamaica, the principal source

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

in recent years, decreased for the second consecutive year and on a dry weight basis accounted for 48 percent of the total. Imports from Surinam were 37 percent of the total, and the remainder was from the Dominican Republic, Haiti, British Guiana, and European countries. Total imports on an as-shipped basis were 9,591,000 long tons.

On a dry basis, 42 percent of the imports entered through the New Orleans, La., customs district; 29 percent through the Galveston, Tex., district; 27 percent through the Mobile, Ala., district; and 2 percent through other districts.

TABLE 11.—U.S. imports for consumption of bauxite (crude and dried) by countries [1]

(Thousand long tons and thousand dollars)

	1951-55 (average)	1956	1957	1958	1959	1960
North America:						
Dominican Republic (dry equivalent)					384	632
Haiti (dry equivalent)			318	317	[2] 307	341
Jamaica (dry equivalent)	1,028	2,573	3,622	4,950	[2] 4,220	4,180
Trinidad and Tobago	6					
Total	1,034	2,573	3,940	5,267	[2] 4,911	5,153
South America:						
British Guiana	165	269	391	223	[2] 160	330
Surinam	2,798	2,798	2,767	2,425	[2] 3,078	3,256
Other South America	(3)					
Total	2,963	3,067	3,158	2,648	[2] 3,238	3,586
Europe	2			(3)		5
Asia	77					
Africa		30				
Grand total	4,076	5,670	7,098	7,915	[2] 8,149	8,744
Value	$28,704	$44,414	$60,933	$70,107	[2] $73,549	$78,065

[1] Import figures for Jamaican, Haitian and Dominican Republic bauxite adjusted by Bureau of Mines to dry equivalent. Other imports, which are virtually all dried, are on an as-shipped basis.
[2] Revised figure.
[3] Less than 1,000 tons.

Source: Bureau of the Census.

Imports of calcined alumina for producing aluminum metal were 88,000 short tons; 98 percent came from Japan and the remainder from West Germany. Other aluminum compounds imported into the United States were chiefly from Canada, West Germany, the United Kingdom, Italy and other western European countries and totaled 8,811 short tons.

On April 22, Public Law 415 was amended to extend the suspension of duty on alumina used for the production of aluminum and on crude or calcined bauxite until July 16, 1962. Duties on imports of aluminum hydroxide and alumina not used for aluminum production remained at 0.25 cent a pound.

Exports.—Exports of bauxite and bauxite concentrate increased 68 percent. Canada, as in past years, received most of the total.

Of the 12,286 short tons of aluminum sulfate exported, about two-thirds was shipped to Canada, Venezuela, and Guatemala. Of the 35,144 short tons of other aluminum compounds exported, 70 percent was shipped to Norway.

TABLE 12.—U.S. exports of bauxite (including bauxite concentrate [1]), by countries

(Long tons)

Destination	1951-55 (average)	1956	1957	1958	1959	1960
North America:						
Canada	36,764	13,337	58,654	9,548	13,377	24,879
Mexico	575	633	862	1,177	1,614	2,781
Other North America	190	167	153	164	92	406
Total	37,529	14,137	59,669	10,889	15,083	28,066
South America	51	80	121	37	346	92
Europe	252	378	403	601	1,082	577
Asia	47	295	764	309	835	542
Africa	16	31	36	32	57	33
Oceania						7
Grand total as exported	37,895	14,921	60,993	11,868	17,403	29,317
Dried bauxite equivalent [2]	58,420	23,128	94,539	18,395	26,975	45,441
Total value thousands	$1,029	$834	$4,847	$968	$1,825	$2,588

[1] Classified as "Aluminum ores and concentrates" by the Bureau of the Census.
[2] Calculated by Bureau of Mines.

Source: Bureau of the Census.

Table 13 shows the international flow of bauxite in 1958. The quantity exported (12.8 million long tons) was the same as in 1957. Jamaica increased its exports by more than 1 million tons and was the world's largest exporter of bauxite.

WORLD REVIEW

World production of bauxite rose 20 percent. Jamaica, as in past years, was the principal producer, supplying 21 percent of the world total. Output in the Republic of Guinea increased 1 million tons and 500,000 tons or more in Jamaica, British Guiana, and the U.S.S.R. Significant developments were announced in plans for exploiting Australian bauxite.

TABLE 13.—Production and trade of bauxite in 1958, by major countries

(Thousand long tons)

Exports, by countries of origin	Production	Exports	Countries of destination: North America: Canada	North America: United States	Europe: Germany, West	Europe: Italy	Europe: Norway	Europe: U.S.S.R.	Europe: United Kingdom	Europe: Other Europe	Asia (Japan)	All other countries
North America:												
Haiti	280	317		[1] 317								
Jamaica	5,722	4,799	(2)	4,799								
United States	1,311	12	10		(2)	(2)			(2)	(2)	(2)	2
South America:												
Brazil	69	3										3
British Guiana	1,586	1,364	989	281	10	5			22	34	9	14
Surinam	2,941	2,820	177	2,629						9		5
Europe:												
Austria	23	8			8							
France	1,788	304			173	4			115			12
Germany, West	4	(2)								(2)		(2)
Greece	843	823			280	2	34	441	37	29		
Hungary	1,032	530						[3] 530				
Italy	294											
Rumania	72	(4)										
Spain	8											
U.S.S.R.	[5] 2,710	(4)										
Yugoslavia	721	583			398	178			3	4		
Asia:												
China (diasporic)	[5] 150	(4)										
India	166	20			9	(2)			2	6	1	2
Indonesia	338	385			[1] 69						[1] 234	[1] 82
Malaya	262	247									232	15
Pakistan	2											
Sarawak	136	93									57	36
Africa:												
Ghana	[6] 207	207			11				196			
Guinea, Republic of	343	260	188		60					(2)		12
Mozambique	5	2										2
Oceania: Australia	7											
Total	[5] 21,020	12,777	1,364	8,026	1,018	189	34	971	375	82	533	185

[1] Imports.
[2] Less than 500 tons.
[3] U.S.S.R. and other Communist nations of East Europe.
[4] Data not available.
[5] Estimate.
[6] Exports.

Compiled by Corra A. Barry, Division of Foreign Activities.

TABLE 14.—Relationship of world production of bauxite and aluminum

(Million long tons)

Commodity	1951-55 (average)	1956	1957	1958	1959	1960
Bauxite	14.4	18.5	[1] 20.2	[1] 21.0	[1] 22.6	27.1
Aluminum	2.4	3.3	3.3	3.5	4.0	4.5
Tons of bauxite per ton of aluminum produced	6.0	5.6	6.1	6.0	5.6	6.0

[1] Revised figure.

TABLE 15.—World production of bauxite by countries[1]

(Thousand long tons)

Country	1951-55 (average)	1956	1957	1958	1959	1960
North America (dried equivalent of crude ore):						
Dominican Republic	-------	-------	-------	-------	759	678
Haiti	-------	-------	263	280	255	268
Jamaica	[2] 1,546	3,141	4,643	5,722	5,125	5,745
United States	1,776	1,744	1,416	1,311	1,700	1,998
Total	3,322	4,885	6,322	7,313	7,839	8,689
South America:						
Brazil	25	69	63	69	95	[3] 98
British Guiana	2,282	2,481	2,202	1,586	1,674	2,471
Surinam	3,087	3,430	3,324	2,941	3,376	3,400
Total	5,394	5,980	5,589	4,596	5,145	5,969
Europe:						
Austria	16	22	22	23	24	26
France	1,221	1,439	1,663	1,788	1,717	2,006
Germany, West	6	5	5	4	4	[3] 4
Greece	321	687	820	843	886	[3] 935
Hungary	1,153	879	893	1,032	923	1,170
Italy	262	271	257	294	287	313
Rumania	21	51	61	72	70	[3] 75
Spain	8	7	8	8	8	4
U.S.S.R.[3]	1,248	2,190	2,410	2,710	2,950	3,445
Yugoslavia	604	868	874	721	802	1,009
Total[3]	4,860	6,419	7,013	7,495	7,671	8,987
Asia:						
China (diasporic)[3]	-------	-------	-------	150	300	350
India	71	91	97	166	215	378
Indonesia	261	299	238	338	381	389
Malaya	112	264	326	262	382	452
Pakistan	[4] 1	3	3	2	2	1
Sarawak	-------	-------	-------	136	207	285
Taiwan (Quemoy)	2	-------	-------	-------	-------	-------
Total	447	657	664	1,054	1,487	1,855
Africa:						
Ghana (exports)	120	138	185	207	148	188
Guinea, Republic of	268	444	360	343	296	1,356
Mozambique	3	4	5	5	4	4
Total	391	586	550	555	448	1,548
Oceania: Australia	6	10	8	7	8	[3] 7
World total (estimate)	14,420	18,540	20,150	21,020	22,600	27,060

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] Average for 1952–55.
[3] Estimate.
[4] One year only, as 1955 was the first year of production reported.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

NORTH AMERICA

Jamaica.—Jamaica continued as the leading producer of bauxite and increased output 12 percent, exceeding the previous high of 1958. Exports totaled 4,148,000 long dry tons, 49,200 tons less than in 1959.

Kaiser Aluminum & Chemical Corp. mined and shipped 2,599,000 long dry tons of bauxite to the United States, a 10-percent increase over 1959.

Alumina Jamaica, Ltd., produced 1,597,000 long dry tons of bauxite, which was used in producing 745,000 short tons of alumina. Exports of alumina increased 67 percent over 1959. Of the exports, 448,000 short tons went to Canada, 286,000 to Norway and Sweden, 10,500 tons to India, 652 to British Guiana, and 128 to Trinidad.

Alcoa Minerals of Jamaica, Inc., completed prospecting in the Mocho area of Clarendon Parish and exercised its option on a lease of over 50 square miles formerly held by Caribex, Ltd. An estimated $15 million was scheduled to be spent by the company on a construction and development program calling for initial production of bauxite by June 1963.

Harvey Aluminum Inc. began prospecting for bauxite under a special exclusive prospecting license in the St. John's-Red Hills area of St. Catherine Parish.

Magnet Consolidated Mines of Canada acquired an option on a property covering 5,000 acres, 50 miles west of Kingston.

Panama.—Alcoa Minerals, Inc. concluded from surveys made in the Chiriqui province, that further exploration was not justified and announced that work had been suspended. Kaiser also renounced exploratory rights to a 10,000-hectare area in the same province.

SOUTH AMERICA

British Guiana.—Production of bauxite increased 48 percent, and exports 38 percent. The Demerara Bauxite Co.'s 245,000-short-ton alumina plant at Mackenzie was virtually completed at yearend. The company spent $22 million on the plant, bringing total expenditures on the project to $60 million.

The British Guiana Geological Survey Department completed the first stage of an exploratory survey of bauxite deposits in the Pakaraima Mountain area and concluded that the deposits are more extensive than previously reported. Potential resources in the area were said to be comparable in size with the bauxite deposits of Australia and West Africa, although of lower grade.[4]

[4] Bleackley, D., Occurrence of Bauxite in the Pakaraima Mountains: Prel. Rept. Geol. Survey Dept., Georgetown. Feb. 26, 1960, 10 pp.

TABLE 16.—British Guiana: Bauxite exports

(Long tons)

Country of destination	1959		1960	
	Dried ore	Calcined ore	Dried ore	Calcined ore
Canada	938,770	80,620	1,315,411	85,831
France	3,700	14,861		21,506
Germany, West		22,240		33,662
Italy		15,275		17,872
Japan		10,540		8,402
United Kingdom	7,920	19,855	11,490	31,709
United States	288,953	83,607	453,908	80,694
Other countries	3,038	25,307	7,154	27,280
Total	1,242,381	272,305	1,787,963	306,956
Value, BWI$ [1]	14,671,463	10,117,781	17,930,693	11,565,070

[1] BWI $=US $0.58.

Surinam.—Exports of bauxite increased 7 percent to 3,578,000 long tons. Shipments by Suriname Aluminum Co. (Suralco) decreased 7 percent to 2,485,000 tons, whereas shipments by N. V. Billiton Maatschappij Suriname increased 63 percent to 1,093,000 tons.

Venezuela.—Bauxite deposits were recently found in the Gran Sabana area of Bolivar State, but the grade of the ore was not determined. Smaller deposits, estimated to contain 1,772,000 long tons, have been found in other parts of the State. Commercial possibilities of large bauxite deposits discovered in the State of Guayana were to be investigated by the Venezuelan Government. The Venezuelan Mines Minister stated that potential reserves of bauxite in Venezuela were estimated at 103 million long tons.[5]

EUROPE

France.—Pechiney, Compagnie de Produits Chimiques et Electrometallurgiques, announced that capacity of the Salindres (Gard) alumina plant was to be increased 110,000 short tons by 1962 and that production of alumina was discontinued at the 110,000-ton capacity plant at Saint Auban (Basses-Alpes) in August.

Greece.—The Greek Government announced the establishment of a $75 million aluminum industry in Greece. The participating companies in the enterprise were Pechiney, Compagnie de Produits Chimiques et Electrometallurgiques, 50 percent, Stavros Niarchos, 21 percent; Reynolds International Inc., 17 percent; and Industrial Development Corp. of Greece (IDC), 12 percent. The proposed project included a 110,000-short-ton-a-year alumina plant, which was to use bauxite from Greek deposits.

Exports of bauxite in 1960 totaled 891,000 long tons, of which 426,000 went to the U.S.S.R.; 303,000 to West Germany; 52,000 to the United Kingdom; 30,000 to Norway; 24,000 to France; 12,000 to Spain; and the remainder to other countries.

Hungary.—As a result of expansion of the Ajka and Magyarovar alumina plants, production exceeded 243,000 short tons in 1960, more than seven times that of 1949. Exports of alumina totaled 134,000 short tons. Bauxite production increased 27 percent to 1,170,000 long

[5] Mining Journal (London), Mining Miscellany: Vol. 255, No. 6536, Nov. 25, 1960, p. 603.

tons. About a third of the bauxite produced was exported, chiefly to Czechoslovakia, East Germany, and Poland.[6]

Italy.—Monte Amiata Co. was granted a license to prospect for bauxite and other aluminous ore in the Sassari and Olmedo districts of Sardinia and reported the discovery of extensive bauxite deposits in the Nurra area.

Poland.—A $42 million plant to produce alumina from bituminous and argillaceous slates was scheduled for completion at Gorka. The plant was to supply alumina to the Skawina aluminum plant, which had been operating on imported alumina from Hungary.

U.S.S.R.—Although large deposits of bauxite had been discovered in recent years, the aluminum industry could not be based solely on known bauxite deposits, and the Government foresaw increased use of nepheline and aluminous clays during the next 15 to 20 years.[7]

ASIA

India.—The Showa Denko K.K. and Toyo Menka Trading Co. of Japan were planning to form a joint company with Bombay Mineral Supply Co. of India to develop a bauxite mine owned by the Indian company and said to have a reserve of 10 million tons of high-grade ore.

Aluminium Corp. of India and the Indian Aluminium Co., Ltd., produced 28,000 short tons of alumina and consumed 39,700 tons. The Government decided to retain the 20-percent concessional rate of import duty on alumina through 1964.

Indonesia.—The 389,000 long tons of bauxite produced was exported to Japan. Another contract was made with Japan for 394,000 long tons of bauxite to be delivered in 1961. The Government reported that the Singkawang region in East Kalimantan had the potential for opening a new bauxite mine.

Malaya.—Bauxite production continued to increase and was 18 percent more than in 1959. A 25-percent interest in the South East Asia Bauxite Co. was sold to the Nippon Keikinzoku K.K. (Japan Light Metal Co., Ltd.).

AFRICA

Guinea, Republic of.—Production of bauxite was 1,356,000 long tons, 4½ times the 1959 output. Bauxites du Midi accounted for 704,000 tons, which was exported chiefly to Canada, 593,000 tons; West Germany, 84,000 tons; and East Germany, 16,000 tons. The remaining 652,000 tons was produced by FRIA, Compagnie Internationale pour la Production d'Alumine, and consumed in the production of 204,000 short tons of alumina. The first shipment of alumina was made in May, and by yearend 66,000 short tons had been shipped to France, 60,000 tons to Cameroon, 41,000 tons to Norway, and 22,000 tons to Canada, a total of 189,000 tons.

Sierra Leone.—Sierra Leone Ore & Metals Co. was formed as a subsidiary of Aluminium Industries, A.G. to investigate and exploit re-

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[6] Metal Industry (London), Hungarian Aluminum Industry: Vol. 98, No. 13, Mar. 31, 1961, pp. 247–248.

[7] Anthropov, M. P., [The Soviet Aluminum Industry Must Use New Sources of Raw Material]: Rev. de l'Aluminium (Paris), No. 277, June 1960, pp. 650, 652, 654.

cently discovered bauxite deposits in the Mokanji Hills in the South West Province.

OCEANIA

Australia.—Bauxite reserves and deposits in Australia were discussed in general terms, and the alumina, silica, and iron content of each of the deposits was given in a report on the aluminum industry in Australia.[8]

Drilling in the Darling Ranges, near Perth, by the Western Aluminium N.L. reportedly disclosed a reserve of 37 million long tons of bauxite averaging 44 percent Al_2O_3, of which 13 million tons contained 47 percent Al_2O_3.[9] The Company negotiated contracts for shipments of 10,000 tons of bauxite to each of the three Japanese aluminum producers. Shipments were scheduled for early 1961. The Western Australian Government approved the mining and export of 1.25 million tons of bauxite from the company's leases.

Consolidated Zinc Corp. bought British Aluminium's share in the jointly owned Commonwealth Aluminium Corp. Pty., Ltd., thus dissolving their partnership formed to develop Australian bauxite resources. Subsequently, Kaiser joined with Consolidated Zinc as an equal partner in Comalco Industries Pty., Ltd., to undertake establishment of an integrated aluminum industry in Australia and New Zealand. The proposed project, scheduled for completion in 1966, included development of the Weipa bauxite deposits on Cape York peninsula in Queensland and construction of a 403,200-short-ton-a-year alumina plant at Weipa. The British Aluminium Co., Ltd. was to take over the lease of the Gove bauxite deposits in Northern Territory and negotiate for the complete ownership of the New Guinea Prospecting Co. (owned jointly with the Government) for the purpose of prospecting for bauxite in New Guinea and studying the hydroelectric potential of the Purari River in Papua.

New Zealand.—The Geological Survey Department confirmed the discovery of bauxite deposits on the Northland peninsula, north of Whangarei.

TECHNOLOGY

Two aluminum metal producers announced developments which could drastically change the bauxite and alumina industries.[10] Aluminium Ltd. planned to build a 6,000-to-8,000-ton-per-year experimental plant at Arvida, Quebec, to make aluminum metal by a new process employing bauxite directly as the principal raw material instead of Bayer process alumina. The French company, Pechiney, in collaboration with Ugine, reportedly planned to start production of aluminum by another method, possibly using bauxite or alumina, at a 5,000-ton-a-year plant at Nogueres, France. Few details of the proposed new methods were released by the companies; however, dur-

[8] The Australian Aluminum Industry, Raw Materials: Industry Study Series, Dept. of Trade. Melbourne, May 1960, pp. 22–25.
[9] Mining Journal (London), Western Australian Bauxite Field Under Ore Test: Vol. 255. No. 6536, Nov. 25, 1960, p. 596.
[10] Chemical Engineering, Process Shakeup Brewing in Aluminum: Vol. 67, No. 21, Oct. 17, 1960, pp. 90–91.
Chemical Engineering, More Details Revealed on New Direct Aluminum Processes: Vol. 67, No. 24. Nov. 28, 1960, p. 69.

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ing the year patents were issued to these companies which were widely believed to pertain to key steps in the respective processes. Aluminium Ltd.'s patent [11] relates to the recovery of aluminum from aluminum monochloride (AlCl) and Pechiney's patent [12] relates to decomposition of aluminum nitride (AlN) to the metal.

A report describing operations of the Kaiser alumina plant at Gramercy, La. was published.[13] This plant, which started production in 1959, incorporates many technical improvements in the Bayer process. Jamaica bauxite containing both monohydrate and trihydrate alumina is digested at 550 p.s.i. and 470° F. to recover 98 percent of the available alumina. Utilization of such rigorous conditions in the digestion step reflects improvements in construction materials. A fluid-bed technique for cooling the alumina after calcining also was described.

Several features of bauxite mining practices in Surinam were published.[14] To overcome problems associated with increasing thickness of overburden, Billiton installed a large bucket-wheel excavator to strip waste, which was then removed from the mining area on a conveyer system over a distance of approximately 2 miles. Operation of an 1,100-ton dredge in stripping the silt, sand, sandy clay, and clay overburden from Suralco's deposit was described.[15] In a normal 8-hour day operation, about 150,000 cubic yards a month was removed through a 24-inch floating pipeline 1,200 feet long at a reported cost of $0.1962 per cubic yard.

Operation of a 1-ton-a-day liquid alum plant, utilizing a continuous method for pressure leaching bauxite with sulfuric acid and steam, was said to give better recoveries, save processing time, space, and manpower, and reduce grinding costs.[16]

High-alumina refractories containing calcined bauxite are dense and do not shrink at high temperatures; however, when these refractories are used in combination with clays, reheating sometimes causes abnormal expansion. In a report, the cause of this undesirable effect was attributed to the formation of mullite between grains or around the edges of the grains.[17] Sodium fluoride additions increased the solubility of mullite in the liquid phase and were effective in preventing excess expansion.

Anaconda Aluminum Co., a subsidiary of The Anaconda Company, had been investigating the recovery of alumina from Idaho clays for a number of years. During 1960, several patents on processes to produce silica- and iron-free alumina from iron-containing aluminous clays were assigned to Anaconda. One patent involves calcining the

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[11] Assigned to Aluminium Laboratories Limited, Recovery of Aluminium in Subhalide Distillation: British Patent 846,189, Aug. 24, 1960.

[12] Assigned to Pechiney, Compagnie de Produits Chimiques et Electrometallurgiques, Improvements in or Relating to the Production of Aluminium: British Patent 842,726, July 27, 1960.

[13] Chemical Engineering, New Ideas Refresh Alumina Process: Vol. 67, No. 24, Nov. 28, 1960, pp. 108–111.

[14] Mining World, Bauxite . . . Mines Try Several Types of Equipment to Strip Waste from Hidden Ore: Vol. 22, No. 6, May 1960, pp. 54–57.

[15] Cazort, John G., Jr., Stripping Overburden With a Dredge: Min. Eng., vol. 12, No. 10, October 1960, pp. 1083–1089.

[16] Chemical Engineering, Liquid Alum Goes Continuous: Vol. 67, No. 23, Nov. 14, 1960, p. 116.

[17] McGee, T. D., and Dodd, C. M., Mechanism of Secondary Expansion of High Alumina Refractories Containing Calcined Bauxite: Ind. Heating, vol. 27, No. 6, June 1960, pp. 1265–1268.

clay and dissolving aluminum and iron with hydrochloric acid, leaving silica in an insoluble residue. The resulting mixture of iron and aluminum chlorides is evaporated and heat-treated at 1,000 to 1,300° F. to produce iron and aluminum oxides. The alumina and residual chlorides are dissolved in caustic soda, and alumina trihydrate is precipitated from the solution and calcined.[18] Another patent claimed that calcining the mixed chlorides at 1,500 to 1,900° F. produced an iron-containing crude alumina free from chloride and silica. Sintering of the calcined material at 1,500° F. with sodium carbonate converted the alumina to sodium aluminate that could be extracted with an aqueous medium.[19] The third patent involved sintering of an aluminiferous raw material, containing iron and a very small quantity of silica, with sodium carbonate and calcium oxide above 1,700° F. to form insoluble calcium aluminum silicate and soluble sodium aluminate. The mixture is leached with aqueous alkaline solution, and the alumina is precipitated and calcined.[20]

The Federal Bureau of Mines published reports describing aspects of its research to recover alumina from anorthosite by the lime-soda-sinter process.[21]

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[18] Laist, Frederick (assigned to The Anaconda Company), Production of Alumina: U.S. Patent 2,947,604, Aug. 2, 1960.

[19] Laist, Frederick (assigned to The Anaconda Company), Production of Alumina: U.S. Patent 2,947,605, Aug. 2, 1960.

[20] Holderreed, Francis L., and Sullivan, Robert E. (assigned to The Anaconda Company), Production of Silica-Free Alumina: U.S. Patent 2,947,606, Aug. 2, 1960.

[21] Lundquist, R. V., and Carpenter, Lloyd, Structural Phases in Lime-Soda Sinters for Alumina Recovery: A Progress Report: Bureau of Mines Rept. of Investigations 5678, 1960, 12 pp.

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Beryllium

By Donald E. Eilertsen [1]

A RECORD quantity of 9,692 tons of cobbed beryl was consumed in the United States in 1960. Extensive research programs on beryllium, from ore discovery through refinement and applications of the metal, were vigorously pursued. Ductile beryllium was particularly sought for greater use in aircraft, missiles, and nuclear reactors.

LEGISLATION AND GOVERNMENT PROGRAMS

The Government, through General Services Administration (GSA), bought an additional 233 short tons of beryl on its program, encouraging domestic production of cobbed beryl containing at least 8 percent beryllium oxide (BeO). A cumulative total of 2,720 tons had been bought thus far on the program, which started in 1952 and terminates June 30, 1962, or when 4,500 tons of beryl has been delivered, whichever occurs first.

Approximately 1,000 tons of cobbed beryl and 2.8 million pounds of beryllium-copper master alloy, containing approximately 4 percent beryllium, was acquired through the U.S. Department of Agriculture barter program in which Commodity Credit Corporation (CCC) exchanged surplus agricultural commodities for strategic materials.

TABLE 1.—Salient beryl statistics

(Short tons)

	1951–1955 (average)	1956	1957	1958	1959	1960
United States:						
Beryl, approximately 10–12 percent BeO unless otherwise stated:						
Domestic beryl, shipped from mines [1]	584	445	521	505	425	509
Value [2]	$264,225	$231,126	$275,855	$243,017	$179,145	$162,355
Imports	6,029	12,371	7,290	4,599	8,038	8,943
Consumption	3,067	4,341	4,309	6,002	8,173	9,692
Price, approximate, per unit BeO, domestic, cobbed beryl, delivered [3]	$45	$47	$48	$47	$47	$46
Price, per unit BeO, other domestic lower grade beryllium ore, delivered	----------	----------	----------	$42	$20	$31
Price, approximate, per unit BeO, imported cobbed beryl, at port of exportation (estimated 10 percent BeO)	$41	$36	$35	$34	$29	$32
World: Production [1]	8,000	12,900	11,300	7,500	8,100	11,100

[1] Includes other lower grade beryllium ore: 42 tons in 1958, 97 tons in 1959, and 265 tons in 1960.
[2] Includes other lower grade beryllium ore: $5,000 in 1958, $8,622 in 1959, and $41,250 in 1960.
[3] Estimated 10 percent BeO, 1951–55, estimated 11 percent BeO 1956–58.

[1] Commodity specialist, Division of Minerals.

The Office of Minerals Exploration (OME)offered financial assistance until August to explore for beryl and thereafter for all types of beryllium ores. OME participation in approved projects was 50 percent. During the year, OME participated in exploration for beryl-tantalum in Taos County, N. Mex.; Beryllium in Juab County, Utah; and beryl-columbium-tantalum in Custer County, S. Dak.

DOMESTIC PRODUCTION

Mine Production.—Cobbed beryl production was the smallest since 1948. Based on mine shipments, a total of 244 tons was produced from 170 operations in 8 States. Individual production ranged from a few pounds to 34 tons. South Dakota produced 68 percent of the domestic beryl; Colorado, 16 percent; New Hampshire, 6 percent; and 5 other States, 10 percent. The Boomer Lode and Redskin mines in Park County, Colo. shipped 265 tons of lower grade beryllium ore for industrial use. There was widespread and intensified search for domestic beryllium deposits by private companies and by the Government.

TABLE 2.—Beryllium concentrates shipped from mines in the United States, by States

State	1959				1960			
	Cobbed beryl (short tons)	Units BeO	Lower grade beryllium ore (short tons)	Units BeO	Cobbed beryl (short tons)	Units BeO	Lower grade beryllium ore (short tons)	Units BeO
Colorado	124	1,274	97	431	39	396	265	1,325
New Hampshire	20	239			14	160		
New Mexico	11	126						
South Dakota	156	1,714			167	1,807		
Other States [1]	17	200			24	276		
Total	328	3,553	97	431	244	2,639	265	1,325
Value	$170,523		$8,622		$121,105		$41,250	

[1] Arizona 1960, Connecticut, Maine, New York 1960, and Wyoming.

Refinery Production.—The Beryllium Corp. plants at Reading and Hazleton, Pa., and The Brush Beryllium Co. plant at Elmore, Ohio, processed beryl into beryllium metal, various alloys, and compounds. Figures on production were not available for publication. About the same quantity of beryllium metal was produced as in 1959; however, beryllium-copper master alloy production decreased. The third year elapsed of the 5-year contracts awarded to these two firms for annual delivery of 37,500 pounds of nuclear-grade beryllium to the Atomic Energy Commission (AEC).

CONSUMPTION AND USES

Beryl consumption of 9,692 tons in 1960 was the largest ever recorded in a single year. Nearly all was imported and processed into beryllium metal and its alloys and compounds.

Sales of The Beryllium Corp. were $24.3 million compared with $21.2 million in 1959. The Brush Beryllium Co. sales were $28.8 million, compared with $18.1 million in 1959.

Five other consumers of cobbed beryl were: Beryl Ores Co., Arvada, Colo., which produced specialized beryl materials for the ceramic industry; Glass Coating Materials Division, A. O. Smith Corp., Milwaukee, Wis., which produced ground-coat frit (glass) for ceramics; Lapp Insulator Co., LeRoy, N.Y., which used ground beryl in making high-voltage electrical porcelain; the Ceramic Division, Champion Spark Plug Co., Detroit, Mich., which used beryl as a minor constituent in special ceramic compositions (primarily for spark plugs); and Delta Star Electric Division, H. K. Porter Co. (Delaware), Lisbon, Ohio, which used beryl in other ceramic products.

Mineral Concentrates and Chemical Co., Inc., Loveland Colo., consumed lower grade beryllium ore for production of small quantities of various beryllium compounds.

A substantial quantity of beryllium was produced for the AEC and for special uses in aircraft and missiles, as well as for research and development seeking new applications of the metal. Beryllium oxide was used in nuclear, refractory, and electronic applications. Beryllium-copper was used in business machines, electronic devices, automobile and aircraft products, and household appliances.

STOCKS

Consumer stocks of cobbed beryl at the end of the year totaled 1,934 tons. Stocks of beryllium metal were larger and those for beryllium-copper master alloy were smaller than in 1959.

No imported beryl or domestically produced beryllium-copper was added to the national strategic stockpile. The inventory of beryl in the strategical stockpile slightly exceeded the basic and maximum objectives. Other stocks of beryllium-bearing materials at the end of 1960 were as follows: Supplemental stockpile, 8,427 tons of beryl, including the beryl content of 10,026,299 pounds of beryllium-copper master alloy, and CCC stocks, 1,011 tons of beryl and 1,164,961 pounds of beryllium-copper master alloy.

PRICES AND SPECIFICATIONS

The price quoted for domestically produced beryl containing 10–12 percent BeO was \$46–\$48 per short-ton unit of BeO, f.o.b. mine. The price of imported beryl per short-ton unit of BeO, based on 10–12 percent BeO, c.i.f. U.S. ports, was \$34–\$34.50 on term contracts and \$31.75–\$32.50 on spot contracts.[2] GSA bought domestically produced beryl at depots in Franklin, N.H., Spruce Pine, N.C., and Custer, S. Dak. Purchases were made on the basis of a short-ton unit (20 pounds) of contained BeO, and prices per unit were as follows: 8 to 8.9 percent BeO, \$40; 9 to 9.9 percent BeO, \$45; and 10 percent BeO and over, \$50.

The price of beryllium metal, 97 percent pure, lump or beads, f.o.b. Cleveland, Ohio, and Reading, Pa., was \$71.50 per pound until August and thereafter \$70 per pound in small quantities and \$62 per pound in quantities of 1,000 to 2,000 pounds. Starting in August, beryllium powder was quoted at \$64–\$76 per pound, and vacuum cast ingot at \$67–71 per pound. Beryllium-copper master alloy was

[2] E&MJ (Engineering and Mining Journal) Metal and Mineral Markets, vol. 31, No. 1–52, January–December 1960.

quoted f.o.b. Reading, Pa., Detroit, Mich., and Elmore, Ohio, at $43 per pound of contained beryllium, with copper paid for at the market price on date of shipment. Beryllium-aluminum was quoted f.o.b. Reading, Pa., Detroit, Mich., and Elmore, Ohio, at $74.75 per pound of contained beryllium until April and thereafter at $65 per pound, with aluminum paid for at the market price. Starting in June, beryllium in beryllium-magnesium-aluminum alloy was quoted at $57 per pound. Beryllium-copper strip was quoted at $1.975 per pound until October and thereafter at $1.945 per pound. Beryllium-copper rod, bar, and wire was quoted at $1.955 per pound until October and thereafter at $1.945 per pound.[3]

FOREIGN TRADE[4]

Imports.—In addition to handsorted beryl imports shown in table 3 some metallic beryllium, not separately reported from other commodities, was imported. Imports in 1960 of beryllium oxide or carbonate (not specifically provided for) were: 2 pounds, valued at $1,311 from United Kingdom; 813 pounds, valued at $9,583, from France; and 1,788 pounds, valued at $5,315, from West Germany.

TABLE 3.—U.S. imports for consumption of beryl, by countries

(Short tons)

Country	1959	1960
South America:		
Argentina	2,480	[1] 1,212
Brazil	2,833	3,493
Total	5,313	4,705
Europe:		
Norway	4	
Portugal	77	28
Sweden	41	
Total	122	28
Asia:		
India		1,000
Pakistan		
Total		1,000
Africa:		
British East Africa (principally Uganda)	15	260
British West Africa, n.e.c.		9
Congo, Republic of,[2] and Ruanda and Urundi	395	534
French Samaliland		11
Malagasy Republic[3]	329	140
Mozambique	1,382	1,694
Rhodesia and Nyasaland, Federation of	151	236
Union of South Africa (includes South-West Africa)	331	326
Total	2,603	3,210
Grand total: Short tons	8,038	8,943
Value	$2,345,285	$2,863,503

[1] Adjusted by Bureau of Mines.
[2] Effective July 1, 1960, formerly Belgian Congo.
[3] Effective July 1 1960, formerly Madagascar and Dependencies.

Source: Bureau of the Census.

[3] American Metal Market, vol. 67, No. 1–249, January–December 1960.
[4] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

Exports.—Exports of beryllium ore were 14,156 pounds valued at $6,082, to United Kingdom. Separate data on beryllium-copper alloy exports were not available.

TABLE 4.—U.S. exports of beryllium products, in 1960, by countries

Destination	Beryllium and beryllium alloy (except beryllium copper) metal powders		Beryllium metal and alloys (except beryllium copper) in crude form, and scrap		Beryllium and beryllium alloys in semifabricated forms, n.e.c.	
	Pounds	Value	Pounds	Value	Pounds	Value
Australia			415	$4,054		
Austria			2,100	7,374		
Belgium-Luxembourg			423	1,506	1,963	$246,384
Canada	600	$1,543	8,823	17,493	2,447	10,830
Colombia	4,300	1,808				
Denmark	4	360	44	450	(1)	665
France	11	868	53	4,140		
Germany, West	967	5,642	48,994	128,827	34	13,545
India			(1)	875	10	1,557
Israel					21	4,724
Italy			4,342	15,735	8	1,225
Japan	1,100	3,603	3,761	14,081	35	1,572
Mexico			180	644		
Netherlands			38	172	(1)	528
Norway			4,032	13,690		
Switzerland			1,964	6,532		
United Kingdom	2,184	166,289	22,695	422,042	1,539	224,370
Yugoslavia			4,400	14,080	5	602
Total	9,166	180,113	102,264	651,695	6,062	506,002

[1] Less than 1 pound.

Source: Bureau of the Census.

WORLD REVIEW

World production of cobbed beryl increased 33 percent.

Argentina.—COCOMINE, the Government agency which controls purchases of domestic beryl, raised its purchase price from 17 to 21 pesos (approximately 83 pesos equal US$1) per kilogram of beryl containing 10 percent BeO. A premium of 2.4 pesos was paid for each percent BeO over 10 percent. For each percent of BeO under 10 percent there was a discount of 2.6 pesos.

A Japanese trade mission visited Argentina and studied the possibility of acquiring larger quantities of beryl and kaolin. Japanese industries were soon expected to use as much as 80 tons of beryl monthly.

Australia.—The Government suspended its purchasing program for beryl pending a reappraisal of the stockpiling policy. Exports of beryl were permitted to approved destinations.[5]

India.—The Government announced the grant of rewards for the discovery of new deposits of uranium and beryllium ores. The maximum reward for discovery of new deposits of beryl having a minimum of 10 percent BeO was $420.

United Kingdom.—Consolidated Beryllium, Ltd., jointly owned by The Beryllium Corp. of Reading, Pa., and Imperial Smelting Corp., Ltd., of London, acquired the United Kingdom Atomic Energy Authority's plant at Milford Haven, England, which processes beryl into beryllium hydroxide and beryllium oxide. The plant also had facili-

[5] Metal Bulletin (London), Beryllium: No. 4527, Sept. 9, 1960, p. 23.

ties for converting beryllium metal into fine powder and fabricating beryllium oxide into various shapes and forms.

TABLE 5.—World production of beryl by countries[1]

(Short tons)

Country	1951-55 (average)	1956	1957	1958	1959	1960
North America: United States (mine shipments):						
Cobbed beryl	584	445	521	463	328	244
Other lower grade beryllium ore				42	97	265
Total	584	445	521	505	425	509
South America:						
Argentina	748	1,722	1,571	1,004	645	739
Brazil	2,152	2,321	1,452	1,295	[2] 2,961	3,849
Total	2,900	4,043	3,023	2,299	3,606	4,588
Europe:						
Norway (U.S. imports)				3	4	
Portugal	267	244	191	52	41	24
Sweden				28	[3] 41	
U.S.S.R.[4]	110	110	110	110	110	110
Total[4]	380	350	300	190	200	130
Asia:						
Afghanistan	15	30	15			11
India (U.S. imports)	417	3,360	1,256	600		1,000
Korea, Republic of	[3] 6		(5)			
Total	438	3,390	1,271	600		1,011
Africa:						
Congo, Republic of the (formerly Belgian)	[6] 106	1,860	1,666	1,063	280	[4] 340
Kenya	[7] 1		6	4	2	[4] 2
Malagasy Republic (Madagascar)	500	169	299	180	468	[4] 660
Morocco: Southern zone	58					
Mozambique	545	944	1,870	1,161	1,559	1,650
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia	8	13	5	13	2	2
Southern Rhodesia	1,222	606	572	332	440	539
Ruanda-Urundi	[8] 69	45	106	51	187	[4] 190
Somali Republic	[9] 19	17				
South-West Africa	[6] 610	454	385	246	170	413
Uganda	50	98	78	86	234	[2] 427
Union of South Africa	388	133	711	464	203	325
Total	3,576	4,339	5,698	3,600	3,545	4,548
Oceania: Australia	152	356	442	278	355	[4] 300
World total (estimate)[1]	8,000	12,900	11,300	7,500	8,100	11,100

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] Exports.
[3] U.S. imports.
[4] Estimate.
[5] Less than 0.5 ton.
[6] Average for 1954-55.
[7] Average for 1952-55.
[8] Average for 1953-55.
[9] 1 year only, as 1955 was 1st year of commercial production.

Compiled by Augusta W. Jann, Division of Foreign Activities.

TECHNOLOGY

The Federal Bureau of Mines continued its expanded research program on beryllium, seeking to establish an adequate and dependable long-range supply of domestic beryllium, developing milling methods to recover beryl and other beryllium minerals, and developing techniques to extract and purify beryllium. The search for beryllium was greatly aided by two fluorescent methods [6] capable of detecting as little as 0.01 percent beryllium in rock samples and a mobile laboratory containing a spectroscope, all developed by the Bureau, and by using various nuclear electronic instruments for rapid detection of beryllium.[7] Mineral deposits in 24 States particularly nonpegmatitic deposits, were studied for occurrences of beryl, phenacite, bertrandite, and other beryllium minerals. Deposits in the Badger Flats area in Park County, Colo., continued to be explored in detail for beryllium. Under a cooperative agreement, the Federal Bureau of Mines and the Idaho Bureau of Mines and Geology discovered widespread occurrences of beryllium mineralization in granite in the Sawtooth Mountains and Yellow Jacket Mountains of Idaho.[8] The occurrence of beryl in a Colorado deposit was described.[9]

Substantial progress was made in the Bureau's experimental flotation plant on developing methods to recover beryl and other minerals from flotation tailing of a commercial spodumene mill in North Carolina. Feed material for the mill was rock from a small area within the extensive pegmatite belt, which has been estimated to contain 0.4 percent beryl or 41,000 tons of beryllium. Good progress also was made in the laboratory on developing methods to recover beryl, phenacite, and bertrandite from various western ores. Tests also were made on developing techniques to recover beryllium salts from various grades of concentrates and in producing and purifying beryllium. Electrorefining techniques were under development for recovering beryllium from scrap and for the production of high-purity metal.[10]

Occurrences of bertrandite in Utah and Colorado, and bertrandite and phenacite in Nevada were described.[11]

Numerous prospectors searched for beryl and particularly for new source minerals of beryllium such as phenacite and bertandite. Certain beryllium deposits were explored in detail for beryllium ore, especially in Utah, Nevada, New Mexico, South Dakota, and Colorado. Three techniques were investigated for making high-purity beryllium. One of these, zone purification in modern vacuum, proved impractical; another, distillation under high vacuum, showed promise; and the third purification through halide reduction, produced 99.6 percent pure beryllium and also showed promise for improvement.[12] Beryllium-silver and silver each was found to yield high joint strengths in joining beryllium to itself.[13] Braze welding with silver filler metal

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[6] McVay, T. N., Field Test for Beryllium Minerals: The Morin Fluorescence Method: Bureau of Mines Rept. of Investigations 5620, 1960, 10 pp.
Dressel, W. M., and Ritchey, R. A., Field Test for Beryllium: Bureau of Mines Inf. Circ. 7946, 1960, 5 pp.

[7] Moyd, Louis, and Moyd, Pauline, The Gamma Ray-Neutron Beryllium Detector as a Reconnaissance Tool: Paper pres. at Annual Meeting of AIME, New York, February 1960, Preprint No. 60H95, 11 pp.

[8] Reid, R. R., and Choate, Raoul, Prospecting for Beryllium in Idaho (prepared in cooperation with the U.S. Bureau or Mines): Idaho Bureau of Mines and Geol. (Moscow, Idaho), Inf. Circ. No. 7, November 1960, 19 pp.

[9] Gilkey, M. M., Hyatt Ranch Pegmatite, Larimer County, Colo.: Bureau of Mines Rept. of Investigations 5643, 1960, 18 pp.

[10] Wong, M. M., Cattoir, F. R., and Baker, D. H., Jr., Electrorefining Beryllium, Preliminary Studies: Bureau of Mines Rept. of Investigations 5581, 1960, 9 pp.

[11] Geological Survey, Geological Survey Research 1960, Synopsis of Geologic Results: Professional Paper 400–A, 1960, pp. 5–6.

[12] Basche, Malcolm, and Schetky, Lawrence M. (The Alloyd Corp.), Research on Techniques for the Production of Ultra-Pure Beryllium: Wright Air Development Center Tech. Rept. 58–457, pt. II, PB 161877, Office of Tech. Services, U.S. Dept. of Commerce, Washington 25, D.C., March 1960, 48 pp.

[13] Cohen, J. B. (Research and Advanced Development Division Avco Corp.), Beryllium Joining RAD Sponsored Program: Wright Air Development Center Tech. Rept. 59–695, pt. I, PB 161830, Office of Tech. Services, U.S. Dept. of Commerce, Washington 25, D.C., April 1960, 39 pp.

and presssure welding were found to be promising techniques for joining beryllium.[14] Five different fabrication techniques were studied to determine which process would yield the best beryllium plate or sheet. Cold compacting of beryllium powder followed by upsetting yielded optimum uniaxial and biaxial properties.[15] Superior beryllium sheet was obtained by etching the surface to remove surface defects.[16] The bend ductility for fabricated beryllium strip, beryllium strip containing alternate strips of beryllium and aluminum or silver filler metal, and clad beryllium was investigated.[17] Various aspects of beryllium casting were studied to obtain information leading to the development of sound fine-grained cast material.[18] Mechanical and physical properties were reported for extruded and rolled products fabricated from various beryllium rich alloys and beryllium fabricated from powder.[19] A selective bibliography on beryllium was published.[20]

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[14] Passmore, E. M. (Research and Advanced Development Division Avco Corp.). Beryllium Joining WADC Sponsored Programs: Wright Air Development Center, Tech. Rept. 59-695, pt. II, PB 161831, Office of Tech. Services, U.S. Dept. of Commerce, Washington 25, D.C., April 1960, 113 pp.

[15] Muvdi, B. B. (The Martin Co.), Structural Evaluation of Beryllium Produced by Several Processes: Wright Air Development Technical Rept. 58-162. ASTIA DOCUMENT No. AD 155562, PB 151263, Office of Tech. Services, U.S. Dept. of Commerce, Washington 25, D.C., June 1958, 66 pp.

[16] Matthews, C. O., Jacobson, M. I., Jahsman, W. E., and Ward, W. V. (Lockheed Aircraft Corp., Missiles and Space Division), Beryllium Crack Propagation and Effects of Surface Condition: Wright Air Development Tech. Rept. 60-116, PB 171088, Office of Tech. Services, U.S. Dept. of Commerce, Washington 25. D.C., July 1960, 182 pp.

[17] Greenspan, Jacob, Henrickson, Gerald A., and Kaufmann, Albert R. (Nuclear Metals, Inc.), Beryllium Research and Development in the Area of Composite Materials: Wright Air Development Center Tech. Rept. 60-32, PB 171083, Office of Tech. Services, U.S. Dept. of Commerce, Washington 25, D.C., July 1960, 108 pp.

[18] Crossley, Frank A., Metcalfe, Arthur G., and Graft, William H. (Armour Research Foundation of Illinois Institute of Tech.), Beryllium Research for Development in the Area of Casting: Wright Air Development Center Tech. Rept. 59-500, PB 161754, Office of Tech. Services, U.S. Dept. of Commerce, Washington 25, D.C., February 1960, 92 pp.

[19] Klein, John G., Perelman, Leslie M., Beaver, Wallace W. (The Brush Beryllium Co.), Development in Wrought Beryllium Alloys of Improved Properties: Wright Air Development Center Tech. Rept. 58-478, pt. II, PB 171389, Office of Tech. Services, U.S. Dept. of Commerce, Washington 25, D.C., September 1960, 113 pp.

[20] U.S. Department of Commerce, Office of Technical Services, OTS Selective Bibliography, Beryllium (1945-1960): SB 413, June 1960, 19 pp.

Bismuth

By G. Richards Gwinn[1] and Edith E. den Hartog[2]

INCREASED imports and declines in industrial consumption, consumer stocks, and refined metal output characterized the domestic bismuth industry in 1960. No purchases were made by the Government for the strategic stockpile; however, barter contracts were executed by the Commodity Credit Corporation, and about 350,000 pounds of bismuth was acquired for the supplemental stockpile.

The Joint Defense Production Congressional Committee placed high-purity bismuth metal and bismuth alloys on the list of metals that will be needed in significantly larger quantities from 1960 to mid-1964.

World output in 1960 was estimated at about 5.2 million pounds, essentially equal to that of 1959. The quoted market price of bismuth metal in New York remained throughout the year at $2.25 per pound, in ton lots, unchanged since September 5, 1950.

TABLE 1.—Salient bismuth statistics

	1951-55 (average)	1956	1957	1958	1959	1960
United States:						
Consumption ..pounds..	1,613,400	1,513,000	1,615,200	1,242,700	[1] 1,598,000	1,527,300
Imports, general ...do....	620,705	918,152	847,868	637,309	457,163	1,167,019
Exports............do....	172,066	287,092	158,393	316,318	179,744	156,636
Price: New York, ton lots	$2.25	$2.25	$2.25	$2.25	$2.25	$2.25
Stocks Dec. 31: Consumer and dealer.....pounds..	212,140	229,000	375,300	546,100	472,000	362,800
World: Production ....do....	4,200,000	5,300,000	5,000,000	4,600,000	5,100,000	5,200,000

[1] Revised figure.

DOMESTIC PRODUCTION

Production of refined bismuth, derived from foreign and domestic ores, came almost entirely from metallurgical byproducts of lead refining. Output declined slightly from 1959. Companies reporting production were American Smelting and Refining Co., The Anaconda Company, United States Smelting Lead Refinery, Inc. (a subsidiary of United States Smelting, Refining and Mining Co.), and United Refining & Smelting Co. Bismuth recovered from alloy scrap in alloy products increased substantially over 1959.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

CONSUMPTION AND USES

Consumption of refined bismuth metal reached 1.5 million pounds—4 percent below 1959. In addition, considerable bismuth contained in bismuth-lead bars was used in fabricating alloys. Fusible and other bismuth alloys, used to improve the machinability of aluminum alloys, and malleable irons and steels accounted for about 49 percent of the industrial use of this metal. Pharmaceuticals, which include an increasingly large quantity of industrial and laboratory chemicals, consumed 47 percent. The remaining 4 percent was consumed in experimental and miscellaneous uses.

TABLE 2.—Bismuth metal consumed in the United States, by uses

(Pounds)

Use	1959	1960	Use	1959	1960
Fusible alloys	[1] 547,668	515,570	Experimental uses	161,040	24,667
Other alloys	[1] 349,093	239,757	Other uses	56,692	36,627
Pharmaceuticals [2]	483,554	710,631			
			Total	[1] 1,598,047	1,527,252

[1] Revised figure.
[2] Includes industrial and laboratory chemicals.

STOCKS

Under the pressure of relatively high consumption and despite the large increase in imports, consumer and dealer stocks of bismuth fell sharply to 363,000 pounds. Stocks at domestic refineries declined 7 percent from 1959. The U.S. supplemental stockpile total on December 31, 1960, was 1,146,323 pounds.

PRICES

The E&MJ Metal and Mineral Markets continued to quote the New York price for refined bismuth metal at $2.25 per pound, in ton lots, throughout 1960—a price that has remained unchanged since September 1950. The Metal Bulletin (London) quotation also remained unchanged at $2.24 per pound. Commercial grade bismuth ore is not produced in the United States, and ore is not quoted on the domestic market; however, the Metal Bulletin (London) quoted ore at $1.10 per pound of contained bismuth in concentrate having a minimum of 65 percent bismuth. Bismuth concentrate of lower grade commanded proportionally lower prices. Prices of bismuth chemicals and compounds, per pound, in drums ranging in weight from 25 to 250 pounds, as listed in Oil, Paint and Drug Reporter, were:

	Price per pound		*Price per pound*
Chloride (in jars)	$5.11	Subiodide	$5.37
Hydroxide	4.65	Subnitrate	3.15
Nitrate	2.25	Subsalicylate	4.15
Oxychloride	4.42	Ammonium citrate (in jars)	4.22
Subcarbonate	3.70	Trioxide	4.40
Subgallate	3.98		

FOREIGN TRADE [3]

Imports of refined metal reached 1,167,000 pounds—an increase of 155 percent over 1959. Purchases of bismuth on barter contracts executed by the Commodity Credit Corporation accounted for most of the increase. Metal imports were augmented by receipts of bismuth-enriched intermediate smelter products, bismuth-lead bars, and concentrate. Most of the bismuth-lead bars were consumed directly in alloy fabrication, and the economically recoverable bismuth contents of the smelter products and concentrate entered the market as domestically refined bismuth. Statistics in this chapter exclude imported bismuth-lead bars, which were estimated at 53,700 pounds.

Exports of bismuth metal and alloys totaled 157,000 pounds (gross weight)—a decline of 12 percent from the 179,700 pounds exported in 1959. Bismuth-metal exports reported to the Bureau of Mines were 17,300 pounds and represented 11 percent of the total exports, compared with 44,200 pounds and 25 percent in 1959.

TABLE 3.—U.S. imports [1] of metallic bismuth, by countries

(Pounds)

Country	1959	1960	Country	1959	1960
North America:			Europe:		
Canada	2,948	90,536	Netherlands		5,437
Mexico	155,156	190,827	United Kingdom	3,000	53,003
			Yugoslavia	46,295	69,390
Total	158,104	281,363	Total	49,295	127,830
South America:					
Argentina		12,334	Grand total	457,163	1,167,019
Peru	249,764	745,492			
Total	249,764	757,826			

[1] Data are "general" imports; that is, they include bismuth imported for immediate consumption plus material entering the country under bond.

Source: Bureau of the Census.

TABLE 4.—U.S. exports of bismuth metal and alloys

Year	Gross weight (pounds)	Value	Year	Gross weight (pounds)	Value
1951-55 (average)	172,066	$372,299	1958	316,318	$389,078
1956	287,092	558,601	1959	179,744	261,367
1957	158,393	213,313	1960	156,636	275,540

Source: Bureau of the Census.

WORLD REVIEW

World production of bismuth in 1960, about 5.2 million pounds, was essentially equal to 1959 output. Bolivia, Canada, Mexico, Peru, the Republic of Korea, the United States, and Yugoslavia were the major producers.

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

Bolivia.—Production of bismuth declined slightly, owing largely to the reduced output of tin, which is the major product recovered from mines that produce bismuth ores and concentrates.

Canada.—Bismuth metal was recovered as a byproduct of silver, copper, and molybdenum disulfide production. The metal produced as a byproduct of molybdenum disulfide production was in the form of bars containing 98 percent bismuth.

Korea, Republic of.—The entire output of bismuth was recovered as a byproduct in processing tungsten ores and concentrates. The Tungsten Mining Company, a Government agency, was by far the largest producer, recovering bismuth from the tungsten (scheelite) ores of the Sang-dong mine. The bismuth metal produced was 99.5 percent pure.

TABLE 5.—World production of bismuth, by countries [1] [2]

(Pounds)

Country [1]	1951–55 (average)	1956	1957	1958	1959	1960
North America:						
Canada (metal) [3]	206,922	285,861	319,941	412,792	334,736	464,440
Mexico [3]	745,267	1,391,100	780,200	417,700	524,700	[4] 440,000
South America:						
Argentina (in ore) [4]	6,600	20,000	47,800	[5] 59,000	[5] 114,600	(6)
Bolivia [7]	107,820	74,800	90,600	244,700	487,400	[4] 403,000
Peru [3]	670,445	634,757	804,800	851,560	775,323	921,814
Europe:						
France (in ore)	128,087	112,400	99,200	[4] 110,000	[4] 110,000	[4] 180,000
Spain (metal)	39,546	71,650	190,500	116,229	53,168	[8] 25,000
Sweden [4]	104,000	88,000	120,000	110,000	60,000	80,000
Yugoslavia (metal)	219,896	245,039	219,805	169,670	200,026	231,582
Asia:						
China (in ore)	[4] 137,000	(6)	(6)	(6)	(6)	(6)
Japan (metal)	111,963	156,859	144,800	168,751	223,187	[4] 243,000
Korea, Republic of (in ore)	268,000	396,000	240,000	198,000	227,000	[4] 350,000
Africa:						
Congo, Republic of the (formerly Belgian)	716					
Mozambique	5,174	785	6,975	2,167	21,980	25,000
South-West Africa (in ore)	1,036	310	670	680	520	[4] 300
Uganda	3,437	660	2,700	15,030	18,984	[4] 17,600
Union of South Africa (in ore)	2,663	360	145	2,023	526	[4] 650
Oceania: Australia (in ore)	2,149	5,150	1,340	2,352		(6)
World total (estimate) [1] [2]	4,200,000	5,300,000	5,000,000	4,600,000	5,100,000	5,200,000

[1] U.S. production included in total; Bureau of Mines not at liberty to publish separately. Bismuth is believed to be produced in Brazil, East Germany, West Germany, and U.S.S.R. Production figures are not available for these countries, but estimates for them are included in the world total.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Refined metal plus bismuth content of bullion exported.
[4] Estimate.
[5] Exports.
[6] Data not available; estimate included in world total.
[7] Content in ore and bullion exported, excluding that in tin concentrates.
[8] Estimated recoverable content of ore produced.

Compiled by Augusta W. Jann, Division of Foreign Activities.

Mexico.—Metalurgica Penoles, S.A., a subsidiary of American Metal Climax, Inc., was again the only producer of refined bismuth metal. As domestic requirements were relatively small, most of the refined metal was shipped to the United States, England, Netherlands, and West Germany.

Peru.—Bismuth production in Peru was reported in the form of refined bismuth metal and the bismuth content of bullion exported. Cerro Corp. was the sole producer in 1960; most of the bismuth was recovered from the Cerro de Pasco mine and reduced to metal at the La Oroya metallurgical works.

Yugoslavia.—Bismuth metal was recovered as a byproduct in the refining of lead-zinc ores. A large part of the production came from the ores of the Zletovo and Rudnik mines in southern Serbia. Several deposits containing native bismuth and bismuthinite at Aldimac and Jasikovo in eastern Serbia, although of low grade, are possible future sources of bismuth.

TECHNOLOGY

Bismuth continued to gain favor as a component in thermoelectric elements, particularly thermoelectric generators. A new alloy of bismuth and antimony was reported to give an optimum efficiency of 11.4 percent when incorporated into a generator with junctions operated at 600° and 300° K.[4] Such low efficiencies would prohibit the adoption of the unit for the large-scale production of electric power, but the unit would be suitable as a small primary source of electricity in applications where long service without attention is required. A quaternary alloy composed of bismuth, tellurium, selenium, and antimony, for use as a semiconductor to cool solid-state electronic devices, reached the pilot-plant stage.[5]

Data were given on an electrolytic method of plating bismuth on copper, copper alloys, and steel.[6]

Experiments on the production of high-purity single crystals of bismuth for use in thermoelectric units continued, and a method of pulling single crystals from the melt was reported.[7]

Additional experimental work on the study of heat emission accompanying the passage of current in p-type bismuth-telluride polycrystals was completed,[8] and the effect of pressure on magnetoelectric properties of bismuth utilized in the semiconductors was investigated.[9]

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[4] Metal Bulletin (London), Thermoelectric Reviewed: No. 4510, July 8, 1960, p. 20.

[5] Chemical Week, Newest Semiconductor Material to Bid for Thermoelectric Cooling: Vol. 86, No. 21, May 21, 1960, p. 72.

[6] Lerner, M. Y., and Gadushko, A. D., An Electrolytic Method for Depositing Bismuth, U.S.S.R.: Bulletin' Izobriteniy, vol. 4, 1960, p. 54.

[7] Packman, J. E., The Growth of Bismuth Single Crystals by Pulling: Jour. Inst. Metals (London), vol. 88, No. 3, November 1960, p. 112.

[8] Baranskii, P. I., and Tomkevich, S. L., Bridgman Effect in Bismuth Telluride Crystals: Fizika Tverdogo Tela, vol. 2, No. 8, August 1960, pp. 1714–1722. (English translation in Soviet Physics Solid State, vol. 2, No. 8, February 1961, pp. 1551–1557. Published by Am. Inst. Physics.)

[9] Sekoyan, S. S., and Likhter, A. I., Effect of Pressure on Magnetoelectric Properties of Bismuth: Fizika Tverdogo Tela, vol. 2, No. 8, August 1960, pp. 1940–1942. (English translation in Soviet Physics Solid State, vol. 2, No. 8, February 1961, pp. 1748–1750. Published by Am. Inst. Physics.)

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Boron

By Henry E. Stipp [1] and Victoria M. Roman [2]

THE SHARP increase in exports of boric acid, borates, and boron compounds, 19 percent above 1959, was chiefly responsible for a 3-percent increase in total sales of boron minerals and compounds.

DOMESTIC PRODUCTION

Boron minerals and compounds were produced from the brine of Searles Lake by American Potash & Chemical Corp. at Trona, Calif., and West End Chemical Division of Stauffer Chemical Co. at Westend, Calif. In California, Pacific Coast Borax Division of United States Borax & Chemical Corp. mined borax and kernite from a deposit in the Kramer district near Boron, colemanite at Death Valley Junction, and ulexite from a deposit near Shoshone.

Production of alloy steel ingots containing boron totaled 282,063 short tons in 1959 compared with 219,250 tons in 1958.[3]

The Carborundum Co. made boron nitride at Niagara Falls, N.Y. The production process consisted of mixing boric acid and tricalcium phosphate in a water-paste form, which was heated at 1,650° F. in an

TABLE 1.—Salient boron minerals and compounds statistics in the United States

	1951-55 (average)	1956	1957	1958	1959	1960
Sold or used by producers:						
Short tons:						
Gross weight [1]	694,838	544,677	541,124	528,209	619,946	640,591
B_2O_3	220,025	267,864	269,251	265,613	314,286	323,955
Value thousands	$21,849	$32,812	$38,041	$38,310	$46,150	$47,550
Imports for consumption:						
Short tons	9	[2] 74	[2 3] 5,077	24	41	43
Value thousands	$26	[2] $174	[2] $284	$133	$144	$172
Exports:						
Short tons	176,851	243,725	214,497	235,584	253,674	300,606
Value thousands	$11,291	$16,596	$15,975	$18,292	$21,047	$25,576
Consumption, apparent:						
Short tons	517,996	301,026	[3] 331,704	292,649	366,313	340,028

[1] Gross weight reported for 1951-54 included a higher proportion of crude ore to finished products than in 1955-60.
[2] Imports for 1956 and 1957 include a higher proportion of crude ore to refined products.
[3] Revised figure.

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.
[3] American Iron and Steel Institute, Annual Statistical Report: New York, N.Y., 1959, p. 56.

ammonia atmosphere. The material was leached with hydrochloric acid, washed, dried, and pressed.

Kern County Land Co. obtained court approval to purchase two mining claims near Death Valley, Calif. The claims contain colemanite.

American Potash & Chemical Corp. and Firth Sterling, Inc., agreed to develop applications for titanium diboride. Use of the boron compound as electrodes for preparing aluminum was promising.

A conveyor system was being installed in the open-pit borate mine at Boron, Calif.[4] It was designed to lift ore 315 feet on an 18° slope from the floor of the pit to the rim. A 91,000-pound hammer mill was installed in the pit.

United States Borax Research Corp. and The Dow Chemical Co. successfully completed their joint venture to develop an economic process for the manufacture of boron trichloride.

CONSUMPTION AND USES

It was estimated that the glass and ceramics industries consumed about 42 percent of the boron compounds sold. Consumption of boron compounds in agriculture was estimated to be about 14 percent of total sales. Boron and boron compounds had numerous and varied other industrial uses. Borax or boric acid was used in soaps and detergents, rust inhibitors, textiles, paper, metallurgy, starch, medical and pharmaceutical preparations, flameproofing compounds, electrolytic condensers, dyes, cosmetics, adhesives, inks, leather, paint and varnish, photography, waxes, and preservatives for animal and vegetable products. Boron compounds were used in nuclear energy applications, missile fuels, refractories, and metallurgical processing.

Increased use of glass fibers in reinforced resins for small boats, insulation, home furniture, construction materials, and textiles indicated increased sales of boric acid and boron oxide. However, the declines in new construction and automobile sales were said to be factors that would lower the consumption of boric acid in 1960.

Several new uses for boron compounds were reported in 1960. Triethyl borine was used as a fungicide, a polymer catalyst with silicones, and an intermediate; trimethyl borate, as a brazing flux and an intermediate for producing high-energy fuels; tri-n-butyl borate, as an antigelling agent and wax-suppressor catalyst; trihexylene glycol diborate, as a gasoline additive; and trimethoxyboroxine, as a metal-fire extinguishing fluid. A paper coated with a solution containing boron mixed with a polyvinyl acetate solution was reported to be glossy, fire resistent, and longer lasting for packaging purposes.

Nonyl boric acid was suggested for use as a bacteriostat and fungestat in polymer systems, cutting oils, paper, leather, and fibers, as an esterifying agent, and as a gasoline, glassware, and detergent additive. Sodium hexylene glycol monoborate was offered for use as a flame-retardant additive in nonaqueous paints, an oil additive to decrease sludge formation, a corrosion inhibitor, and an additive to siloxane resins. Borosilicate glass fittings were used in water

[4] Engineering and Mining Journal, Open Pit Conveyor Lifts Borates 315 Feet on 18° Incline: Vol. 161, No. 12, December 1960, pp. 106–107.

drainline systems. Sheets of polyethylene that contained boron were used as radiation shielding on vessels powered by nuclear energy. The sheets, produced by special extrusion techniques, were lighter than other shielding materials such as lead or concrete.

Chromium boride, dichromium boride, molybdenum boride, molybdenum diboride, titanium boride, vanadium boride, and zirconium boride powders were used in plasma-arc spraying equipment.

Small quantities of hydrazine diborane were made available for use as rocket propellants.

PRICES

The price of most grades of borax and boric acid remained steady throughout the year. The following prices were quoted by Oil, Paint and Drug Reporter:

Compound:	*January–December (per ton)*
Borax, technical:	
Anhydrous, 99.5 percent:	
Bags, carlots, works	$92.00
Ton lots, bags, exwarehouse, New York or Chicago	148.40
Bulk, carlots, works	83.00
Granular, decahydrate, 99.5 percent:	
Bags, carlots, works	50.00
Ton lots, bags, exwarehouse, New York or Chicago	106.40
Bulk, carlots, works	43.50
Granular, pentahydrate, 99.5 percent:	
Bags, carlots, works	64.50
Ton lots, bags, exwarehouse, New York or Chicago	121.00
Bulk, carlots, works	58.00
Powder, 99.5 percent:	
Bags, carlots, works	54.00
Ton lots, bags, exwarehouse, New York or Chicago	129.00
Borax, U.S.P., $15 per ton higher than technical.	
Boric acid, technical:	
Anhydrous, 99.9 percent:	
Bags, carlots, works	335.00
Ton lots, bags, exwarehouse, New York or Chicago	392.40
Crystals, 99.9 percent:	
Bags, carlots, works	163.50
Ton lots, bags, exwarehouse, New York or Chicago	221.00
Granular, 99.9 percent:	
Bags, carlots, works	112.00
Ton lots, bags, exwarehouse, New York or Chicago	169.40
Powder, 99.9 percent:	
Bags, carlots, ton lots, bags, exwarehouse, New York or Chicago	177.00
Boric acid, U.S.P., $25 per ton higher than technical.	

FOREIGN TRADE [5]

Imports of boron carbide totaled 85,965 pounds valued at $171,805 compared with 81,000 pounds valued at $144,000 in 1959.

Exports of boric acid, borates, and compounds increased 19 percent compared with 1959. Exports to Europe and Oceania showed the largest percentage increases. Industrial expansion, principally in the field of glass production, was largely responsible for increased exports.

[5] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 2.—U.S. exports of boric acid, borates, and compounds,[1] by countries

Destination	1959		1960	
	Short tons	Value	Short tons	Value
North America:				
Canada	13,361	$1,537,248	13,351	$1,588,352
Costa Rica	289	24,170	289	26,064
Cuba	655	66,239	529	54,260
Dominican Republic	96	10,788	8	1,006
Mexico	5,235	484,753	5,688	581,759
Nicaragua	26	7,715	18	5,566
Trinidad and Tobago	28	2,342	17	1,495
Other	31	9,404	25	4,515
Total	19,721	2,142,659	19,925	2,263,017
South America:				
Brazil	4,559	378,780	4,734	432,269
Colombia	354	32,571	605	60,274
Peru	533	39,773	615	54,353
Uruguay	352	42,384	172	19,801
Venezuela	185	22,154	184	24,871
Other	82	15,552	154	16,553
Total	6,065	531,214	6,464	608,121
Europe:				
Austria	3,445	172,368	4,145	229,058
Belgium-Luxembourg	3,914	373,977	5,172	507,590
Denmark	707	95,185	1,236	96,774
Finland	1,262	92,127	1,311	99,228
France	28,899	2,091,397	34,757	2,627,604
Germany, West	50,501	3,723,584	65,523	4,864,963
Greece	181	11,518	520	42,442
Ireland	361	28,073	1,068	73,330
Italy	9,458	692,995	12,295	903,521
Netherlands	14,039	1,384,784	15,304	1,537,092
Norway	2,497	191,224	2,427	221,398
Poland	2,756	146,703	551	32,775
Portugal	946	76,582	732	61,626
Spain	5	712	4,420	229,536
Sweden	3,551	314,527	2,860	240,772
Switzerland	2,855	220,049	3,044	290,660
Trieste	----	----	143	11,631
United Kingdom	51,826	3,812,334	62,730	4,961,077
Yugoslavia	826	80,262	1,403	128,598
Total	178,029	13,508,401	219,641	17,159,675
Asia:				
Ceylon	177	$13,892	137	$9,573
Hong Kong	4,320	368,409	3,695	325,938
India	6,284	499,685	6,366	527,935
Indonesia	342	22,550	204	15,160
Iran	223	19,874	126	10,368
Israel	527	50,464	738	64,710
Japan	21,128	1,873,734	21,865	2,067,341
Korea, Republic of	281	24,650	421	32,623
Lebanon	47	3,975	56	4,672
Malaya, Federation of	74	7,686	242	17,715
Pakistan	788	58,763	1,416	107,483
Philippines	709	75,520	482	48,400
Singapore	114	8,334	26	2,399
Taiwan	401	29,154	1,187	74,169
Thailand	340	29,627	445	43,938
United Arab Republic (Syria Region)	22	1,316	28	2,796
Viet-Nam	106	7,211	100	5,750
Other	4	1,014	35	4,316
Total	35,887	3,095,858	37,569	3,365,286
Africa:				
Rhodesia and Nyasaland, Federation of	437	32,669	241	19,143
Union of South Africa	2,026	232,565	1,914	209,439
United Arab Republic (Egypt Region)	256	28,082	368	38,048
Other	93	11,221	216	26,628
Total	2,812	304,537	2,739	293,258
Oceania:				
Australia	8,588	1,186,311	9,983	1,367,363
New Zealand	2,572	278,082	4,239	516,456
Other	----	----	46	2,990
Total	11,160	1,464,393	14,268	1,886,809
Grand total	253,674	21,047,062	300,606	25,576,166

[1] Classified by the Bureau of the Census as boric acid and borates, crude, refined, and compounds (including borate esters and other boron compounds) n.e.c.

Source: Bureau of the Census.

The U.S. Department of Commerce prevented four foreign companies from buying boron materials in the United States.[6]

WORLD REVIEW

SOUTH AMERICA

Argentina.—Boroquimica Limitada constructed a plant at Campo Quijano, Salta. The firm was to export boron derivatives and produce anhydrous borax and boric acid.[7]

Chile.—Sales of ulexite during 1960 totaled 3,312 short tons compared with 6,345 tons in 1959. The low sales were a result of a decline in consumption by the glass and ceramics industries. Mine production of ulexite was kept to 1,654 tons, as yearend stocks exceeded 18,739 tons. It was planned to close the mines for 1 or 2 years beginning in 1961, owing to decreased consumption and high stocks of ulexite. Anglo-Lautaro Nitrate Co. continued work on its new boric acid plant at Maria Elena. The plant was scheduled to be in operation by late 1961.[8]

EUROPE

France.—Devinean Co. and American Potash & Chemical Corp. of the United States planned to form a joint subsidiary, the Société des Produits du Bore. The new firm was to produce boron products from Turkish boron minerals.[9]

Germany, West.—Boron compounds production totaled 54,298 short tons in 1959 compared with 49,549 tons in 1958.[10]

Italy.—Production of boric acid totaled 2,741 short tons in 1959, 28 percent less than the 3,805 tons produced in 1958.[11]

United Kingdom.—Imperial Chemical Industries, Ltd., and the Callery Chemical Co. of the United States agreed to exchange information on boron compounds. Nonexclusive royalty-bearing licenses and related technical information could be acquired by either firm.[12]

The Board of Trade granted an application for removal of duty on disodium tetraborate anhydrous, 99 percent pure.[13]

ASIA

Turkey.—Borax Consolidated, Ltd. (London) and Philipp Brothers Ore Corp. (New York) were considering building a borax refinery in Turkey.[14] Boron minerals production increased in 1959 to a new high of 80,838 short tons compared with 76,502 tons in 1958. Exports of boron minerals in 1959 totaled 67,787 short tons compared

[6] Chemical Week, Policing Borax Exports: Vol. 86, No. 26, June 25, 1960, p. 100.
[7] World Mining, Latin America: Vol. 13, No. 2, February 1960, p. 75.
[8] U.S. Embassy, Santiago, Chile, State Department Dispatch 724: May 3, 1961, pp. 19–20.
[9] Chemical Trade Journal and Chemical Engineer (London), Notes from Abroad: Vol. 146, No. 3807, May 20, 1960, p. 1159.
[10] U.S. Embassy, Duesseldorf, West Germany, State Department Dispatch 294: Apr. 27, 1960, p. 1.
[11] Bureau of Mines, Mineral Trade Notes: Vol. 51, No. 4, October 1960, p. 24.
[12] Chemical Trade Journal and Chemical Engineer (London), Items of Interest: Vol. 147, No. 3823, Sept. 9, 1960, p. 552.
[13] Chemistry and Industry (London), Parliamentary News: No. 46, Nov. 12, 1960, p. 1423.
[14] U.S. Embassy, Ankara, Turkey, State Department Dispatch 664: Apr. 15, 1960, p. 22.

with 56,506 tons in 1958. Exports to the United States totaled 23,437 short tons in 1959 compared with 24,158 tons in 1958. A price reduction in 1959 contributed to the increase in production and exports. Exploration for boron minerals continued as Turk Boraks Madencilik examined favorable areas in search of a replacement for the Sultan Cayiri mine. The discovery of borates near Canakkale was confirmed.[15]

TECHNOLOGY

A new boron mineral species, reedmergnerite ($NaBSi_3O_8$), was discovered in unmetamorphosed dolomitic oil shales of the Green River formation in Duchesne County, Utah.[16] The mineral is triclinic, colorless, prismatic with wedge-shaped ends, biaxial, negative, $2V=80°$. Indices of refraction are $\alpha 1.554$, $\beta 1.565$, $\gamma 1.573$, all ± 0.001.

Two new boron minerals, anhydrous calcium borate (calciborite) and hydrous calcium borate (frolovite), were discovered in the Turkish region (Northern Urals) of Russia.[17]

The handling of large volumes of borax ore and in-process slurries and solutions by instruments was described.[18] Borax ore storage tanks were monitored by electronic capacitance probes installed horizontally at high and low levels. Variations in the ore level controlled input flow of ore. Continuous monitoring and control of borax slurry and solution levels was accomplished with flexible capacitance probes mounted vertically in stilling pipes.

A process for preparing boric acid from calcium borate was developed on a pilot-plant scale at the University of Pisa, Italy.[19] Calcium borate was decomposed with a solution of ammonium bicarbonate and free ammonia. Calcium carbonate and insolubles were decanted or filtered out. Ammonium borate was then decomposed by boiling to give ammonia and boric acid.

An apparatus was developed for detecting and monitoring boron in the atmosphere.[20] A test was developed which could be used to indicate the presence of 0.00 to 0.02 micrograms of boron.

The infrared spectrum of boron nitride was obtained by using a cell that contained diamond or sapphire windows.[21] The spectrum of boron nitride could not be obtained by any other technique because boron nitride could not be ground or shaped without introducing impurities.

Borundum material (borosilicon carbide) was prepared by heating a mixture of boric acid, quartz sand, and carbon black.[22] Samples of

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[15] Bureau of Mines, Mineral Trade Notes: Vol. 52, No. 2, February 1961, pp. 5–8.

[16] American Mineralogist, Reedmergnerite, $NaBSi_3O_8$, The Boron Analogue of Albite, From the Green River Formation, Utah: Vol. 45, Nos. 1 and 2, January–February 1960, pp. 188–199.

[17] Petrova, S. S. [A New Hydrous Borate of Calcium Frolovite]: Translation of Vsesoyuznoye Mineralogicheskoye Obshchestvo Zapioki (U.S.S.R.), 1957, ser. 2, pt. 86, No. 5, pp. 622–625; Tech. Trans., Off. Tech. Services, U.S. Department of Commerce, vol. 3, No. 10, May 25, 1960, p. 643.

[18] Mining Magazine (London), Instrumentation and Process Control: Vol. 103, No. 2, August 1960, pp. 86–89.

[19] Chemical Trade Journal and Chemical Engineer (London), Boric Acid From Colemanite: Vol. 146, No. 3795, Feb. 26, 1960, p. 451.

[20] Powell, W. A., Poindexter, E. H., and Hardcastle, J. E., Turmeric Paper Test for Boron: Richmond University, Richmond, Va., Rept. on Project Zip, July 5, 1957, 14 pp.

[21] Chemical and Engineering News, Diamonds and Sapphires Broaden IR Use: Vol. 38, No. 39, Sept. 26, 1960, p. 120.

[22] Ormont, B. F., Epel'baum, V. A., and Shafron, I. G., [Investigation in the Region of the Boron-Carbon-Silicon System and the Production of Borundum]: Trudy Konferentsii po khimii bora i yego soyedineniy (Moskva), Goskhimizdat, 1958, pp. 177–181.

borundum were similar to silicon carbide and had good grinding ability. Borundum was more economical to prepare and consumed less raw material than silicon carbide.

Insulation material prepared from old newspapers and boric acid protected a man's hand from a 4,000° F. flame.[23] The material was lightweight and water resistant and had a thermal conductivity of 0.19 B.t.u./hr./sq.ft./° F/ft.

The structures and properties of rare-earth borides were reviewed in a report obtainable from the Library, Atomic Energy Research Establishment, Harwell, England.[24]

A method of removing boron bromide from silicon bromides was patented.[25] A chlorinated hydrocarbon was reacted with boron bromide and formed gaseous boron trichloride, which escaped from the reaction mixture. Silicon bromide was recovered and purified by fractional distillation.

Boron fluoride prepared by decomposition of phenyl-diazonium fluoroborate had less silicon fluoride than boron fluoride obtained by usual methods.[26] It was used as a pure gas for some purposes.

A book which reviewed the use of boron fluoride, its derivatives, and coordination compounds as catalysts in organic chemistry was published.[27]

A patent was granted for purifying boron trichloride or boron tribromide, by repeatedly passing them through an aromatic hydrocarbon containing aluminum chloride.[28]

A molybdenum silicide-boron carbide thermocouple for measuring temperatures up to 1,800° C. was developed at the Academy of Sciences, Ukrainian S.S.R.[29] The thermocouple produced an electromotive force of 40 microvolts per degree and could be placed in a blast furnace melt for 30 minutes, when protected by a sheath of zirconium boride or titanium boride containing molybdenum.

A semiconductor thermocouple which could be used at 2,000° to 2,300° C. was also developed. The outer tube of this thermocouple was titanium carbide, and the core was boron carbide.

Another thermocouple of boron carbide and silicon carbide was said to produce an electromotive force of up to 600 microvolts per degree.

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[23] Chemical Engineering News, Old Newspapers Plus H_3BO_3 Yield Insulation: Vol. 38, No. 9, Feb. 29, 1960, p. 47.

[24] Chemical Age (London), Rare-Earth Metal Borides: Vol. 83, No. 2134, June 4, 1960, p. 921.

[25] Belecke, Branz Arthur Pohl (assigned to Licentia Patent-Verwaltungs–G.m.b.H., Hamburg, West Germany), Method of Purifying Silicon Bromides Contaminated With Boron Bromide and Silicon Iodides Contaminated With Boron Iodide: U.S. Patent 2,947,607, Aug. 2, 1960.

[26] Panchenkov, G. M., Moiseyev, V. M., and Levedev, Yu. A., [On the Decomposition of Aryl-Diazonium Fluoroborates as a Method of Obtaining Pure Boron Trifluoride]: Translation of Akad. Nauk S.S.S.R., Doklady, 1955, vol. 100, No. 6, pp. 1103–1106; Tech. Trans., Off. Tech. Services, U.S. Department of Commerce, vol. 4, No. 1, July 13, 1960, p. 19.

[27] Topchiev, A. V., Zavgorodnii, S. V., and Paushkin, Ya. M., [Boron Fluoride and Its Compounds as Catalysts in Organic Chemistry]: Pergamon Press, New York, N.Y., 1959, 319 pp.

[28] Bratt, Lars C., Leffler, A. J., and Louis, G. A., Purification of BCl_3 with Aluminum Chloride: U.S. Patent 2,920,942, Jan. 12, 1960.

[29] Borisov, Ye. [Automatic Control and Semiconductors]: Znaniyl-Sila, vol. 34, No. 8, August 1959, pp. 28–32; Sci. Information Rept., Off. Tech. Services, No. PB 131891 T–32, Oct. 23, 1959, pp. 40–45.

A thermocouple was patented that contained an element of crystalline carbon impregnated with boron.[30] The instrument was used for measuring temperatures above 2,000° C.

A mixture of ammonia and boric acid was considered to be a good preservative for rubber latex.[31] A slight excess of ammonia was added to form ammonium borate equivalent to 0.2 to 0.3 percent boric acid. The preservative overcame the disadvantage of high-ammonia-type preservatives and had no tendency to discolor latex films.

Boron triiodide was prepared by reacting crystalline boron with vaporized iodine and argon in a vertical reactor.[32] Unreacted iodine was stripped by distillation. Maximum yield of 70-percent boron triiodide was obtained at 900° C. Decomposition of boron triiodide on a hot tantalum wire at 800° to 1,000° C. yielded dense (2.459) red crystals of boron.

A brake fluid that consisted of a borax-glycol complex combined with alkali was developed by the U.S. Army Ordnance Corps. It was reported to be noncorrosive and nongumming, had an acceptable boiling point, and caused little deterioration of rubber.

A hydraulic fluid was patented that consisted of a silicon compound containing a product obtained by reacting a dihydroxy hydrocarbon compound with boric acid or boron oxide and further reacting this product with a monohydroxy organic compound.[33]

A report was issued on perfluorovinylboron compounds.[34]

An alkyl borine, $(n\text{-}C_4H_9)BCl$, was reacted with trimethylsilyl cyanide, $(CH_3)_3$ SiCN, to form polymeric alkyl borocyanide.[35]

A group of polymers was discovered which was reported to be stable at temperatures of about 1,110° F.[36] The polymers were said to contain boron and phosphorous.

A boron catalyst was used to polymerize methylene groups derived from decomposition of a diazo compound.[37] This technique gave a polymethylene without branched components. The polymethylene was used as a linear reference standard in polymer research.

A simple method was discovered for preparing tetra (dimethylamino) diboron, a source for other diboron compounds that could be useful intermediates.[38] It was prepared in excellent yield by reacting dispersed sodium with chloro- or bromo-bis (dimethylamino) borane. Haloboranes were obtained by reacting tris (dimethylamino) borane with boron trihalides.

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[30] Westbrook, Russell D., and Shepard, Robert L. (assigned to Union Carbide Corp., New York), U.S. Patent 2,946,835, July 26, 1960.

[31] Chemical Trade Journal and Chemical Engineer (London), Rubber Latex Preservatives: Vol. 145, No. 3785, Dec. 18, 1959, p. 1215.

[32] McCarty, L. V., and Carpenter, D. R., The Preparation of a New Crystalline Modification of Boron, and Notes on the Synthesis of Boron Triiodide: Jour. Electrochem. Soc., vol. 107, No. 1, January 1960, pp. 38–42.

[33] Cook, James R. (assigned to Union Oil Co. of California, Los Angeles, Calif.), Silicon Hydraulic Fluids Containing Boron Esters: U.S. Patent 2,962,446, Nov. 29, 1960.

[34] Stone, F. G. A., Stafford, S. L., and Treichel, P. M., Perfluorovinylboron Compounds [and] Dialkylbis (Pentafluoroethyl) Tin Compounds: Mallinckrodt Chem. Lab., Harvard Univ., Cambridge, Mass., Rept. on Contract AF 49 (638) 518, June 1960, 12 pp.; U.S. Govt. Res. Repts, Off. Tech. Services, U.S. Department of Commerce, vol. 34, No. 6, Dec. 16, 1960, p. 688.

[35] Pennsylvania University, Philadelphia, The Interaction of Alkyl Borines with Trimethylsilyl Cyanide: Tech. Rept. No. 5, Oct. 15, 1958, 14 pp.

[36] Chemical Engineering, Mystery Polymer Resists Brutal Heat: Vol. 67, No. 13, June 27, 1960, pp. 53–54.

[37] Chemical Engineering News, Dist. Anal Markets Polymethylene: Vol. 38, No. 20, May 16, 1960, pp. 69, 75.

[38] Chemical Engineering News, U.S. Borax Makes Diborons: Vol. 38, No. 16, Apr. 18, 1960, p. 69.

A patent was issued for a motor gasoline which contained hexylene glycol and a boron compound.[39]

A new procedure for analyzing fatty acids by gas chromatography used boron trifluoride to convert fatty acids to their methyl esters.[40] A complete analysis that formerly took 3 to 4 hours could be performed in 20 minutes.

Dicyclohexylphosphinoborine trimer, an inorganic polymer, was reported to be stable at 900° F.[41] Borosiloxane polymers previously had been prepared which were stable at 500° F., but their physical properties were not good.

Triphenyl-p-biphenylyl silane glass scintillators were loaded with triphenyl-borazole for use in an instrument that gave a pulse peak for alpha particles from the B^{10} thermal neutron reaction.[42]

Problems encountered in the manufacture of a wide range of borate glasses were reviewed.[43] A study was made of the technology of glass melting, processes and reactions of glass formation, crystallization and composition of glasses, the physicochemical properties of the systems and their relation to the composition, structure, and properties of glass, and the calculation of the properties.

An electrical resistor consisting of a nonconducting vitreous body coated with tin, antimony, and boron oxide was patented.[44] The electrically conductive coating had a surface resistivity of 1 to 10,000 ohms per square centimeter.

Borated graphite blocks were used for the first time in the shield surrounding the fast breeder reactor at Dounreay, Scotland.[45] The graphite contained from 0.3 to 5.0 percent boron distributed uniformly. Borated graphite slows down fast neutrons and absorbs them in a short distance.

A mixture of boron 10 and polonium or plutonium was used as a neutron source to measure the carbon content of rock formations.[46] The gamma radiation produced by neutron bombardment of the carbon was detected and recorded by a device used for logging well holes.

Boron was diffused in silicon by use of a modified closed-box system.[47] Concentrations of 0.2 percent boron by weight to pure boron oxide were obtained. Effects of atmospheres and materials on deposition were described.

Tetraboron silicide (B_4Si) was prepared by heating a mixture of boron (86.6 percent pure) and silicon (98 percent pure) in an

[39] de Gray, R. J. (assigned to The Standard Oil Co., Cleveland, Ohio), Motor Gasoline Containing Boron and Hexylene Glycol: U.S. Patent 2,931,714, Apr. 5, 1960.

[40] Chemical Engineering News, Fatty Acid Analysis Moves Out to the Plant: Vol. 38, No. 29, July 18, 1960, pp. 58–59.

[41] Chemical Week, New Heat on High-Temperature Polymers: Vol. 80, No. 11, Mar. 12, 1960, p. 58.

[42] Kemler, Emory Neudeck, The Use of Boron Loaded Silane Glass Scintillators for Thermal Neutron Detection: Air Force Inst. of Tech., Wright-Patterson AFB, Ohio, February 1959, 47 pp.; U.S. Govt. Res. Repts., Off. Tech. Services, U.S. Department of Commerce, vol. 32, No. 3, Sept. 11, 1959, p. 372.

[43] Mazelev, L. Ya. [Borate Glass]: Glass Ind., vol. 41, No. 5, May 1960, p. 283.

[44] Dearden, Jack (assigned to Welwyn Electrical Laboratories, Ltd., Bedlington, England), Electrical Resistors: U.S. Patent 2,920,005, Jan. 5, 1960.

[45] Chemical Trade Journal and Chemical Engineer (London), Borated Graphite Blocks: Vol. 146, No. 3787, Jan. 1, 1960, p. 38.

[46] Bonner, T. W., and Caldwell, R. L. (assigned to Socony Mobil Oil Co., Inc., New York), Neutron Production by Alpha Disentegration of Boron 10: U.S. Patent 2,948,811, Aug. 9, 1960.

[47] Yatsko, R. S., and Kesperies, J. S., A Modified Closed Box System for the Diffusion of Boron in Silicon: Jour. Electrochem. Soc., vol. 107, No. 11, November 1960, pp. 911–915.

electrical resistance furnace with an argon atmosphere at 1,370° C. for 4 to 5 hours.[48] The product was then soaked at 1,370° C. for 2 to 3 hours and furnace-cooled. Boron silicide was highly resistant to oxidation. Shapes fabricated by powder metallurgical techniques were oxidation resistant in air for over 100 hours and showed excellent thermal-shock resistance.

A refractory material stable in air to 1,550° C. was formed by reacting silicon and boron.[49] The material consisted of free silicon tetraboride (SiB_4) dispersed in a borosilicate matrix. The refractory composition was resistant to thermal shock and had a low density.

Silicon tetraboride (SiB_4) was prepared by reacting silicon (99.82 percent pure) and boron trioxide in boron to silicon ratios of 0.9 to 5.0 at 1,000° to 1,400° C.[50] Silicon tetraboride was concentrated and separated from the reaction product.

Small additions of boron to wrought type 304 stainless steel improved the corrosion resistance; however, boron did not provide complete or satisfactory protection.[51] All samples tested in boiling 65-percent nitric acid exhibited intergranular corrosion in the sensitized condition. The rate at which corrosion occurred varied with the boron content.

A type 304 base stainless steel containing up to 2 percent boron 10 was said to have improved corrosion resistance and good mechanical properties.[52] The new boron steel was to be used for control rods, burnable poison, and shielding for nuclear reactors. It could lead to improved design flexibility, increased safety, and reduced maintenance costs for nuclear power plants.

Enriched boron 10 was obtained in commercial quantities by distilling boron trichloride.[53] A product containing 75 mole-percent $B^{10}Cl_3$ was obtained from a distillation column that contained 800 plates.

Composite materials of aluminum and boron or rare-earth oxides that were ductile and had excellent physical properties were prepared by a powder metallurgy technique.[54] Composites contained an oxide, carbide, boride, or intermetallic compound dispersed in a metal or alloy matrix. The process for preparing these materials consisted of mixing weighed components of the materials in special mills and forming green compacts using hydrostatic presses. A solid but porous billet was then prepared from the green compacts by sintering at a low temperature. Compacts were sintered at high temperature several times to minimize porosity. The materials were fabricated by cold-rolling, sizing, slitting, or machining.

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[48] Colton, Ervin, Preparation of Tetraboron Silicide, B_4Si: Jour. Am. Chem. Soc., vol. 82, No. 4, Feb. 20, 1960, p. 1002.

[49] Rizzo, H. F., Weber, B. C., and Schwartz, M. A., Refractory Compositions Based on Silicon-Boron-Oxygen Reactions: Jour. Am. Ceram. Soc., vol. 43, No. 10, Oct, 1, 1960, pp. 497–504.

[50] Rizzo, H. F., and Bidwell, L. R., Formation and Structure of SiB_4: Jour. Am. Ceram. Soc., vol. 43, No. 10, October 1960, pp. 550–552.

[51] Metal Progress, How Boron Affects Corrosion of Type 304 Stainless: Vol. 77, No. 2, February 1960, pp. 101–103.

[52] Materials In Design Engineering, A Boron Stainless Steel With Better Toughness, Corrosion Resistance: Vol. 51, No. 4, April 1960, pp. 9–10.

[53] Sevryugova, N. N., Uvarov, O. V., and Zhavorankov, N. M., [Separation of Boron Isotopes by the Distillation of Boron Chloride]: Doklady Akad. Nauk, Moscow, U.S.S.R., vol. 126, No. 5, June 11, 1959, pp. 1044–1046; Sci. Information Rept., Off. Tech. Services, No. PB 131891 T-32, Oct. 23, 1959, p. 20.

[54] Light Metal Age, Ductile Aluminum—Boron Composites: Vol. 18, Nos. 7 and 8, August 1960, p. 21.

Various metallurgical techniques were used to study properties of boron carbide-molybdenum disilicide alloys.[55] The formation of a homogeneous quaternary phase that was highly resistant to oxidation was reported.

Two new phases were found in the nickel-boron-system with compositions close to Ni_4B_3.[56]

Hexaborides of several rare-earth elements were prepared by heating the rare-earth oxides and boron carbide or carbon in a vacuum.[57] The compounds were analyzed by X-ray diffraction and their densities were determined.

Borides of transition elements were characterized as compounds with extreme hardness, low volatility, high stability, and low electrical resistivity. They melted between 1,550° and 3,000° C.[58] Mixtures of chromium boride and molybdenum boride had service temperatures from 1,800° to 2,100° F., superior oxidation resistance, and high temperature strength. Their thermal-shock resistance was excellent. Borides of chromium and zirconium have been used in jet and rocket engines. Molybdenum boride powder has been used in the electronics industry for metal brazing.

A ferrous metal that contained 1 to 2.5 percent carbon, 1.5 to 3.2 percent boron silicon, 0.001 to 0.05 percent boron, and the remainder iron was said to have high tensile strength and a modulus of elasticity of about 27 million pounds per square inch.[59]

Methods for preparing cubic boron phosphide and boron arsenide and the physical and chemical properties of these materials were described.[60] Cubic boron phosphide was expected to be harder than silicon carbide. Preliminary measurements indicated a very high energy gap for boron phosphide.

Borax Consolidated, Ltd., Borax House, Carlisle Place, London, S.W. 1, issued a revised edition of Technical Data Sheet No. 6–B, Boron Phosphate.[61]

A method of locating boron-rich areas in metallurgical and biological specimens was reported.[62] Alpha particles, emitted when neutrons were captured by boron nuclei, were recorded on a photographic emulsion. The recorded tracks showed the location of areas rich in boron. The method was most useful where boron was not distributed uniformly in the sample.

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[55] Samsonov, G. V., Sivelnikova, V. S., and Kislyy, P. S., [Alloys of the Boron Carbide-Molybdenum Disilicide System]: Doklady Akad. Nauk Ukrain. S.S.R. (Kiev), No. 8, August 1959, pp. 866–868; Sci. Information Rept. Off. Tech. Services, No. PB 131891 T–32, Oct. 23, 1959, p. 102.

[56] Rundquist, Stig, [An X-ray Investigation of the Nickel-Boron System. The Crystal Structure of Orthorhombic and Monoclinic Ni_4B_3]: Uppsala U. (Sweden), Mar. 14, 1959, 27 pp.; U.S. Govt. Res. Repts., Off. Tech. Services, U.S. Department of Commerce, vol. 32, No. 6, Dec. 11, 1959, p. 769.

[57] Tvorogov, N. N., [An Investigation of the Hexaborides of Rare-Earth Elements and of Yttrium]: Academy of Sciences U.S.S.R. (Moscow), Zhurnal Neorganicheskoy Khimii, vol. 4, No. 9, September 1959, pp. 1961–1966; Sci. Information Rept., Off. Tech. Services, No. PB 131891 T–36, Dec. 18, 1959, p. 21.

[58] Benn, W. R., Metal Borides and Carbides Materials of the Future: Ind. Eng. Chem., vol. 52, No. 5, May 1960, pp. 40A–44A.

[59] White, Philip R., Thomson, Robert F., and Joseph, Carl F. (assigned to General Motors Corp., Detroit, Mich.), Boron-Containing Ferrous Metal Having As-Cast Compacted Graphite: U.S. Patent 2,943,932, July 5, 1960.

[60] Williams, F. V., and Ruehrwein, R. A., The Preparation and Properties of Boron Phosphides and Arsenides: Jour. Am. Chem. Soc., vol. 20, No. 6, Mar. 20, 1960, pp. 1330–1332.

[61] Chemical Trade Journal and Chemical Engineer (London), Boron Phosphate in Ceramics: Vol. 145, No. 3786, Dec. 25, 1959, p. 1254.

[62] Transactions of the Metallurgical Society of AIME, Determining Boron Distribution in Metals by Neutron Activation: Vol. 218, No. 2, April 1960, pp. 228–231.

Diborides of transition elements and gadolinium hexaboride were measured for thermionic emission.[63] Samples were prepared by powder metallurgical methods. The emission constant and work function for each metal was calculated from emission data.

Titanium diboride crystal boules were prepared by a verneuil-type process.[64] Most boules cracked upon cooling; however, single crystal pieces one-fourth inch in diameter and half an inch long were recovered. Crystalline boules of ditungsten pentaboride were also produced. The preparation of pure powders and process improvement were the chief obstacles encountered in the study.

Two crystalline forms of boron were prepared by a solid-state transformation process.[65] X-ray diffraction patterns obtained for boron deposited at temperatures of 550° to 1,500° C. showed at least two crystalline forms of boron. Samples deposited at 125° to 772° C. were heat-treated. The structure of specimens was independent of the method of cooling after heat treatment. Recrystallization was studied in a sample at 1,482° C.

Borides of alkaline-earth metals were prepared by reducing the metal oxides with boron carbides under vacuum, combining boron directly with beryllium or magnesium, or reducing metal oxides with boron under vacuum.[66] Diberyllium boride (Be_2B), beryllium tetraboride (BeB_4), and beryllium hexaboride (BeB_6) were prepared. Magnesium tetraboride (MgB_4) was prepared at 1,300° C. Magnesium hexaboride (MgB_6) formed at 1,400° C. Hexaborides of calcium, strontium, and barium were obtained in high yield at 1,500° to 1,600° C.

Elemental boron about 99.8 percent pure was prepared by an electolytic-anode-transfer technique.[67] The electrolytic cell contained boron carbide packed between a porous carbon basket and diaphragm in a dense graphite crucible. The electrolyte was composed of 40 percent each (by weight) of sodium chloride and potassium chloride and 20 percent potassium fluoborate. Graphite resistors were used to heat the cell. Concentration of impurities increased with an increase in cell voltage. Major impurities in the boron were sodium, silicon, iron, and carbon.

Boron with good mechanical properties was prepared by reducing boron tribromide (BBr_3) with a tungsten filament at incandescent temperature.[68] The boron had a value of 64 x 10^6 pounds per square inch for Young's modulus and a modulus of rupture of 230,000 to 350,000 pounds per square inch.

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[63] Steinitz, R., Research on Thermionic Emission of Borides: Am. Electro Metal Div., Firth Sterling, Inc., Yonkers, N.Y., May 1, 1957, 36 pp.; U.S. Govt. Res. Repts., Off. Tech. Services, U.S. Department of Commerce, vol. 33, No. 1, Jan. 15, 1960, p. 42.

[64] Kiffer, A. D., Research Investigation to Determine the Optimum Conditions for Growing Single Crystals of Selected Borides, Silicides, and Carbides: Linde Co., Indianapolis, Ind., April 1960, 31 pp.; U.S. Govt. Res. Repts., Off. Tech. Services, U.S. Department of Commerce, vol. 34, No. 3, Sept. 16, 1960, p. 310.

[65] Jacobsmeyer, V. P., Gebhart, F. L., and Juenke, E. F., Semiconducting Properties of Boron: St. Louis University, Mo., 1958, 61 pp.; U.S. Govt. Res. Repts., Off. Tech. Services, U.S. Department of Commerce, vol. 34, No. 3, Sept. 16, 1960, p. 344.

[66] Samsonov, G. V., and Serebryakova, T. I., [Preparation of Borides of Group IIA Metals]: Zhurnal Prikladnoy Khimii, vol. 33, No. 3, 1960, pp. 563–569.

[67] Stern, David R., Preparation of Boron From Boron Carbide: Jour. Electrochem. Soc., vol. 107, No. 5, May 1960, pp. 441–445.

[68] Journal of the Institute of Metals (London), Mechanical Properties of Glassy Boron: Vol. 27, pt. 8, April 1960, pp. 481–482.

A patented nickel-base alloy that contained from 0.025 to 0.55 percent boron in addition to other metals was reported to have high corrosion resistance and high hardness without brittleness.[69]

Hexaborides of the alkaline-earth and rare-earth metals and thorium were found to have good properties for thermionic emission.[70] The stability of tungsten and thorium borides in the presence of thorium or boron was also studied. The compound $ThWB_4$ was reported to be monoclinic with a=12.25A., b=3.75A., c=614A., and B=104.1°.

The surface hardness of titanium was raised from 250 or 300 to 700 or 950 (Vickers hardness, 5-kilogram load) by electrolytic treatment in fused borax at 900° to 930° C. for 3 hours at about 0.1 ampere per square centimeter.[71] The treated material was equivalent in wear resistance to cemented or nitrided steel. Oxidation was the chief process in this technique; boriding was slight or absent. An alloy containing 5 percent chromium was borided with boron powder at 100° to 1,050°C. A diffusion layer of titanium boride that gave a hardness of 1,000 to 1,150 (Vickers hardness, 5-kilogram load) was formed.

The corrosion resistance of high-temperature materials used in aircraft power plants was studied in boron oxide at 1,750° to 2,200° F. and in air.[72] Alloys of aluminum, manganese, and carbon were detrimental to corrosion resistance, whereas silicon appeared to produce beneficial results.

The corrosive effects of boron fuels combustion products on high-temperature alloys were studied.[73] A method was perfected for evaluating the effects of boric oxide on high-temperature alloys.

Chemical plating of nickel and cobalt on metals and nonmetals by use of borohydride baths was reported.[74] The pH of borohydride plating baths was kept above 12 to prevent reaction of metal salts with solutions of borohydrides. Nickel or cobalt ion concentration was held below 0.15 *N* to prevent formation of a complex borohydride salt. Spontaneous decomposition of the solution occurred above 0.60 *N* borohydride concentration. The plating reaction was started by heating the bath from 40° to 50° C. or by adding a noble metal catalyst. The borohydride plating process had advantages for plating thermoplastic materials as well as steel, copper, ceramics, and glass.

A report described the X-ray diffraction study of boron crystals.[75] The structure of fused boron was found to be rhombohedral.

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[69] Johnson, Thomas E. (assigned to Stainless Foundry and Engineering, Inc., Milwaukee, Wis.), Nickel Base Alloys Containing Boron and Silicon: U.S. Patent 2,938,786, May 31, 1960.

[70] Pitman, D. T., and Das, D. K., A Study of the Thorium-Tungsten-Boron System: Jour. Electrochem. Soc., vol. 107, No. 9, September 1960, pp. 763–766.

[71] Minkevich, A. N., and Shulga, Yu, N. [Surface Hardening of Titanium by Treatment in Fused Borax]: Translation of Metallovedeniye i Termicheskaya Obrabotka Metallov, U.S.S.R., 1957, No. 12, pp. 53–61; Tech. Trans., Off. Tech. Services, U.S. Department of Commerce, vol. 4, No. 1, July 13, 1960, p. 55.

[72] Rosenbery, J. W., Further Investigation of the Effects of Molten Boron Oxide on High Temperature Materials: Dayton University Res. Inst., Ohio, W.A.D.C. Tech. Rept. 59–205, January 1960, 102 pp.; U.S. Govt. Res. Repts., Off. Tech. Services, U.S. Department of Commerce, vol. 34, No. 2, Aug. 19, 1960, p. 202.

[73] Industrial and Engineering Chemistry, Effects of Boron-Containing Combustion Products on High Temperature Alloys: Vol. 51, No. 12, December 1959, pp. 75A–76A.

[74] Industrial and Engineering Chemistry, Borohydrides Expand Chemical Plating: Vol. 52, No. 12, December 1960, pp. 42A, 44A, 46A.

[75] Carpenter, R. L., and Kato, H., X-Ray Crystallography of Boron: Bureau of Mines, Rept. of Investigations 5636, 1960, pp. 1–8.

A paper that reviewed the purity, crystal structure, physical properties, mechanical properties, and oxidation resistance of elemental boron was published.[76] Properties of elemental boron that determine its use as a structural material were low density, high melting point, high room-temperate hardness, high elastic modulus, and relatively high specific heat. However, the purest material was reported to have no ductility and poor thermal-shock resistance.

The lack of adequate concentrations of boron in soils treated with large amounts of potassium depressed the growth of soybean plants.[77]

Boron deficiency adversely effected phosphorous intake, distribution, and transformation in the sunflower plant.[78] In the flowering period, it led to a sharp decrease in quality and yield of seeds.

Traces of boron and copper applied prior to planting increased the resistance of potato tubers to bacterioses and increased yield.[79] The effect of trace elements depended upon the type of fertilizer used and the moisture content of the soil.

The growth of hops was increased by boron feeding.[80] Boron affected the carbohydrate metabolism and chlorophyll content and increased the quantity of soluble sugars in the leaves. It promoted the utilization of phosphorus and potassium.

Sodium borohydride and sulfuric acid were used to supply hydrogen for fuel cells developed for the U.S. Navy.[81] The cells contained a solid ion-exchange membrane cell in place of the liquid electrolyte normally used. This gave the cells freedom from electrolyte problems, good operation at ambient temperature and pressure, and high power-to-weight and power-to-volume ratios. The high cost of these units limited their use.

The potassium borohydride-boron trifluoride reaction for preparation of diborane was studied.[82] Potassium borohydride was less soluble than sodium borohydride in diethylene glycol dimethyl ether; however, a 91-percent yield of diborane was obtained from the reaction.

The structures of the known boron hydrides were studied, and molecular models were developed for diborane, tetraborane, pentaborane, hexaborane, and decaborane.[83]

Substituting deuterium for hydrogen in lithium borohydride methanolysis increased borohydride reactivity 1.6 times.[84] The reaction

[76] Williams, D. H., The Properties of Boron: Defense Metals Information Center, Battelle Memorial Inst., Columbus, Ohio, Memorandum 41, January 4, 1960, 8 pp.

[77] Woodruff, C. M., McIntosh, J. L., Mikulcik, J. D., and Sinha, H., How Potassium Caused Boron Deficiency in Soybeans: Better Crops With Plant Food, vol. 44, No. 4, July–August 1960, pp. 4–8, 11; Contribution from Dept. of Soils, Missouri Agricultural Experiment Station, Jour. Series No. 2031.

[78] Shestakov, A. G., Nelyubova, G. L., and Pryanishnikova, Z. D. [The Effect of Boron on the Development of the Reproductive Organs of Plants]: Translation of Monograph, Trudy Vsesoyuznogo Soveshchaniya po Mikroelementam, 1956, pp. 155–166; Tech. Trans., Off. Tech. Services, U.S. Department of Commerce, vol. 3, No. 12, June 24, 1960, p. 761.

[79] Malenev, F. A. [Effect of Boron, Copper, Manganese, and Zinc on the Resistance of Potatoes to Phytophthora and Other Diseases]: Translation of Monograph, Trudy Vsesoyuznogo Soveshchaniya po Mikroelementam, 1956, pp. 429–436; Tech. Trans., Off. Tech. Services, U.S. Department of Commerce, vol. 3, No. 12, June 24, 1960, p. 760.

[80] Parshikov, B. M. [The Effect of Boron on the Development and Productivity of Hops]: Translation of Akad. Nauk, Kiev, U.S.S.R., Dapovidi, 1957, No. 6, pp. 602–604; Tech. Trans., Off. Tech. Services, U.S. Department of Commerce, vol. 4, No. 1, July 13, 1960, p. 2.

[81] Chemical Engineering, Fuel Cells Outgrowing Novelty Phase: Vol. 67, No. 10, May 16, 1960, p. 76.

[82] Pearson, R. K., Lewis, L. L., and Edwards, L. J., Reaction of Potassium Borohydride With Boron Trifluoride: Callery Chemical Co., Rept. on Project Zip, Dec. 4, 1957, 7 pp.

[83] Maginnity, P. M., Structures and Molecular Models of Boron Hydrides: Callery Chemical Co., Pittsburgh, Pa., Rept. on Project Zip, Mar. 1, 1958, 29 pp.

[84] Chemical and Engineering News, Large Inverse Isotope Effect Found: Vol. 38, No. 38, Sept. 19, 1960, pp. 53–54.

helped in studying secondary isotope effects and gave a better understanding of the reaction between a proton and a hydride ion.

Sodium borohydride was prepared by reacting 4 moles of solid sodium hydride with 1 mole of gaseous boron trifluoride.[85] The hydride was agitated in the presence of boron trifluoride and in the absence of moisture, air, and liquid solvents at 150° to 400° C.

Information on the combustion of boron hydrides and some of their combustion properties was reviewed.[86] Fundamental chemical reactions and mechanisms were not thoroughly understood.

A patent was granted for manufacturing sodium borohydride by agitating together sodium hydride and anhydrous boric oxide at about 300° to 400° C. in the absence of air and moisture.[87]

Up to 100 pounds per day of diborane was produced in a pilot plant by reacting potassium borohydride with boron trifluoride in diethylene glycol dimethyl ether (diglyme) to yield potassium fluoroborate and diborane.[88] About 60 gallons of diglyme was metered into a 100-gallon jacketed steel vessel. A charge of 80 to 135 pounds of potassium borohydride was dumped into a nitrogen-blanketed hopper and from the hopper into the reactor. Additional diglyme was added to the reactor and the contents were circulated through a heat exchanger. Then 40 to 50 pounds per hour of boron trifluoride was added until the evolution of diborane began. The rate of boron trifluoride additions was reduced to about 20 pounds per hour after the evolution of diborane. The reaction was completed in 6 to 8 hours. The diborane gas was freed of solvent and condensed before storing. Waste was filtered from the solvent, which was stored for use again.

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[85] Hansley, V. L., and Pryde, E. H. (assigned to E. I. duPont de Nemours & Co., Wilmington, Del.), Preparation of Sodium Borohydride: U.S. Patent 2,934,401, Apr. 26, 1960.

[86] Berl, W. G., and Renick, W., The Combustion of Boron Hydrides: Applied Physics Lab., Johns Hopkins University, Silver Spring, Md., July 1958, 60 pp.; U.S. Govt. Res. Repts., Off. Tech. Services, U.S. Department of Commerce, vol. 33, No. 1, Jan. 15, 1960, p. 29.

[87] Pryde, Everett H. (assigned to E. I. duPont de Nemours & Co., Inc., Wilmington, Del.), Preparation of Sodium Borohydride: U.S. Patent 2,926,989, Mar. 1, 1960.

[88] Chemical Engineering Progress, Small Quantity Diborane Production: Vol. 56, No. 2, February 1960, pp. 118, 120, 122.

Bromine

By Henry E. Stipp [1] and Victoria M. Roman [2]

ALTHOUGH domestic sales of bromine and bromine compounds decreased, exports increased. Consumption of bromine increased in many countries throughout the world, leading to general shortages, particularly in Europe.

DOMESTIC PRODUCTION

The 10-percent drop in sales of bromine and bromine compounds was attributed chiefly to the decline in domestic business activity. However, several other factors have been responsible for a general decline in the bromine growth rate.[3] These factors included lower demand for antiknock additive because more gasoline was made by catalytic re-forming, decreased demand for aviation gasoline due to an increasing use of jet-powered aircraft, and the use of smaller automobiles which require lower octane gasoline and consume less gasoline per mile. U.S. gasoline production totaled 1,528 million barrels in 1960, compared with 1,489 million barrels in 1959.

TABLE 1.—Sales of bromine and bromine compounds (bromine content) by primary producers in the United States

(Thousand pounds and thousand dollars)

Year	Quantity	Value	Year	Quantity	Value
1951–55 (average)	164,352	$34,672	1958	176,397	$46,689
1956	196,730	47,434	1959	195,483	51,508
1957	191,971	48,038	1960	175,010	44,637

Ethyl Dow Chemical Co. recovered bromine from sea water at Freeport, Tex., and Westvaco Chemical Division of Food Machinery and Chemical Corp. extracted bromine from sea-water bittern at Newark, Calif. Plants of The Dow Chemical Co. at Midland and Ludington, Great Lakes Chemical Corp. at East Lake and St. Louis, and Morton Chemical Co. at Manistee recovered bromine from well brines in Michigan. Westvaco Chemical recovered bromine from well brines at South Charleston, W. Va. Michigan Chemical Corp.

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.
[3] Oil, Paint and Drug Reporter, Bromine Use in 1965 to Pass 200 Million Pounds Provided Ethylene Dibromide Hangs On: Vol. 177, No. 15, Apr. 4, 1960, pp. 1, 32, 35.

TABLE 2.—Bromine and bromine compounds sold by primary producers in the United States

(Thousand pounds and thousand dollars)

	Gross weight	Bromine content[1]	Value
1959:			
Elemental bromine	12,537	12,537	$2,785
Bromine compounds[2]	218,901	182,946	48,723
Total	231,438	195,483	51,508
1960:			
Elemental bromine	18,878	18,878	3,892
Methyl bromide	10,247	8,625	4,141
Other bromine compounds[2]	177,823	147,507	36,604
Total	206,948	175,010	44,637

[1] Calculated as theoretical bromine content present in compound.
[2] Includes ethylene dibromide, sodium bromide, ammonium bromide, potassium bromide, ethyl bromide, and other bromine compounds.

recovered bromine from oil-well brines at El Dorado, Ark. American Potash & Chemical Corp. extracted bromine from the brine of Searles Lake at Trona, Calif.

Great Lakes Chemical Corp. and Houston Chemical Corp. formed a new company, Arkansas Chemicals, Inc., to extract bromine from well brines in a plant to be constructed near El Dorado, Ark. At the Filer City, Mich., plant of Great Lakes Chemical Corp., the bromine productive capacity was increased 70 percent and methyl bromide productive capacity was increased 40 percent.

Michigan Chemical Corp. acquired the anhydrous hydrogen bromide producing facilities of Food Machinery and Chemical Corp. at South Charleston, W. Va. The plant was moved to St. Louis, Mich. Expansion of the Michigan Chemical Corp. bromine plant at El Dorado, Ark., was completed in 1960.

CONSUMPTION AND USES

Ethylene dibromide, sodium bromide, ammonium bromide, potassium bromide, ethyl bromide, and other bromine compounds composed 84 percent of the total bromine and bromine compounds sold in 1960. Ethylene dibromide, used chiefly as an additive to tetraethyl lead antiknock fluid, accounted for the largest part of sales in this category. Ethylene dibromide was used in fumigating mixtures for treating soil and seeds. Some was used as a solvent for celluloid, resins, gums, and waxes and as an anesthetic, sedative, and antispasmodic agent. Methyl bromide (5 percent of consumption) and 1,2-dibromo-3-chloropropane were also used for this purpose. The use of tetramethyl lead in gasoline antiknock fluid could increase future consumption of ethylene dibromide.[4]

Elemental bromine in 1960 constituted 11 percent of all sales of bromine and compounds and was used chiefly for preparing ethylene dibromide. Other uses included chemical synthesis, water purifi-

[4] Chemical Engineering, Tetramethyl Lead Goes Commercial: Vol. 67, No. 10, May 16, 1960, pp. 69, 71.

cation, laboratory reagent, bleaching and disinfecting agent, brominating dyes, and lachrymators. The increase in sales of elemental bromine was attributed principally to its use in swimming-pool sanitation and chemical synthesis. The use of elemental bromine should be facilitated by the introduction of vermiculite packaging.[5]

Potassium bromide was the chief inorganic bromine compound consumed in 1959; however, significant quantities of sodium and ammonium bromide were also used. Important uses for these alkali bromides include preparation of pharmaceutical sedatives and photographic plates, films, and emulsions. Sodium and potassium bromates were used as oxidizing agents in laboratory reactions. Potassium bromate was also used as an additive to improve the quality of flour.

Bromine compounds such as monobromotrifluoromethane and bromodichloromethane were used as fire-extinguishing fluids. Chlorobromotrifluoroethane was used as a nonflammable anaesthetic.

New bromine compounds reported in use in 1960 were: Dimethyl 1, 2-dibromo-2, 2-dichloroethyl phosphate as an insecticide and a 1-to-3 mixture of 5, 4′-dibromosalicylanilide and 3, 5, 4′-tribromosalicylanilide as a bacteriostat for soaps, cosmetics, and pharmaceuticals. Tetrabromoethane was used as a dense medium in processing ores or separating solid materials.

Two epoxy resins that contained bromine as a fire retardant were marketed.[6] Loss in physical properties from introduction of bromine into the resins was negligible. Potential uses for the resins were: Aircraft laminates, electrical circuit boards, potted electrical circuits, encapsulated motors, filled castings, adhesives for aircraft and missiles, and coatings and laminates in curtain-wall construction.

Four n-alkyl compounds, cetyl bromide, hexyl bromide, myristyl bromide, and stearyl bromide, were offered in semicommercial quantities for use as germicide or algicide additives to quaternary derivatives.

Other uses were reported for bromine compounds as catalysts, dehumidifying agents, atomic energy shields and viewing solutions, hydraulic liquids, flotation media for mineral recovery, lithographic chemicals, additives to rubber, and effervescent mineral waters.

PRICES

The following prices were quoted by the Oil, Paint and Drug Reporter:

	Cents per pound
Bromine, purified, cases, carlots, ton lots, delivered east of Rocky Mountains	32
Cases, less than carlots, same basis	34–39
Drums, carlots, ton lots, delivered east of Rocky Mountains	31
Drums, less than carlots, same basis	31–34
Tanks, carlots, same basis	21½
Ammonium bromide, N.F. granular, drums, carlots, freight equalized	44
Drums, less than carlots, same basis	46

[5] Chemistry and Industry (London), Vermiculite Packaging Reduces Bromine Hazards: No. 12, Mar. 19, 1960, p. 310.
[6] Chemical and Engineering News, Two Self-Extinguishing Epoxies Hit Market: Vol. 38, No. 49, Dec. 5, 1960, pp. 58–59.

	Cents per pound
Bromochloromethane, drums, carlots, freight equalized	48
Drums, less than carlots, same basis	50
Tanks, same basis	47
Ethylene dibromide, drums, carlots, freight equalized	30½
Drums, less than carlots, freight equalized	31½
Tanks, freight equalized	28½
Potassium bromide, U.S.P., granular, barrels, kegs	39–40
Potassium bromate, drums, 1,000-pound lots, works, January through October	50
Oct. 3 through Oct. 9	53½
Oct. 10 through December, 200-pound drums, carlots, freight allowed	49
Sodium bromide, U.S.P., granular, barrels, drums, works	40

FOREIGN TRADE [7]

U.S. exports of bromine, bromides, and bromates increased to 10.2 million pounds valued at $2.9 million, compared with 9.2 million pounds valued at $2.6 million in 1959. Exports almost equaled the record of 10.5 million pounds established in 1957. The largest exports in 1960 again went to Canada and Brazil; 48 other countries received smaller shipments. Canada consumed bromine in producing ethylene dibromide for use in antiknock fluid, and Brazil used it chiefly in fumigants for control of the Sauba ant. Although exports to most countries increased, shipments to several European countries increased more than the average. The increase in number of countries reporting in 1960 accounted for a negligible part of the increase in exports.

Imports of bromine and bromine compounds totaled 121,943 pounds valued at $102,015, compared with 12,253 pounds valued at $28,694 in 1959. Sodium bromide imports totaled 225,220 pounds valued at $89,299, compared with 24,000 pounds valued at $9,400 in 1959.

WORLD REVIEW

France.—Bromine production in 1959 totaled 1,885 short tons valued at US$525,800.[8]

Germany, West.—Output of bromine and bromine compounds totaled 1,852 short tons valued at US$915,000.[9]

Israel.—Production of bromine and bromine compounds in 1959 by Dead Sea Works, Ltd., the only producer, totaled 2,183 short tons valued at about US$945,000, compared with 1,572 tons valued at US$667,000 in 1958. Owing to plant expansion, production was expected to increase to about 3,300 tons in 1960, 4,400 to 5,000 tons in 1961, and eventually to 11,000 tons. Exports of bromine and bromine compounds, chiefly to England and Italy, totaled 1,764 tons.[10]

Japan.—Elemental bromine production in 1959 totaled 1,736 short tons. Output of 356 tons of potassium bromide was reported.[11]

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[7] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

[8] U.S. Embassy, Paris, France, State Department Dispatch 86, July 21, 1960, encl. 1, p. 1.

[9] U.S. Embassy, Düsseldorf, West Germany, State Department Dispatch 316, Feb. 19, 1960, p. 1.

[10] Bureau of Mines, Mineral Trade Notes: Vol. 51, No. 3, September 1960, p. 11.

[11] U.S. Embassy, Tokyo, Japan, State Department Dispatch 1353, May 11, 1960, encl. 1, p. 2.

Mexico.—Petroleos Mexicanos planned to produce bromine, ethylene dibromide, and numerous other chemical products.[12]

TECHNOLOGY

Completely dry bromine was found to be harmless to many nonferrous metals.[13] Chemical lead, ounce metal (85 percent copper, 5 percent zinc, 5 percent lead, and 5 percent tin), muntz metal, monel, and nickel were considered satisfactory for bromine liquid or vapor exposure. Aluminum was highly reactive with wet or dry bromine. The water content of dry bromine was maintained at 20 to 30 parts per million. Moist atmospheres were avoided, as bromine had an affinity for moisture and became saturated at 300 to 400 parts per million water.

A process was patented for manufacturing 1,1,1-trifluoro-2-bromo-2-chloroethane.[14]

A patent was granted for the preparation of bromochlorofluoroethanes.[15]

Carbon compounds were removed from bromine by bubbling oxygen through a mixture of bromine and sulfuric acid at 30° C.[16] When heated to 1,000° C. only bromine and oxygen vapor formed a residue free of carbon compounds. Bromine was frozen out of the residue, melted, and mixed with sulfuric acid to remove water.

Oxyhalide-free lithium bromide was formed when lithium hydroxide was reacted with bromine from 150° C. to below the melting point of the reaction mixture.[17]

Arsenic tribromide in an ethyl bromide solution of aluminum bromide conducted an electric current.[18] The specific conductivity decreased as the arsenic tribromide concentration was increased or as the solution was diluted. At an electrolytic decomposition potential of 0.69 volt, arsenic formed at the cathode and bromine at the anode.

The effect of bromine on the crystallization temperature, electrical conductivity, thermoelectromotive force, thermal conductivity, chemical processes near the electrodes, and optical properties of selenium was studied.[19] The crystallization temperature of selenium was lowered by admixture of 0.016 to 0.130 percent bromine. Selenium began

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[12] U.S. Embassy, Mexico City, Mexico, State Department Dispatch 1494, June 15, 1960, p. 5.

[13] Chemical Engineering, Moisture: Key to Bromine Corrosion: Vol. 67, No. 22, Oct. 31, 1960, pp. 136, 138.

[14] Suckling, Charles Walter, and Raventos, James (assigned to Imperial Chemical Industries, Ltd., London), Process for the Preparation of 1,1,1-Trifluoro-2-Bromo-2-Chloroethane: U.S. Patent 2,921,098, Jan. 12, 1960.

[15] Chapman, James, and McGinty, Robert Leslie (assigned to Imperial Chemical Industries, Ltd., London), Process for the Preparation of Bromochlorofluoroethanes: U.S. Patent 2,921,099, Jan. 12, 1960.

[16] Codell, Maurice, and Norwitz, George (assigned to the United States of America as represented by the Secretary of the Army), Purification of Bromine: U.S. Patent 2,929,686, Mar. 22, 1960.

[17] Verdieck, R. G., and Bravo, J. B. (assigned to Foote Mineral Co., Berwyn, Pa.), Manufacture of Anhydrous Lithium Halide by Direct Halogenation of Lithium Hydroxide: U.S. Patent 2,968,526, Jan. 17, 1961.

[18] Plotnikov, V. A., and Yokubson, S. I., [An Electrochemical Investigation of the System $AlBr_3$–$AsBr_3$ in Ethyl Bromide]: Trans. Zhurnai Obshchey Khimii (USSR), vol. 6, No. 11, 1936, pp. 1694–1697: Department of Commerce, Office of Technical Services: Tech. Trans., vol. 2, No. 11, Dec. 4, 1959, p. 768.

[19] Bashshaliyev, A. A., [Effect of Admixtures of Bromine on Some Physical Properties of Selenium]: Trudy Inst. Fiz. i Mat. Akad. Nauk Azerb. (U.S.S.R.), vol. 9, 1958, pp. 42–59, (Abstract resulting from the SOV/STEP Program under the sponsorship of the U.S. Air Force): Department of Commerce, Office of Technical Services: Tech. Trans., vol. 4, No. 5, Sept. 14, 1960, p. 295.

to crystallize at 80° C. At 190° C. and above, the degree of crystallization was independent of bromine admixtures. Bromine increased the electrical conductivity, the thermoelectromotive force, and (at room temperature) the effective mobility of the charge carriers. The absolute values of thermal conductivity for samples of crystalline selenium with 0.25 to 0.5 percent and 0.008 to 0.130 percent bromine were two and three times greater, respectively, than for amorphous selenium. The interaction of water and selenium containing admixtures of bromine formed selenious acid (H_2SeO_3) and hydrogen bromide. Studies of absorption, transmission, and reflection of thin films of selenium with bromine showed that admixtures of bromine caused local impurity levels in the selenium lattice.

Hall mobility measurements were made on electronic holes in silver bromide in a bromine atmosphere at room temperature to 150° C.[20] The mobility ranged from 2.0±0.5 square centimeters per volt-second at 27° C. 0.5±0.15 square centimeter per volt-second at 150° C. Hole mobility was about 30 times smaller than the electron mobility at 27° C. The temperature dependence of the hole mobility was T^{-4}. Silver bromide thermoelectric power was also measured in a bromine atmosphere.

A method of shrinkproofing wool with potassium bromate in concentrated sodium chloride solution was described.[21] The process was reported to have possible industrial value. Treatment of wool resulted in minor losses in bursting strength, decreased resistance to abrasion, the same or slightly lowered "washfastness" of cloth dyed with adequate fastness dyes, insufficient yellowing during soap washing to affect color, and relatively good handling quality.

Compounding of blends of butyl and brominated butyl rubber was studied.[22] Use of approximately 25 percent brominated butyl gave best metal-oxide cure results. Retarded cure and poorer physical properties were obtained with smaller quantities of brominated butyl.

A compilation of radiochemical information and procedures on bromide and other halogen elements was published by the National Academy of Sciences—National Research Council.[23] The publication will be useful to radio chemists and other persons who use radiochemical elements.

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[20] Hanson, Roland Clements, Hall Mobility of Holes in Silver Bromide: Tech. Note No. 4 on Contract AF 49(638)579, June 1960, 78 pp. AFOSR TN-60-795, AD-240108; U.S. Govt. Res. Repts. Off. Tech. Services, U.S. Dept. of Commerce, Solid States Physics: Vol. 34, No. 6, Dec. 16, 1960, p. 783.

[21] McPhee, J. R., Shrinkproofing of Wool With Neutral Permanganate or Acid Bromate in Concentrated Sodium Chloride Solution: Textile Research Jour., vol. 30, May 1960, pp. 358-365.

[22] Bluestein, A. C., and Grossman, R. F., Effects of Brominated Butyl in Butyl Rubber Compounds: Rubber World, vol. 142, No. 1, April 1960, pp. 98-102.

[23] Kleinberg, Jacob, and Cowan, G. A., The Radiochemistry of Fluorine, Chlorine, Bromine, and Iodine: Univ. of California, Los Alamos Sci. Lab., Los Alamos, N. Mex., January 1960; Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C.

Cadmium

By John E. Shelton [1] and Esther B. Miller [2]

HIGHER EXPORTS, coupled with lower imports in 1960, reduced stocks of cadmium metal in the United States to less than 2 million pounds. Exports to Japan, the first since World War II, were 350,000 pounds. Apparent consumption of cadmium metal was 10.2 million pounds. Nickel-cadmium storage batteries were used in the solar and meteorological satellites of U.S. space projects.

TABLE 1.—Salient cadmium statistics

(Thousand pounds of contained cadmium)

	1951–55 (average)	1956	1957	1958	1959	1960
United States:						
Production [1]	9,166	10,614	10,549	9,673	8,602	10,180
Imports for consumption, metal	891	3,116	1,586	1,002	1,638	942
Exports	714	1,284	693	580	900	2,448
Consumption, apparent	(2)	12,711	10,999	8,177	[3] 11,471	10,166
Price: Average per pound	$2.05	$1.70	$1.70	$1.52	$1.35	$1.52
World: Production	15,400	[3] 20,000	[3] 20,800	[3] 19,800	[3] 19,800	21,700

[1] Primary and secondary cadmium metal.
[2] Apparent consumption of primary and secondary metal not available before 1956.
[3] Revised figure.

LEGISLATION AND GOVERNMENT PROGRAMS

The General Services Administration rejected, as inadequate, all bids to purchase 4,413 short tons of cadmium-magnesium scrap from the national stockpile of strategic materials.

In January, the U.S. Department of Agriculture Commodity Credit Corporation (CCC) added cadmium to the list for barter of surplus perishable goods for foreign-produced metal. Cadmium was removed from barter in November. No contracts were negotiated in 1960.

DOMESTIC PRODUCTION

Combined production of primary and secondary cadmium metal increased 18 percent over 1959 to 10.2 million pounds—the first gain in production for 4 years.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

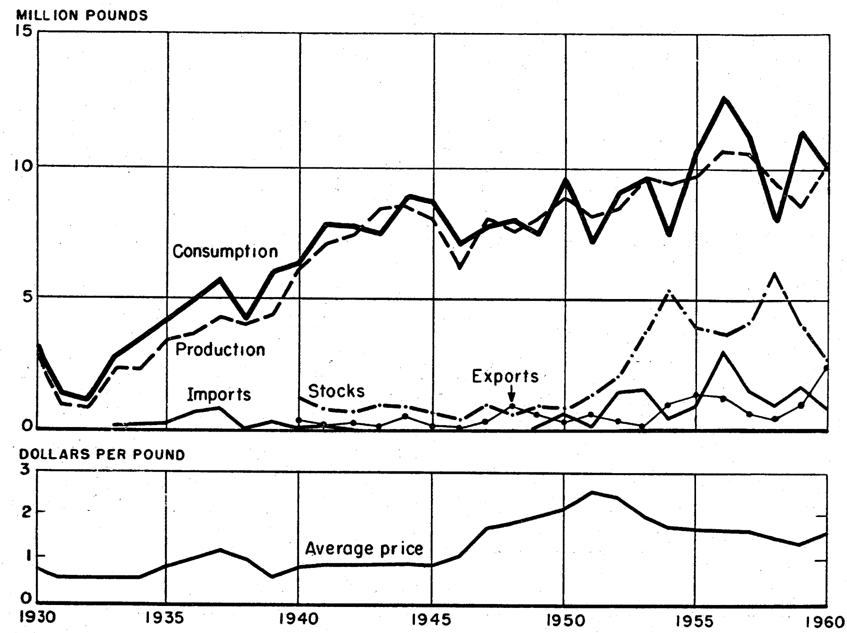

FIGURE 1.—Trends in production, consumption, yearend stocks, imports, exports, and average price of cadmium metal in United States, 1930–60.

Flue dust, primarily from Mexico, provided 18 percent of the total cadmium metal. An estimated 45 percent came from foreign zinc ores and concentrates and other base-metal concentrates. The remainder was from domestic zinc ore, except for a small amount of secondary production. The main foreign sources of zinc concentrate were Mexico, Canada, Peru, Spain, and Australia.

Secondary cadmium was recovered from scrap alloys and zinc sulfate solutions used in making lithopone.

Production of cadmium compounds, including cadmium sulfide, cadmium sulfoselenide, and cadmium lithopone, decreased 13 percent to 1.1 million pounds in 1960.

Figures on annual oxide output are withheld to avoid disclosing individual company data.

The Alton, Ill., plant of American Smelting and Refining Company, was closed early in 1960.

TABLE 2.—Primary and secondary cadmium metal produced and shipped in the United States

(Thousand pounds of contained cadmium)

	1951–55 (average)	1956	1957	1958	1959	1960
Production	9, 166	10, 614	10, 549	9, 673	8, 602	10, 180
Shipments by producers	8, 677	10, 936	10, 091	7, 921	11, 273	12, 151
Value	$16, 109	$16, 283	$14, 921	$10, 067	$12, 054	$14, 924

TABLE 3.—Cadmium sulfide[1] produced in the United States

(Thousand pounds)

Year	Gross weight	Cadmium content	Year	Gross weight	Cadmium content
1951-55 (average)	3,473	1,095	1958	2,884	983
1956	3,937	1,258	1959	3,701	1,243
1957	3,198	1,041	1960	3,484	1,084

[1] Includes cadmium lithopone and cadmium sulfoselenide.

The following plants produced cadmium metal in the United States in 1960:

Primary metallic cadmium:
- Colorado: Denver—American Smelting and Refining Company.
- Idaho: Kellogg—The Bunker Hill Co.
- Illinois:
  - Depue—The New Jersey Zinc Co.
  - East St. Louis—American Zinc Co. of Illinois.
- Kansas:
  - Coffeyville—Sherwin-Williams Co.
  - Galena—The Eagle-Picher Co.
- Missouri: Herculaneum—St. Joseph Lead Co.
- Montana: Great Falls—The Anaconda Company.
- Oklahoma:
  - Bartlesville—National Zinc Co., Inc.
  - Blackwell—Blackwell Zinc Co.
- Pennsylvania:
  - Josephtown—St. Joseph Lead Co.
  - Palmerton—The New Jersey Zinc Co.
- Texas: Corpus Christi—American Smelting and Refining Company.

Secondary metallic cadmium:
- Arkansas: Jonesboro—Arkansas Metals Co.
- New York: Whitestone, L.I.—Neo-Smelting & Refining, Inc.
- Illinois: Chicago—United Refining & Smelting Co.

Zinc- and lead-producing plants that did not produce refined cadmium but had facilities for collecting cadmium fume, dust, sponge, or residues are as follows:

- Arkansas:
  - Fort Smith—Athletic Mining and Smelting Co.
  - Fort Smith—The Residue Co.
- Colorado: Canon City—The New Jersey Zinc Co.
- Illinois:
  - La Salle—Matthiessen & Hegeler Zinc Co.
  - Monsanto—American Zinc Co. of Illinois.
- Texas:
  - Amarillo—American Smelting and Refining Company.
  - Dumas—American Zinc Co. of Illinois
- Utah: Tooele—International Smelting & Refining Co.

CONSUMPTION AND USES

The total new supply of cadmium metal in 1960 was 9 percent above the apparent consumption. The decline of 11 percent below 1959 in apparent consumption was due primarily to cutbacks in automobile, aircraft, and machine-parts production.

Cadmium was consumed in electroplating automobile engine parts, aircraft parts, radio and television parts, and nuts and bolts. Cadmium was also used in bearing and fusible alloys, dentistry, photography, paint pigments, dyeing, and nuclear energy reactors and as organo-cadmium compounds to provide heat and light stabilization in plastics.

STOCKS

Stocks of cadmium metal were 1.97 million pounds at the end of the year, or 43 percent below yearend 1959. Stocks of cadmium compounds increased 19 percent. Total stocks declined 33 percent to 2.7 million pounds.

The Government supplemental stockpile contained 6,331,616 pounds of cadmium metal at the end of 1960. Although there were no contracts for bartered cadmium, 177,000 pounds was delivered under previous contracts to the CCC stockpile.

TABLE 4.—Industry stocks, Dec. 31

(Thousand pounds of contained cadmium)

Stocks	1959 [1]			1960		
	Metallic cadmium	Cadmium compounds	Total cadmium	Metallic cadmium	Cadmium compounds	Total cadmium
Metal producers	3,105		3,105	1,579		1,579
Compound manufacturers	183	588	771	243	711	954
Distributors [2]	175	59	234	149	59	208
Total	3,463	647	4,110	1,971	770	2,741
Consumer	(3)	(3)	[4] 1,000	(3)	(3)	[4] 1,000

[1] Figures partly revised.
[2] Comprises principally 8 largest dealers and producers of plating salts; it was estimated that about 112,000 pounds of metal and 10,000 pounds of oxide were in the hands of dealers and distributors at the end of 1959. Comparable figures for 1960 were 99,000 pounds of metal and 8,000 pounds of oxide.
[3] Data not available.
[4] Estimate.

PRICES

The quoted price of cadmium metal increased January 7, 1960, from $1.40 to $1.50 a pound for sticks, bars, and shapes in lots under 1 ton and from $1.30 to $1.40 for lots over 1 ton. On September 28 the prices increased to $1.60 and $1.50, respectively. These prices were maintained for the remainder of the year. Principal factors in the price increase were the increase in exports and the resulting decline in stocks.

Cadmium in the London market was quoted at 10s. ($1.40 on the basis of $2.80 per pound sterling) until the price advanced in March to 10s. 6d. ($1.47). In November the price advanced to 11s. ($1.54). In Italy the price was 2,200 lire per kilogram or about $1.54 per pound on the basis of $0.00154 per lire. The price rose to 2,250 lire ($1.57) in April. In France the price rose from 14.25 francs a kilogram ($1.55 per pound on the basis of $0.24 per franc) to 15.75 francs (about $1.70 a pound) in April.

Cadmium-mercury lithopone, orange (deep-shade), increased to $1.65 a pound in barrel lots in February.

FOREIGN TRADE[3]

Imports.—General imports of cadmium and imports for consumption decreased 12 percent compared with imports in 1959. Mexico supplied over 99 percent of the 1.9 million pounds of cadmium contained in flue dust.

Exports.—Exports increased 172 percent in 1960 to 2.45 million pounds, the highest since 1944. The United Kingdom received the largest quantity, about 1.1 million pounds. Japan received cadmium for the first time since World War II, about 350,000 pounds.

Tariff.—The import duty on cadmium metal remained at 3.75 cents per pound in 1960—the rate effective January 1, 1948, as established at the Geneva Trade Conference of 1947. Cadmium contained in flue dust remained duty free.

TABLE 5.—U.S. imports of cadmium metal and flue dust, by countries

(Thousand pounds and thousand dollars)

Country	General imports[1]				Imports for consumption[2]			
	1959		1960		1959		1960	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Metallic cadmium:								
North America:								
Canada	839	$920	839	$1,033	839	$920	839	$1,033
Mexico	91	47	11	13	91	47	11	13
Total	930	967	850	1,046	930	967	850	1,046
South America: Peru	110	128	30	33	110	128	30	33
Europe:								
Belgium-Luxembourg	187	209	33	42	180	201	39	49
Germany, West	55	53			55	53		
Italy	16	16			16	16		
Netherlands	33	38			40	45		
Norway	22	24			22	24		
United Kingdom	(3)	(3)	(3)	1	(3)	(3)	(3)	1
Total	313	340	33	43	313	339	39	50
Asia: Japan	116	125			149	162		
Africa: Congo, Republic of the[4]	163	176	6	6	136	148	23	28
Total	1,632	1,736	919	1,128	1,638	1,744	942	1,157
Flue dust (Cd content):								
North America:								
Canada			18	25			9	11
Mexico	1,544	584	1,852	767	1,544	584	1,852	767
Total	1,544	584	1,870	792	1,544	584	1,861	778
Grand total	3,176	2,320	2,789	1,920	3,182	2,328	2,803	1,935

[1] Comprises cadmium imported for immediate consumption plus material entering bonded warehouses.
[2] Comprises cadmium imported for immediate consumption plus material withdrawn from bonded warehouses.
[3] Less than 1,000.
[4] Belgian Congo prior to July 1, 1960.

Source: Bureau of the Census.

[3] Figures on U.S. imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 6.—U.S. exports of cadmium metal, alloys, dross, flue dust, residues, and scrap

(Thousand pounds and thousand dollars)

Year	Quantity	Value	Year	Quantity	Value
1951–55 (average)	714	$1,329	1958	580	$771
1956	1,284	1,932	1959	900	1,024
1957	693	1,060	1960	2,448	3,014

Source: Bureau of the Census.

WORLD REVIEW

World production of cadmium metal increased about 10 percent, primarily because of the increase in U.S. output.

TABLE 7.—World production of cadmium, by countries [1] [2]

(Thousands of pounds)

Country	1951–55 (average)	1956	1957	1958	1959	1960
North America:						
Canada	1,280	2,339	2,368	1,756	2,160	2,245
Guatemala		107	84	52		123
Mexico (refined metal) [3]				42	114	[4] 132
United States (primary and secondary metal)	9,166	10,614	10,549	9,673	8,602	10,180
South America: Peru (refined metal) [3]	6	25	58	141	141	[4] 186
Europe:						
Austria		5	25	25	44	[4] 44
Belgium	[4] 1,155	[4] 1,488	[4] 1,323	[4] 1,488	[5] 1,512	[4] [5] 1,500
France	275	240	388	385	539	564
Germany, West	370	645	611	703	926	902
Italy	411	412	492	410	552	587
Netherlands [4]	[6] 28	36	77	88	88	88
Norway	203	278	244	240	284	244
Poland [4]	473	542	560	573	595	595
Spain	16	25	20	14	14	[4] 31
U.S.S.R. [4] [7]	406	700	900	975	1,005	1,035
United Kingdom [8]	341	251	228	278	310	236
Yugoslavia		18	57	[4] 55	[4] 55	[4] 55
Asia: Japan	491	886	873	964	1,082	[4] 1,180
Africa:						
Congo, Republic of the (formerly Belgian)	135	611	911	1,080	1,047	[4] 1,050
Rhodesia and Nyasaland, Federation of Northern Rhodesia		117	125	38		58
Oceania: Australia	629	618	880	791	763	662
World total (estimate) [1] [2]	15,400	20,000	20,800	19,800	19,800	21,700
Exports:						
Mexico [3]	1,935	1,892	1,673	1,655	1,151	[9] 1,852
Peru [3]	47	81	46	50	44	[4] 44
South-West Africa [3]	1,352	2,328	2,838	2,698	1,193	[4] 1,830

[1] Data derived in part from bulletins of the World Non-Ferrous Metal Statistics and annual issues of Metal Statistics (Metallgesellschaft).
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] In addition to metal refined within the country, cadmium is exported in zinc concentrates, flue dusts, etc., for treatment elsewhere and accounted for in country where smelted. To avoid duplicating figures, these export data are not included in the world total.
[4] Estimate.
[5] Exports.
[6] Average for 1954–55.
[7] Estimates based on an assumed average cadmium content of 0.1 percent in zinc concentrates.
[8] Includes secondary.
[9] U.S. imports.

Compiled by Augusta W. Jann, Division of Foreign Activities.

Japan.—Imports of cadmium metal from the United States were 350,000 pounds.

Mexico.—The production of cadmium contained in zinc concentrates, flue dust, etc., increased 61 percent, and output of refined metal increased 16 percent over 1959. Almost the entire output was exported to the United States.

United Kingdom.—Internal production was 200,000 pounds and imports were 3.1 million pounds, a total increase of 15 percent in supply over 1959. Consumption was 3.1 million pounds and was used for various purposes (in thousand pounds) as follows: Plating anodes, 1,411; plating salts, 315; cadmium-copper alloys, 101; other alloys, 92; alkaline batteries, 168; dry batteries, 11; solder, 178; colors, 769; and miscellaneous, 71.

TECHNOLOGY

Cadmium in lead smelter fumes was recovered by utilizing the chlorides in the ore to make the cadmium water soluble.[4]

Increased current densities and deposits of satisfactory quality were obtained by rotating the cathodes during electrodeposition of cadmium.[5]

Nickel-cadmium storage batteries were used in solar satellite Pioneer V, meteorological satellite Tiros I and Explorer VI. These batteries have a long cycle life and can be recharged with solar cells. Cordless electric shavers, rechargeable portable radios, and flashlight batteries using nickel-cadmium batteries were marketed.[6]

The reaction mechanism of the nickel-cadmium cell was studied.[7] Patents were issued for making sintered-type cadmium electrodes[8] and hermetically sealed nickel-cadmium storage batteries.[9]

Cadmium sulfide, selenide, and telluride showed potential uses as semiconductors.[10] Amplifying changes in the properties of cadmium sulfide by variation of light or X- and gamma-ray intensities can be utilized in radiation monitoring.[11] [12]

Photodielectric properties of polycrystalline cadmium selenide at high temperatures were determined.[13]

Papers on the luminescence of cadmium sulfide phosphors were abstracted.[14] The discussions covered emission intensity, X-ray diffraction studies, and preparation and purification of the phosphors.

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[4] Gibson, F. W., New Twist in Cadmium Production: Chem. Eng. Prog., vol. 56, June 1960, pp. 120–122.

[5] Khan, O. A., and Kabanova, L. M., Electrolysis of Cadmium with Increased Current Densities in Electrolyzers with Rotating Cathodes: Soviet Jour. Nonferrous Metals, January 1960, pp. 45–56.

[6] Wall Street Journal, vol. 155, Mar. 28, 1960, p. 1.

[7] Falk, S. Uno, Investigations on the Reaction Mechanism of the Nickel-Cadmium Cell: Jour. Electrochem. Soc., vol. 107, August 1960, pp. 661–667.

[8] Heuninckx, Alphonse M. (assigned to Union Carbide Corp., New York), Process for Making Sintered Type Cadmium Electrodes: U.S. Patent 2,952,570, Sept. 13, 1960.

[9] Mandel, Hyman J. (assigned to United States of America as represented by the Secretary of the Army), Hermetically Sealed Nickel Cadmium Storage Battery: U.S. Patent 2,941,022, June 14, 1960.

[10] Electronic News, vol. 5, May 23, 1960, pp. 4–6.

[11] Electronic News, Cadmium Sulfide Transistor Evolved at GM Laboratories: Vol. 5, Feb. 22, 1960, p. 31.

[12] Chemistry and Industry (London), Cadmium Sulfide Photocells as Radiation Monitors: No. 30, July 23, 1960, p. 969.

[13] Oksman, Y. A., and Burlakov, A. V., Photodielectric Properties of Polycrystalline Cadmium Selenide: 1. High Temperatures: Soviet Phys.—Solid State, vol. 2, February 1961, pp. 1700–1703.

[14] Journal of the Electrochemical Society, vol. 107, March 1960, pp. 60C–65C.

Thick, uniform cadmium coatings on steel and other metals were deposited by vacuum metalizing.[15] These coating can be applied on complex shapes and will eliminate hydrogen embrittlement of high-strength steels. A new brightener was developed that increased plating speed and thickness of the cadmium deposit without affecting brilliance.[16]

Polarographic determinations for zinc and cadmium in formamide solutions containing 90 to 94 percent cadmium were described.[17]

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[15] Clough, Phillip J., and Farrow, Howard M., Thick Vacuum Metalized Coatings Are Durable, Corrosion Resistant: Mat. Design Eng., vol. 52, September 1960, pp. 12–15.

[16] Materials in Design Engineering, vol. 51, June 1960, p. 218.

[17] Brown, Glenn H., and Hsiung, Hsiao-shu, Polarography in Formamide, Jour. Electrochem. Soc., vol. 107, January 1960, pp. 57–58.

Calcium and Calcium Compounds

By C. Meade Patterson [1]

RADIOACTIVE calcium isotopes were produced in larger quantities for medical and metallurgical investigations in 1960, and calcium was the only common element that could be used in soils to counteract the toxicity of strontium 90, which settles to the earth as fallout. Calcium remained an important reductant for extracting metals from refractory oxides and for separating rare-earth metals. More calcium chloride was used on highways for snow and ice removal than ever before.

DOMESTIC PRODUCTION

Calcium was produced by Nelco Metals, Inc., Canaan, Conn., and Union Carbide Metals Co., Niagara Falls, N.Y. Production of the radioactive isotope calcium 47 for nationwide distribution began at Oak Ridge National Laboratory, Oak Ridge, Tenn.[2] Argonne National Laboratory, Argonne, Ill., developed a new chemical process for separating calcium and strontium.[3] A costly metal fire started spontaneously on January 31 in part of the plant of Oregon Metallurgical Corp., Albany, Oreg., where calcium and vanadium oxide were blended to produce high-purity vanadium.

Shipments of natural and synthetic solid and flake calcium chloride (77–80 percent $CaCl_2$) in 1959 were 579,909 short tons, valued at $16 million. Brine (40–45 percent $CaCl_2$) shipments totaled 252,431 tons, valued at $2.3 million. Production of natural and synthetic solid and flake calcium chloride was 593,969 tons in 1959; and that of calcium chloride brine was 259,644 tons, excluding all brine that went into the production of solid and flake calcium chloride.[4]

Calcium chloride statistics[5] for 1958 were as follows: Solid and flake (77–80 percent $CaCl_2$)—528,882 short tons produced for all purposes, and 531,565 tons valued at $15.3 million shipped, including interplant transfers. Liquid (40–45 percent $CaCl_2$)—200,866 tons produced for all purposes (but excluding the liquid calcium chloride

[1] Commodity specialist, Division of Minerals.
[2] Chemical and Engineering News, Calcium-47: Vol. 38, No. 42, Oct. 17, 1960, p. 64. Chemical Week, Cancer Tracker: Vol. 87, No. 19, Nov. 5, 1960, p. 109.
[3] Chemistry, Fallout Measurements: Vol. 34, No. 2, October 1960, p. 14.
[4] U.S. Department of Commerce, Bureau of the Census, Industry Division, Inorganic Chemicals and Gases, 1959: Current Industrial Reports Series M28A–09, Sept. 1, 1960, p. 11.
[5] U.S. Department of Commerce, Bureau of the Census, 1958 Census of Manufactures: Ind. and Product Repts. MC(P)–28A–2 (subject to revision), May 1960, p. 6.

that was used to produce solid calcium chloride), and 204,359 tons valued at $2 million shipped, including interplant transfers.

Calcium chloride and calcium-magnesium chloride from natural brines in 1956–60 averaged 403,000 tons annually, valued at $7.3 million. Production came from three States: California, Michigan, and West Virginia. The brines of Bristol Dry Lake in San Bernardino County, Calif., have yielded calcium chloride since 1910.[6]

CONSUMPTION AND USES

Economic factors determined whether calcium or its substitute, magnesium, would be used to reduce uranium oxide to uranium. Calcium was utilized economically where relatively small quantities of uranium were produced, and magnesium was used as the reductant where large quantities of uranium were produced.[7] Uranium dioxide powder mixed with calcium hydride powder was compacted and heated. Decomposition of the calcium hydride yielded disseminated calcium, which reduced the uranium dioxide to uranium on continued heating at the sintering temperature.[8]

Very pure calcium was used in the presence of calcium chloride to obtain very pure thorium from thorium oxide.[9] Union Carbide Metals Co., Niagara Falls, N.Y., announced a new magnesium-calcium-silicon alloy that was used to flush out gases in high-alloy steel melted in an induction furnace. Rejection rate due to gas imperfections was reduced from 30 to 5 percent on a 35-percent nickel, 15-percent chromium casting.[10]

Calcium 47 was used for bone cancer studies in preference to calcium 45, because it has a shorter half life (4½ days) than calcium 45.[11]

Applying calcium to soil as lime and pulverized limestone was recommended to counteract the tendency of plants to absorb strontium 90 from radioactive fallout.[12] In New Zealand, the addition of 2 to 5 tons an acre of calcium compounds reduced strontium 90 absorption by acid soils 20 percent. It had no beneficial effect on neutral soils. However, crops grown on soils high in calcium absorbed about one-tenth as much strontium 90 as soils of low calcium content.[13]

Sticks of calcium hydride were dropped into oil wells to stimulate flow. The hydride reacted with water at the bottom of the well, and the rapidly generated hydrogen forced oil to flow out of the well head.[14]

The State highway departments of Illinois, Kansas, Maryland, Massachusetts, Michigan, New York, Ohio, Pennsylvania, Virginia,

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[6] Campbell, Ian, 56th Report of the State Mineralogist: Calif. Div. Mines, San Francisco, Calif., 1960, p. 94.

[7] Jackson, W. H., Calcium, 1959: Canada Dept. Mines and Tech. Surveys, Ind. Min. Div., Ottawa, Rev. 6, May 1960, 3 pp.

[8] Roake, William E. (assigned to the United States of America as represented by the Chairman of the Atomic Energy Commission), Sintering Metal Oxides: U.S. Patent 2,952,535, Sept. 13, 1960.

[9] Fuhrman, N., Holden, R. B., and Whitman, C. I., Production of Thorium Powder by Calcium Reduction of Thorium Oxide: Jour. Electrochem. Soc. (London), vol. 107, 1960, pp. 127–131.

[10] Iron Age, vol. 185, No. 19, May 12, 1960, p. 98.

[11] Works cited in footnote 2.

[12] O'Neil, Hugh, Leukemia and Strontium 90 Fallout: Pit and Quarry, vol. 53, No. 4, October 1960, p. 131.

[13] Fertiliser and Feeding Stuffs Journal (London), Radioactive Fall-out: Vol. 53, No. 5, Sept. 7, 1960, pp. 194–195.

[14] Chemical and Engineering News, More Ways to Unlock Oil and Gas Wells: Vol. 38, No. 16, Apr. 18, 1960, p. 97.

and Wisconsin applied calcium chloride-salt mixtures to keep highways bare. Ten more States either had adopted the routine use of calcium chloride-salt mixtures for snow and ice removal or were experimenting with them by the end of 1960: Connecticut, Indiana, Iowa, Maine, Minnesota, Missouri, New Hampshire, New Jersey, Vermont, and West Virginia. Use of calcium chloride to remove snow and ice was confined to States north of 37° latitude. The Ohio Turnpike had never been shut down by winter weather, partly because the Turnpike Commission spread a 1:2 calcium chloride-salt mixture to melt snow and ice in subfreezing temperatures. The Pennsylvania Turnpike and New York Thruway also established calcium chloride-salt mixture applications as routine winter maintenance. Each winter recently Michigan has used about 15,000 tons of calcium chloride. Pennsylvania ordered 21,255 tons of calcium chloride in 1960. Kansas Highway Commission successfully spread 1:4 calcium chloride-salt mixture at the rate of 400 pounds per mile to melt snow and ice in the Kansas City and Topeka areas during the winter of 1958–59, instead of the 2,500 pounds of sand and salt per mile formerly spread on icy roads. One dump truck could load enough chloride mixture to cover 25 miles of highway. In the winter of 1959–60, the Commission spread 1:4 calcium chloride-salt mixture on 5,000 miles of major routes and on other curves, hills, and bridge floors. The concentration of chlorides was low enough not to corrode automobile finishes, but washing of exposed automobiles once or twice a month was recommended.[15]

The value of calcium chloride as a dustlayer was first discovered on farm roads in 1910 by the U.S. Department of Agriculture. In the ensuing 50 years it became recognized as the most efficient low-cost dustlaying agent for unpaved roads. Alabama, Iowa, Kentucky, Michigan, Minnesota, New Hampshire, North Carolina, Pennsylvania, Virginia, and West Virginia have specified applications of calcium chloride to lay dust on roads.[16] Calcium chloride also reduced or eliminated dust during highway construction, reduced highway maintenance, and helped preserve the density and stability of highways by controlling moisture.[17]

PRICES AND SPECIFICATIONS

The New York price of calcium, 97–98 percent pure, cast in slabs and small pieces, in ton lots, was quoted at $2.05 a pound in 1960. Smaller quantities were quoted at the following prices per pound throughout the year: 100 pounds to 1 ton—$2.40, and small lots 99.9 percent pure—$4.55. Calcium turnings were quoted at $2.95 and $3.30; and distilled calcium was quoted at $3.75 and $4.55.[18] [19]

Nelco Metals, Inc., Canaan, Conn., quoted two grades of calcium per

[15] Calcium Chloride Institute News: Vol. 10, No. 1, 1960: Patriotic Snow Removal, p. 2; Kansas Adopts Chemical Mixtures, p. 3; Winter Maintenance on the Ohio Turnpike, p. 5. Vol. 10, No. 3, 1960: Chemical Mixture Now Routine Operation in Winter Maintenance, pp. 3–4. Vol. 10, No. 4, 1960: State Usage of Chemical Mixtures Shows Rapid Growth, p. 3; Ordered Early for Winter, p. 10.

[16] Calcium Chloride Institute News, Golden Anniversary for Calcium Chloride as Dustlayer: Vol. 10, No. 3, 1960, p. 9.

[17] Calcium Chloride Institute News, A Plan for Improving Secondary Roads: Vol. 10, No. 2, 1960, p. 3.

[18] E&MJ Metal and Mineral Markets, vol. 31, Nos. 1–52, Jan. 7–Dec. 29, 1960. American Metal Markets, vol. 67, Nos. 1–249, Jan. 1–Dec. 30, 1960.

[19] Iron Age, vol. 185, Nos. 1–26; vol. 186, Nos. 1–26, Jan. 7–Dec. 29, 1960.

pound, on a sliding scale, in nonreturnable containers for which there was no charge, f.o.b. Canaan, Conn. Commercial grade (over 99 percent calcium) was quoted as full crowns, \$2 to \$0.95; broken crowns 5 inches and smaller, \$2.10 to \$1.05; 6-mesh nodules, \$2.50 to \$1.15; turnings, \$3.00 to \$2.50; and ingots or waffles, \$2.80 to \$1.30. Redistilled grade (over 99.4 percent calcium) was quoted as broken crowns 8 inches and smaller, \$3.75 to \$1.50; 6-mesh nodules, \$4 to \$1.60; and ⅛-inch nodules, \$5 to \$2.50. Commercial-grade calcium was quoted in three quantity ranges at decreasing prices: Less than 100 pounds; 100 to 1,999 pounds; and 2,000 pounds and over. Redistilled-grade calcium was offered in four quantity ranges at decreasing prices: Less than 100 pounds; 100 to 1,999 pounds; 2,000 pounds to 5,999 pounds; and 6,000 pounds and over.

The following calcium chloride prices did not change in 1960: USP granular—\$0.32 per pound (drums); purified granular—\$0.27 per pound (drums); powdered, 77 percent minimum—\$37 per ton (paper bags, carlots, at works, freight equalized); solid, 73–75 percent—\$29.50 per ton (drums, carlots, at works, freight equalized); solid, 73–75 percent—\$36–\$73 (drums, less than carlots, at works, freight equalized); and liquor, 40 percent—\$12.50 per ton (tankcars, at works, freight equalized). Some calcium chloride prices were increased April 4 and remained at the higher levels during the rest of the year. These were: Flake or pellet, 77–80 percent—from \$31 per ton (paper bags, carlots, at works, freight equalized) to \$32 per ton, and concentrated flake or pellet, 94–97 percent—from \$37.80 per ton (paper bags, carlots, at works, freight equalized) to \$39.30 per ton.[20]

In the first quarter of 1960, Columbia-Southern Chemical Corp., Pittsburgh, Pa., increased calcium chloride prices \$2 a ton on concentrated (Hi-Test) flake (94–97 percent $CaCl_2$), in bulk, to \$32.50 a ton and on regular flake (77–80 percent $CaCl_2$), in bulk, \$1 a ton to \$26. Powdered calcium chloride (77 percent $CaCl_2$ minimum) in 100-pound bags rose to \$38 a ton.[21]

FOREIGN TRADE[22]

Imports.—Calcium was imported only from Canada. The U.S. duty was 17½ percent ad valorem. Imports of calcium-silicon alloy came from France, 96 percent; Canada, 3 percent; and the United Kingdom, 1 percent. Calcium chloride was imported from Belgium-Luxembourg, 41 percent; West Germany, 35 percent; the United Kingdom, 21 percent; and Canada, 3 percent.

Exports.—Calcium chloride was exported mainly to Canada, 84 percent; Mexico, 7 percent; Cuba and Uruguay, 2 percent each; and the Republic of Korea, 1 percent. The remaining 4 percent of the exported calcium chloride was distributed among 31 other countries in South America, North America, Asia, Europe, Africa, and Oceania, in descending order.

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[20] Oil, Paint and Drug Reporter, vol. 177, Nos. 1–27; vol. 178, Nos. 1–27; Jan. 4–Dec. 26, 1960.

[21] Chemical Week, vol. 86, No. 10, Mar. 5, 1960, p. 84.
Farm Chemicals, Columbia-Southern Increases Prices: Vol. 123, April 1960, p. 48.

[22] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 1.—U.S. imports for consumption of calcium, calcium-silicon, and calcium chloride and exports of calcium chloride

Year	Imports						Exports	
	Calcium		Calcium-silicon		Calcium chloride		Calcium chloride	
	Pounds	Value	Pounds	Value	Short tons	Value	Short tons	Value
1951-55 (average)	740,217	$796,654	173,450	$22,884	1,642	$55,413	16,226	$501,380
1956	8,387	10,109	194,869	32,191	1,855	59,635	32,523	1,056,958
1957	24,204	39,411	498,735	97,077	1,989	77,058	47,965	1,627,545
1958	15,694	24,084	130,866	25,111	1,234	45,977	37,632	1,325,460
1959	7,425	7,506	918,556	138,188	1,756	66,499	39,929	1,376,854
1960	12,618	15,276	352,765	50,899	1,570	61,938	26,792	1,067,909

Source: Bureau of the Census.

WORLD REVIEW

NORTH AMERICA

Canada.—Calcium production in 1959 was 71,610 pounds, valued at Can$82,197 (Can$1.15 a pound), according to a preliminary report. Output of calcium in 1958 (revised figures) was 25,227 pounds, valued at Can$31,256 (Can$1.24 a pound). Dominion Magnesium, Ltd., near Haley Station, Ontario, was the only Canadian producer and the largest producer in the world. Prices quoted throughout 1959 ranged from Can$0.90 a pound for ingots of Commercial grade (98 to 99 percent calcium) to Can$3.50 a pound for Chemical Standards grade (99.9 percent calcium), available only as granules between 4- and 80-mesh. The impurities in Commercial grade calcium were magnesium (0.5 to 1.5 percent), nitrogen (1 percent), and aluminum (0.35 percent). Canada had no tariff on calcium. Exports of calcium totaled 73,555 pounds in 1959. The United Kingdom received 49 percent; India, 19 percent; Belgium, 13 percent; United States, 10 percent; and West Germany, 9 percent. Consumption of calcium in Canada was small. Calcium was used by companies producing lead alloys for battery plates and oil filters. Dominion Magnesium, Ltd., used some captive calcium in the reduction of titanium.[23] Allied Chemical Canada, Ltd., produced calcium chloride.[24]

SOUTH AMERICA

Brazil.—There were seven calcium chloride producers in 1959. They accounted for a total output of 4,600 short tons.[25]

Uruguay.—Imports of calcium chloride came from Poland in 1959.[26]

EUROPE

United Kingdom.—Magnesium reduction of uranium oxide was substituted for calcium reduction at Springfield.[27] Calcium 45 was produced at the Atomic Energy Authority's Radiochemical Centre, Amersham.[28]

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[23] Work cited in footnote 7.

[24] Chemical Age (London), Aluminium Chloride Plant for Allied Chemical Canada, Ltd.: Vol. 83, No. 2123, Mar. 19, 1960, p. 495.

[25] U.S. Consulate, Sao Paulo, Brazil, State Department Dispatch 413, May 12, 1960, p. 3.

[26] U.S. Embassy, Montevideo, Uruguay, State Department Dispatch 907, Mar. 30, 1960, encl. 2, p. 6.

[27] Work cited in footnote 7.

[28] Chemical Trade Journal and Chemical Engineer (London), Radioisotopes and Labelled Compounds, New Production Facilities at Amersham: Vol. 146, No. 3807, May 20, 1960, pp. 1131–1132.

ASIA

India.—Calcium from Canada was used to reduce uranium oxide at Bombay.[29]

Korea.—Oriental Chemical Industry Co., Ltd., planned to produce 5,500 short tons of calcium chloride annually at Samchok; no other calcium chloride was being produced domestically.[30]

OCEANIA

Australia.—Calcium chloride was produced by salt plants at Osborne, South Australia.[31]

TECHNOLOGY

A method of separating calcium from a mixture of calcium and lower melting point contaminants was patented.[32] A column of the mixture was subjected to a decreasing temperature gradient. The highest temperature, between the melting point and boiling point of calcium, was at the top of the column; the lowest temperature, between the melting point of the contaminants and that of calcium, was in the lower part of the column. The difference in temperature caused calcium to rise and form a molten calcium layer at the top of the column. The calcium layer was then drawn off.

Calcium vapor was distilled from calcium silicate in a vacuum at 1,100° C., then condensed to metallic calcium.[33] Calcium was produced by the decomposition of Technical-grade calcium carbide in a vacuum induction furnace at the U.S.S.R. Central Scientific Research Institute of Ferrous Metallurgy. Heating calcium carbide at 1,720°–1,770° C. and 0.5–1 millimeters of mercury yielded calcium (94.8–98.2 percent pure) and graphite. Calcium yield was 80 percent.[34]

U.S. Public Health Service analyzed milk samples for calcium, strontium 90, and cesium 137 from 10 scattered milk stations. The radioactivity from fallout was well under the safety level established by the Federal Radiation Council, but 49 more milk-monitoring stations were added.[35] The Health Service also analyzed bones from 46 persons in the Western States and found 4.6 micromicrocuries of strontium 90 per gram of calcium. Maximum permissible concentration is 67 micromicrocuries per gram of calcium.[36]

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[29] Work cited in footnote 7.
[30] Chemical Week, Soda Ash Korea: Vol. 86, Jan. 2, 1960, p. 17.
[31] Chemical Age (London), Australia's Petrochemical Plants: Vol. 84, No. 2146, Aug. 27, 1960, p. 318.
[32] Cobel, George B. (assigned to The Dow Chemical Co., Midland, Mich.), Separation of Calcium Metal From Contaminants: U.S. Patent 2,960,397, Nov. 15, 1960.
[33] Tayts, A. Yu. [A Vacuum-Thermic Method of Producing Calcium From Calcium Silicate]: Byulleten Izobreteniy (U.S.S.R.), No. 22, 1959, p. 53.
[34] Mikulinskiy, A. S., and Maron, S. S., [Production of Calcium by the Decomposition of Calcium Carbide]: Zhurnal Prikladnoy Khimii (U.S.S.R.), vol. 33, No. 4, 1960, pp. 835–841.
[35] Science Newsletter, Milk Radioactivity Within Safety Levels: Vol. 78, No. 15, Oct. 8, 1960, p. 232.
[36] Chemical and Engineering News, vol. 38, No. 18, May 2, 1960, p. 47.

Cement

By D. O. Kennedy[1] and Ardell H. Lindquist[2]

SEVERE weather retarded construction in almost all sections of the United States during 1960. Accordingly, domestic production and shipments of portland cement decreased, but still were greater than in any other year except 1959. Shipments in August were only 2 percent below the record high of 37 million established in July 1959.

TABLE 1.—Salient cement statistics[1]

(Thousand barrels and thousand dollars)

	1951–55 (average)	1956	1957	1958	1959	1960
United States:						
Production	[2] 279,358	329,238	308,255	321,490	350,419	328,715
Capacity used at portland cement mills ... percent	90.3	90.7	78.2	77.3	80.5	73.5
Shipments from mills	[2] 277,741	321,396	299,189	317,263	346,675	321,646
Value[3]	[2] $757,973	$989,234	$961,499	$1,038,672	$1,144,867	$1,089,134
Average value ... per barrel	$2.73	$3.08	$3.21	$3.27	$3.30	$3.39
Stocks Dec. 31: At mills	17,498	22,412	28,748	[4] 30,664	[4] 31,437	35,480
Imports for consumption	1,492	4,456	4,427	3,390	5,265	4,098
Exports	2,462	1,981	1,331	641	277	187
Consumption, apparent	276,771	323,870	302,285	320,012	351,663	325,557
World: Production	1,057,150	[4] 1,380,866	[4] 1,447,897	[4] 1,540,119	[4] 1,724,403	1,859,415

[1] Barrel as used in this chapter, unless otherwise stated, refers to a 376-pound barrel.
[2] Portland cement, 1951–55; and masonry and natural cement, 1955 only.
[3] Value received f.o.b. mill, excluding cost of containers.
[4] Revised figure.

Decreased demand failed to discourage the cement industry, and production forecasts were made for 600 million barrels in 1970.[3] Plans were announced for the construction of five new plants and the expansion of nine existing plants, a total of over 20 million barrels annual capacity to be added.

Three classes of hydraulic cement were produced in the United States—portland, natural, and slag cements. In addition, prepared masonry cements were produced at many plants.

LEGISLATION AND GOVERNMENT PROGRAMS

For several years various interpretations were made of Section 613 of the Internal Revenue Act of 1954. A number of lawsuits resulted as the Treasury Department and mining companies took dif-

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[3] Rock Products, Will Expansion Bring Prosperity: Vol. 63, No. 5, May 1960, pp. 91–98, 204.

ferent views as to what treatment processes were considered to be mining operations for computing depletion allowances. In June, the Supreme Court ruled that only ordinary treatment processes normally applied by nonintegrated miners could be applied to the value of the raw fire clay in figuring its value for computing gross income from mining. Although many cement companies had not disagreed with the Treasury Department's interpretation, many tax returns had been made with depletion allowances based on the value of the finished cement. Most of the cement companies accepted the Supreme Court ruling in the fire-clay case as applying also to the cement industry and chose not to appeal the stricter tax ruling.

Public Law 86-564, June 30, 1960, "Public Debt and Tax Rate Extension Act of 1960," clearly defined treatment processes for the cement industry as including only those prior to the introduction of the kiln feed into the kiln for taxable years beginning after December 31, 1960.

PORTLAND CEMENT

PRODUCTION AND SHIPMENTS

Production of portland cement decreased 6 percent from the record high of 339 million barrels in 1959. Only 44 of 172 plants producing in 1959 had larger outputs in 1960. No section of the country escaped the ravages of bad weather, and apparent increases in three producing districts were caused by new plants in these districts replacing shipments from other districts. Five new plants reported production in 1960: Dundee Cement Co., Dundee, Mich.; Oklahoma Cement Co., Pryor, Okla.; Texas Industries Inc., Midlothian, Tex.; Hawaiian Cement Corp., Division of American Cement Corp., Oahu, Hawaii; and Permanente Cement Co., Oahu, Hawaii. In addition, new plants were under construction in California and Oklahoma.

Descriptions were published of equipment installed as part of expansion plans or in new cement plants in Clarkdale, Ariz.,[4] Long Beach, Calif.,[5] Dundee, Mich.,[6] Kansas City, Mo.,[7] Ada., Okla.,[8] Pryor, Okla.,[9] Houston, Tex.,[10] Odessa, Tex.,[11] Devil's Slide, Utah,[12] and Bellingham, Wash.[13]

Four cement companies merged with larger companies during the year: Marquette Cement Manufacturing Co. acquired the North Amer-

[4] Utley, H. F., Modern Phoenix Plant Near Clarkdale Supplying 3-Million-Bbl. Glen Canyon Dam Contract: Pit and Quarry, vol. 52, No. 8, February 1960, pp. 90–95.
[5] Pit and Quarry, Permanente Removes "Load" From Producing Mills by Versatile Bulk Loading From Centralized Plant: Vol. 52, No. 8, February 1960, pp. 116–117.
[6] Trauffer, W. E., Dundee—Big in Size and Concept: Pit and Quarry, vol. 53, No. 1, July 1960, pp. 116–125, 133, 136.
[7] Castellani, F., Underground Mining for Cement Rock: Explosive Eng., vol. 38, No. 1, January–February 1960, pp. 21–24.
[8] Herod, B. C., Cement Plant a Primer in Product Use: Pit and Quarry, vol. 53, No. 1, July 1960, pp. 150–158, 163, 173–174.
Meschter, E., One Man Controls Two Cement Plants: Rock Products, vol. 63, No. 3, March 1960, pp. 81–85.
[9] Meschter, E., Cement Capacity Booms in Oklahoma: Rock Products, vol. 63, No. 12, December 1960, pp. 78–83.
[10] Herod, B. C., An Industry Leader Spurs Production Technology: Pit and Quarry, vol. 52, No. 10, April 1960, pp. 118–121, 123–125.
[11] Meschter, E., Climate and Design Spur Cement Plant Construction: Rock Products, vol. 63, No. 8, August 1960, pp. 84–90.
[12] Intermountain Industry and Engineering, Ideal Cement Builds Nine New Silos in $2 Million Expansion: Vol. 62, No. 1, January 1960, pp. 16–17.
Intermountain Industry and Engineering, Ideal Initiates New Bulk Storage Facilities: Vol. 62, No. 10, October 1960, pp. 20, 22–23.
[13] Torgerson, R. S., Bottleneck Surgery Rejuvenates Cement Plant: Rock Products, vol. 63, No. 7, July 1960, pp. 96–98.

TABLE 2.—Finished portland cement produced, shipped, and in stock in the United States,[1] by districts

(Thousand barrels and thousand dollars)

District	Active plants		Production			Shipments from mills								Stocks at mills Dec. 31		
			Quantity		Change from 1959 (percent)	1959			1960					Quantity		Change from 1959 (percent)
						Quantity	Value		Quantity	Value		Change from 1959 (percent) in—				
	1959	1960	1959	1960			Total	Average per barrel		Total	Average per barrel	Barrels	Average value	1959	1960	
Eastern Pennsylvania, Maryland	21	21	38,335	35,290	−8	38,070	$132,279	$3.47	34,679	$118,131	$3.41	−9	−2	[2] 4,915	5,160	+5
New York, Maine	12	12	18,610	20,134	+8	18,666	63,205	3.39	19,301	64,394	3.34	+3	−2	[2] 2,096	2,765	+32
Ohio	11	11	18,028	16,850	−7	18,141	60,560	3.34	16,752	58,470	3.49	−8	+4	[2] 1,938	1,962	+1
Western Pennsylvania, West Virginia	6	6	11,700	10,960	−6	11,631	39,319	3.38	10,505	35,857	3.41	−10	+1	[2] 1,222	1,587	+30
Michigan	8	9	21,561	20,971	−3	21,682	72,198	3.33	21,187	73,082	3.45	−2	+4	[2] 2,911	2,695	−8
Illinois	4	4	9,560	9,270	−3	9,486	30,158	3.18	8,770	29,321	3.34	−8	+5	855	1,201	+40
Indiana, Kentucky, Wisconsin	7	7	20,430	19,723	−4	19,360	64,255	3.32	18,832	64,070	3.40	−3	+2	[2] 1,980	2,011	+2
Alabama	8	8	13,461	11,935	−11	12,998	39,672	3.05	11,355	36,142	3.18	−13	+4	[2] 968	1,145	+18
Tennessee	6	6	8,688	7,926	−9	8,381	26,191	3.12	7,517	24,688	3.28	−10	+5	[2] 581	712	+23
Virginia, South Carolina	4	4	8,282	7,311	−12	8,406	27,609	3.28	7,130	24,409	3.42	−15	+4	536	717	+34
Georgia, Florida	6	6	11,730	11,204	−4	11,723	38,902	3.32	11,110	37,417	3.37	−5	+2	815	867	+6
Louisiana, Mississippi	5	5	7,441	7,267	−2	7,247	22,622	3.12	7,201	23,925	3.32	−1	+6	[2] 699	716	+2
Iowa	5	5	13,147	12,527	−5	12,701	42,081	3.31	12,105	42,330	3.50	−5	+6	[2] 1,250	1,547	+24
Eastern Missouri, Minnesota, South Dakota	6	6	15,329	14,888	−3	15,442	51,028	3.30	14,047	47,969	3.41	−9	+3	[2] 1,455	2,222	+53
Kansas	6	6	10,177	7,996	−22	10,056	30,889	3.07	7,877	25,194	3.20	−22	+4	1,001	1,094	+9
Western Missouri, Nebraska, Oklahoma, Arkansas	7	8	14,369	13,239	−8	13,725	43,960	3.20	13,266	43,036	3.24	−3	+1	[2] 1,506	1,468	−3
Texas	15	16	27,111	23,190	−15	27,215	85,022	3.12	22,721	73,964	3.26	−17	+4	1,980	2,449	+24
Colorado, Arizona, Utah, New Mexico	8	7	11,025	11,908	+8	10,659	35,784	3.36	11,745	40,076	3.41	+10	+1	[2] 840	1,003	+19
Wyoming, Montana, Idaho	3	3	3,067	2,608	−15	3,017	10,648	3.53	2,607	9,503	3.64	−14	+3	310	311	------
Northern California	5	5	17,930	16,534	−8	18,063	58,873	3.26	16,170	52,979	3.28	−11	+1	895	1,258	+41
Southern California	8	8	25,705	23,358	−9	25,572	79,633	3.11	23,542	75,847	3.22	−8	+4	[2] 1,589	1,405	−12
Oregon, Washington	9	9	8,081	8,244	+2	7,819	27,374	3.50	8,319	29,325	3.52	+6	+1	[2] 1,031	953	−8
Hawaii	------	2	------	261	------	------	------	------	113	571	5.03	------	------	------	148	------
Puerto Rico	2	2	5,324	5,415	+2	5,392	16,982	3.15	5,441	14,546	[4] 2.67	+1	−15	[2] 92	66	−28
Total	172	176	339,091	319,009	−6	[3] 335,452	1,099,244	3.28	[3] 312,292	1,045,246	3.35	−7	+2	[2] 31,465	35,462	+13
Pennsylvania	23	23	41,208	37,170	−10	41,270	143,054	3.47	36,374	124,122	3.42	−12	−2	[2] 5,252	5,792	+10
Missouri	5	5	13,610	12,606	−7	13,583	45,430	3.34	11,856	40,915	3.45	−13	+3	1,176	1,852	+57

[1] Includes Puerto Rico.
[2] Revised figure.
[3] Does not include finished cement used in manufacturing prepared masonry cement, as follows: 1959, 2,898,000 barrels; 1960, 2,720,000 barrels.
[4] Not comparable with previous years due to change in method of reporting.

TABLE 3.—Production, shipments from mills, and stocks at mills of finished portland cement in the United States[1] in 1960, by months[2] and districts

(Thousand barrels)

	January	February	March	April	May	June	July	August	September	October	November	December
Production:												
Eastern Pennsylvania, Maryland	1,931	1,531	2,022	3,068	3,902	3,566	3,942	3,694	3,364	3,253	2,924	2,069
New York, Maine	1,472	1,158	1,256	1,575	2,010	2,003	1,907	2,038	1,834	1,808	1,629	1,432
Ohio	601	498	857	1,141	2,074	2,072	1,961	1,881	1,847	1,742	1,274	900
Western Pennsylvania, West Virginia	729	648	521	668	1,015	1,127	1,114	1,247	1,159	1,132	1,002	602
Michigan	497	483	654	1,575	[3] 2,488	2,507	2,748	2,590	2,547	[3] 2,244	1,944	804
Illinois	635	562	393	570	774	921	903	973	1,022	963	848	706
Indiana, Kentucky, Wisconsin	831	853	586	1,787	1,972	2,033	2,039	2,315	2,180	2,251	1,897	930
Alabama	755	740	832	1,090	1,085	1,123	1,111	1,159	1,018	1,097	1,048	857
Tennessee	445	312	434	766	810	827	767	863	675	743	715	568
Virginia, South Carolina	534	455	323	639	881	765	596	721	655	[3] 675	592	476
Georgia, Florida	1,014	924	968	1,009	1,023	1,026	957	893	795	899	918	779
Louisiana, Mississippi	419	432	427	630	670	766	748	770	678	656	579	494
Iowa	790	589	462	865	1,064	1,297	1,340	1,377	1,284	1,445	1,024	993
Eastern Missouri, Minnesota, South Dakota	998	698	725	1,151	1,515	1,373	1,604	1,745	[3] 1,601	1,642	1,086	749
Kansas	381	366	328	797	822	721	861	925	880	932	567	416
Western Missouri, Nebraska, Oklahoma, Arkansas	566	455	467	1,110	1,260	1,447	1,361	1,417	1,502	1,449	1,182	1,022
Texas	1,677	1,223	1,851	2,231	2,329	2,124	1,984	2,094	2,046	2,136	1,844	1,655
Colorado, Arizona, Utah, New Mexico	670	558	815	1.098	1,061	1,094	1,095	1,139	1,139	1,225	1,003	1,010
Wyoming, Montana, Idaho	81	80	85	256	289	303	322	303	274	258	220	139
Northern California	1,237	938	1,380	1,470	1,542	1,454	1,424	1,630	1,506	1,570	1,257	1,124
Southern California	1,738	1,634	2,013	2,215	2,165	2,135	1,931	2,186	1,903	2,013	1,715	1,729
Oregon, Washington	252	529	583	815	766	838	785	857	796	[3] 825	[3] 657	544
Hawaii	---	---	---	---	---	---	---	---	50	100	72	38
Puerto Rico	416	414	440	489	482	408	482	453	426	475	472	469
Total:												
1960	18,669	16,080	18,422	27,015	[3] 31,999	31,930	31,982	33,270	[3] 31,181	[3] 31,533	[3] 26,469	20,505
1959	18,604	16,710	24,337	29,093	33,428	33,455	34,180	34,800	32,590	31,127	26,100	24,111

Shipments:												
Eastern Pennsylvania, Maryland	1,551	1,691	1,669	3,340	3,535	4,054	3,606	3,990	3,138	3,651	[3] 3,162	1,293
New York, Maine	836	853	1,035	1,817	2,034	2,306	2,156	2,212	1,949	1,830	1,489	783
Ohio	387	475	514	1,416	1,801	2,195	2,084	2,082	2,009	1,959	1,378	453
Western Pennsylvania, West Virginia	360	401	395	879	1,005	1,308	1,254	1,402	1,213	1,093	847	348
Michigan	365	469	540	1,259	2,075	2,590	2,721	3,000	2,914	[3] 2,928	1,576	678
Illinois	163	254	304	651	733	1,013	988	1,312	1,219	1,184	649	302
Indiana, Kentucky, Wisconsin	532	629	736	1,567	1,759	2,149	2,242	2,567	2,193	2,238	1,490	729
Alabama	605	709	769	1,101	1,052	1,124	1,038	1,079	1,064	1,090	1,004	698
Tennessee	305	345	358	765	818	808	738	793	736	765	694	392
Virginia, South Carolina	390	408	391	732	764	769	652	735	684	634	597	374
Georgia, Florida	888	877	967	962	1,037	1,032	847	983	783	945	948	840
Louisiana, Mississippi	366	432	570	672	675	813	704	636	796	636	521	381
Iowa	155	222	274	815	1,063	1,467	1,578	1,869	1,801	1,764	753	318
Eastern Missouri, Minnesota, South Dakota	325	482	519	1,269	1,408	1,626	1,670	2,009	1,790	1,592	913	444
Kansas	188	246	303	754	721	813	852	1,045	1,013	961	653	327
Western Missouri, Nebraska, Oklahoma, Arkansas	309	392	600	1,253	1,245	1,448	1,444	1,610	[3] 1,661	1,453	1,251	599
Texas	1,358	1,449	2,119	2,152	2,267	2,093	1,869	2,106	2,147	1,845	1,948	1,367
Colorado, Arizona, Utah, New Mexico	489	620	911	1,058	1,073	1,165	1,070	1,293	1,249	1,151	972	694
Wyoming, Montana, Idaho	72	83	148	244	301	327	303	304	297	258	166	105
Northern California	801	850	1,342	1,345	1,410	1,577	1,535	1,752	1,625	1,624	1,216	1,093
Southern California	1,623	1,733	2,170	2,050	2,120	2,123	2,038	2,176	1,986	2,080	1,640	1,802
Oregon, Washington	300	506	612	774	774	839	811	948	917	[3] 786	[3] 582	471
Hawaii	-------	-------	-------	-------	-------	-------	-------	-------	-------	16	47	50
Puerto Rico	398	450	435	466	515	406	474	484	415	508	465	436
Total:												
1960	12,766	14,576	17,681	27,341	30,185	34,045	32,674	36,387	[3] 33,599	[3] 32,991	[3] 24,961	14,977
1959	14,416	14,785	23,027	30,135	32,992	36,082	37,046	36,836	35,098	32,282	22,025	20,328

See footnotes at end of table.

TABLE 3.—Production, shipments from mills, and stocks at mills of finished portland cement in the United States[1] in 1960, by months[2] and districts—Continued

	January	February	March	April	May	June	July	August	September	October	November	December
Stocks (end of month):												
Eastern Pennsylvania, Maryland	5,397	5,215	5,544	5,221	5,550	5,026	5,322	4,944	5,107	4,670	4,402	5,161
New York, Maine	2,687	2,987	3,203	2,954	2,914	2,592	2,335	2,185	2,032	1,996	2,118	2,763
Ohio	2,220	2,128	2,474	2,193	2.466	2,330	2,222	2,014	1,845	1,628	1,520	1,962
Western Pennsylvania, West Virginia	1,569	1,817	1,940	1.724	1,729	1.536	1,388	1,224	1,162	1,185	1,336	1,587
Michigan	2,453	2,466	2,591	[3] 2,916	3,368	3,395	3.523	3,230	2,887	2,203	2,569	2,696
Illinois	1,321	1,624	1,702	1,605	1,634	1,522	1,423	1,065	856	621	802	1,201
Indiana, Kentucky, Wisconsin	2,285	2,467	2,302	2,423	2,538	2,333	2,013	1,689	1,597	1,538	1,873	2,011
Alabama	1,126	1,136	1,175	1,124	1,116	1,070	1,076	1,108	1,023	998	1,006	1,145
Tennessee	824	783	845	813	769	754	754	696	598	549	549	712
Virginia, South Carolina	681	728	660	567	684	679	623	610	581	621	616	717
Georgia, Florida	935	983	980	1,023	1,003	994	1,098	1,002	1,010	963	928	867
Louisiana, Mississippi	746	744	597	546	540	489	530	661	536	548	606	716
Iowa	2,198	2,556	2,723	2,749	2,701	2,402	2,002	1,505	949	620	875	1,547
Eastern Missouri, Minnesota, South Dakota	2,120	2,330	2,528	2,407	2,508	2,247	2,174	1,906	1,688	1,768	1,921	2,222
Kansas	1,193	1,313	1,329	1,373	1,474	1,373	1,382	1,257	1,119	1,090	1,005	1,094
Western Missouri, Nebraska, Oklahoma, Arkansas	1,764	1,827	1,694	1,552	1,567	1,561	1,457	1,264	1,124	1,120	1,044	1,468
Texas	2,298	2,072	1,803	1,882	1,944	1,975	2,089	2,077	1,977	2,267	2,163	2,451
Colorado, Arizona, Utah, New Mexico	1,021	959	862	902	890	819	845	691	581	656	687	1,003
Wyoming, Montana, Idaho	319	316	253	265	253	229	247	245	223	223	276	311
Northern California	1,331	1,420	1,458	[3] 1,582	1,716	1,592	1,482	1,359	1,240	1,186	1,227	1,258
Southern California	1,703	1,605	1,448	1,613	1,658	1,670	1,563	1,573	1,491	1,424	1,499	1,426
Oregon, Washington	982	1,003	974	1,017	1,009	1,008	984	891	770	806	[3] 880	952
Hawaii	----	----	----	----	----	----	----	----	50	135	160	148
Puerto Rico	111	74	80	103	70	71	79	48	59	26	33	66
Total:												
1960	37,284	38,553	39,165	[3] 38,554	40,101	37,667	36,611	33,244	[3] 30,505	[3] 28,841	30,095	35,484
1959	34.838	36,680	37,711	36,378	36,527	33,605	30,415	28,102	25,308	23,913	27,794	31,328

[1] Includes Puerto Rico.
[2] Difference between monthly and annual reports not adjusted.
[3] Revised figure.

TABLE 4.—Portland cement produced and shipped in the United States,[1] by types
(Thousand barrels and thousand dollars)

Type and year	Active plants	Production, quantity	Shipments: Quantity	Shipments: Value: Total	Shipments: Value: Average per barrel
General-use and moderate-heat (types I and II):					
1951-55 (average)	156	233,580	232,268	$617,785	$2.66
1956	160	[2] 292,598	285,856	858,767	2.99
1957	163	[2] 275,968	268,855	844,962	3.14
1958	167	[2] 291,688	287,377	922,921	3.21
1959	171	[2] 316,600	312,970	1,012,836	3.24
1960	175	[2] 297,279	290,968	962,453	3.31
High-early-strength (type III):					
1951-55 (average)	100	9,066	8,940	27,589	3.09
1956	101	[3] 12,142	11,808	42,596	3.61
1957	111	[3] 12,853	11,867	43,325	3.65
1958	120	[3] 12,161	12,274	45,107	3.67
1959	129	[3] 14,439	14,363	53,484	3.72
1960	135	[3] 13,961	13,772	51,731	3.76
Low-heat (type IV):					
1951-55 (average)	2	286	257	823	3.21
1956	2	14	3	9	3.29
1957	2	21	5	16	3.23
1958	2	7	9	35	3.90
1959	3	10	10	46	4.44
1960	3	7	8	32	4.07
Sulfate-resisting (type V):					
1951-55 (average)	5	79	91	327	3.59
1956	6	93	79	312	3.95
1957	9	191	191	712	3.72
1958	9	244	205	767	3.75
1959	11	189	192	743	3.86
1960	14	445	435	1,664	3.83
Oil-well:					
1951-55 (average)	16	1,750	1,752	5,326	3.04
1956	16	[4] 1,655	1,705	5,687	3.33
1957	16	1,511	1,482	5,161	3.48
1958	15	983	1,058	3,739	3.54
1959	16	1,288	1,182	4,121	3.49
1960	14	1,055	1,059	3,669	3.46
White:					
1951-55 (average)	4	1,127	1,130	6,123	5.42
1956	3	[4] 1,171	1,133	7,025	6.20
1957	4	[4] 1,087	1,024	6,595	6.44
1958	4	[4] 1,377	1,237	8,001	6.47
1959	4	[4] 1,525	1,515	9,819	6.48
1960	4	[4] 1,504	1,384	9,274	6.70
Portland-pozzolan:					
1951-55 (average)	6	2,773	2,703	7,195	2.66
1956	12	[5] 6,936	6,817	20,940	3.07
1957	11	[5] 5,219	5,237	17,246	3.29
1958	11	[5] 4,096	3,977	13,632	3.43
1959	8	[5] 3,653	3,806	12,864	3.38
1960	7	[5] 3,630	3,525	12,057	3.42
Miscellaneous: [6]					
1951-55 (average)	22	1,028	1,035	3,444	3.33
1956	26	1,829	1,277	4,684	3.67
1957	26	[4] 1,574	1,037	3,942	3.80
1958	21	[4] 915	931	3,499	3.76
1959	22	[4] 1,387	1,414	5,331	3.77
1960	20	[4] 1,128	1,141	4,366	3.83
Grand total:					
1951-55 (average)	156	265,853	264,207	709,267	2.68
1956	[7] 160	316,438	308,678	940,020	3.05
1957	[7] 164	298,424	289,698	921,959	3.18
1958	[7] 168	311,471	307,068	997,701	3.25
1959	[7] 172	339,091	335,452	1,099,244	3.28
1960	[7] 176	319,009	312,292	1,045,246	3.35

[1] Includes Puerto Rico.
[2] Includes air-entrained portland cement as follows (in thousand barrels): 1956, 35,458; 1957, 32,791; 1958, 31,470; 1959, 38,961; 1960, 35,473.
[3] Includes air-entrained portland cement as follows (in thousand barrels): 1956, 3,444; 1957, 3,497; 1958, 4,382; 1959, 5,126; 1960, 4,645.
[4] Includes a small amount of air-entrained portland cement.
[5] Includes air-entrained portland cement as follows (in thousand barrels): 1956, 1,382; 1957, 2,311; 1958, 2,164; 1959, 1,969; 1960, 1,400.
[6] Includes hydroplastic, plastic, and waterproofed cements.
[7] Includes number of plants making air-entrained portland cement as follows: 1956, 104; 1957, 112; 1958, 113; 1959, 119; 1960, 120.

ican Cement Co. (3 plants); American-Marietta Co. acquired the Dewey Portland Cement Co. (2 operating plants, 1 under construction); National Gypsum Co. acquired Allentown Portland Cement Co. (2 plants); and Flintkote Co. acquired Diamond Portland Cement Co. (1 plant).

The Los Angeles, Calif., plant, purchased by Flintkote Co. in 1959, was shut down in 1960.

TYPES OF PORTLAND CEMENT

General-use and moderate-heat portland cements (types I and II) were produced at 175 of the 176 operating plants and comprised 93 percent of all portland cement made. High-early-strength portland cement (type III) was produced at 135 plants, 6 more than in 1959.

No production of portland-pozzolan cement was reported in 1960. Seven plants reported production of portland-slag cement, three plants accounting for 75 percent of the 3.6-million-barrel output. All seven plants produced other types of portland cement in addition to portland-slag cement.

CAPACITY OF PLANTS

The estimated annual capacity of all portland cement plants on December 31, as reported by producers to the Bureau of Mines, was 3 percent greater than that on December 31, 1959. The 12.6-million-barrel increase was the result of expansions at 8 of the 171 plants in operation in 1959 and the addition of 5 new plants.

Number of portland cement plants in the United States (including Puerto Rico) in 1960, by size groups

Estimated annual capacity, Dec. 31, million barrels:	*Number of plants*	*Percent of total capacity*
Less than 1	10	1.8
1 to 2	57	19.5
2 to 3	62	33.7
3 to 4	28	20.8
4 to 5	10	9.7
5 to 11	9	14.5
Total	[1] 176	100.0

[1] Does not include clinker-grinding plants, but includes one nonproducing plant in standby condition.

CLINKER PRODUCTION

Output of clinker was 5 percent less than that in 1959 but in May equaled the record high of 32 million barrels per month of 1959. At yearend stocks of clinkers were 27 percent greater than at the end of 1959.

TABLE 5.—Portland-cement-manufacturing capacity of the United States,[1] by districts

District	Capacity Dec. 31, thousand barrels		Percent utilized	
	1959	1960	1959	1960
Eastern Pennsylvania, Maryland	52,529	52,233	73.0	67.6
New York, Maine	25,842	26,431	72.0	76.2
Ohio	23,434	23,520	76.9	71.6
Western Pennsylvania, West Virginia	15,506	15,468	75.5	70.9
Michigan	25,742	31,242	83.8	67.1
Illinois	9,880	9,880	96.8	93.8
Indiana, Kentucky, Wisconsin	23,937	23,350	85.3	84.5
Alabama	16,273	16,340	82.7	73.0
Tennessee	9,554	9,554	90.9	83.0
Virginia, South Carolina	9,390	9,390	88.2	77.9
Georgia, Florida	14,672	14,822	79.9	75.6
Louisiana, Mississippi	9,275	9,245	80.2	78.6
Iowa	14,330	14,330	91.7	87.4
Eastern Missouri, Minnesota, South Dakota	17,722	17,800	86.5	83.6
Kansas	12,441	12,490	81.8	64.0
Western Missouri, Nebraska, Oklahoma, Arkansas	18,117	19,117	79.3	69.3
Texas	37,471	38,949	72.4	59.5
Colorado, Arizona, Utah, New Mexico	12,650	14,150	87.2	84.2
Wyoming, Montana, Idaho	3,150	3,150	97.4	82.8
Northern California	19,235	19,235	93.2	86.0
Southern California	32,320	32,520	79.5	71.8
Oregon, Washington	10,925	11,025	74.0	74.8
Hawaii		2,700		9.7
Puerto Rico	6,000	6,000	88.7	90.3
Total	420,395	432,941	80.7	73.7

[1] Includes Puerto Rico.

TABLE 6.—Capacity of portland cement plants in the United States,[1] by processes

Process	Capacity, Dec. 31						Percent of capacity utilized			Percent of total finished cement produced		
	Thousand barrels			Percent of total								
	1958	1959	1960	1958	1959	1960	1958	1959	1960	1958	1959	1960
Wet	234,130	244,306	252,288	58.1	58.1	58.3	71.3	81.2	74.0	53.6	58.5	58.5
Dry	168,656	176,089	180,653	41.9	41.9	41.7	85.6	79.9	73.3	46.4	41.5	41.5
Total	402,786	420,395	432,941	100.0	100.0	100.0	77.3	80.7	73.7	100.0	100.0	100.0

[1] Includes Puerto Rico.

TABLE 7.—Portland-cement clinker produced and in stock at mills in the United States,[1] by processes[2]

(Thousand barrels)

Process	Plants		Production		Stocks Dec. 31—	
	1959	1960	1959	1960	1959[3]	1960[4]
Wet	103	107	198,903	186,814	8,422	8,282
Dry	68	68	141,807	137,715	8,084	12,606
Total	171	175	340,710	324,529	16,506	20,888

[1] Includes Puerto Rico.
[2] Compiled from monthly estimates of producers.
[3] Revised figure.
[4] Preliminary figures.

TABLE 8.—Production of portland-cement clinker at mills in the United States[1] in 1960, by months and districts

(Thousand barrels)

District	January	February	March	April	May	June	July	August	September	October	November	December
Eastern Pennsylvania, Maryland	2,374	1,691	2,268	3,203	3,777	3,674	3,868	3,489	3,265	3,174	2,788	2,292
New York, Maine	1,399	1,272	1,417	1,581	1,919	1,924	1,886	1,855	1,797	1,602	1,647	1,635
Ohio	957	1,029	1,400	1,144	1,834	1,857	1,705	1,652	1,587	1,512	1,246	1,300
Western Pennsylvania, West Virginia	873	734	888	889	987	981	755	1,076	961	1,011	1,054	816
Michigan	1,589	1,491	1,503	1,885	[2] 3,106	2,181	1,878	1,876	1,854	1,673	1,746	1,743
Illinois	774	701	810	782	747	824	779	829	776	819	835	798
Indiana, Kentucky, Wisconsin	1,538	1,579	1,412	1,731	1,885	1,819	1,937	1,535	1,772	1,869	1,591	1,397
Alabama	876	818	912	983	1,125	1,086	1,090	1,107	1,048	1,108	999	1,009
Tennessee	663	347	604	773	790	787	779	794	632	648	668	587
Virginia, South Carolina	675	653	623	614	726	677	631	702	655	661	653	547
Georgia, Florida	1,104	993	1,039	1,056	1,105	1,051	928	970	720	1,003	953	877
Louisiana, Mississippi	534	495	429	561	637	617	635	[2] 674	620	638	592	565
Iowa	962	850	750	883	1,064	1,090	1,190	1,210	1,067	1,341	1,073	1,047
Eastern Missouri, Minnesota, South Dakota	1,246	1,159	1,127	1,124	1,351	1,138	1,307	1,448	1,363	1,442	1,031	1,101
Kansas	532	546	533	659	[2] 787	698	856	790	811	801	550	448
Western Missouri, Nebraska, Oklahoma, Arkansas	833	814	919	921	998	1,085	1,165	1,303	1,297	1,251	1,236	1,193
Texas	1,712	1,441	2,070	2,294	2,393	2,135	1,969	2,095	2,088	2,166	1,794	1,924
Colorado, Arizona, Utah, New Mexico	906	791	1,022	1,029	1,025	1,040	1,063	1,058	987	1,124	1,011	1,089
Wyoming, Montana, Idaho	221	208	208	212	292	270	288	274	215	163	274	286
Northern California	1,325	1,110	1,326	1,418	1,514	1,448	1,344	1,425	1,332	1,516	1,325	1,360
Southern California	1,993	1,848	2,105	2,154	2,191	2,009	1,942	2,070	2,079	2,012	1,808	1,678
Oregon, Washington	530	489	743	842	875	743	708	[2] 656	679	[2] 708	[2] 753	617
Hawaii	------	------	------	------	------	------	------	------	58	91	101	3
Puerto Rico	463	399	412	427	449	403	422	426	405	452	440	421
Total:												
1960	24,079	21,458	24,520	27,165	[2] 31,577	29,537	29,125	[2] 29,314	[2] 28,068	[2] 28,785	[2] 26,168	24,733
1959	23,367	21,522	26,976	29,087	31,956	30,753	31,296	31,107	30,121	29,588	27,547	27,390

[1] Includes Puerto Rico.
[2] Revised figure.

RAW MATERIALS

Approximately 68 percent of the domestic output of portland cement was made from limestone and clay or shale. Argillaceous limestone (cement rock) or a mixture of cement rock and limestone was used for 27 percent of the portland cement produced. Four plants used marl instead of limestone, and nine plants used shell.

Blast-furnace slag was used as a raw material in producing portland cement at 20 plants, 7 of which used approximately 300,000 tons of slag to produce portland-slag cement.

TABLE 9.—Production and percentage of total output of portland cement in the United States,[1] by raw materials used

(Thousand barrels)

Year	Cement rock and pure limestone		Limestone and clay or shale [2] [3]		Blast-furnace slag and limestone	
	Quantity	Percent	Quantity	Percent	Quantity	Percent
1951-55 (average)	56,371	21.2	189,106	71.1	20,375	7.7
1956	72,722	23.0	221,948	70.1	21,768	6.9
1957	64,776	21.7	211,743	71.0	21,905	7.3
1958	71,681	23.0	225,495	72.4	14,295	4.6
1959	79,895	23.5	239,336	70.6	19,860	5.9
1960	85,924	26.9	215,625	67.6	17,460	5.5

1 Includes Puerto Rico.
2 Includes output of 4 plants using marl and clay in 1951-55 (average); and 4 plants in 1956-60.
3 Includes output of 8 plants using oystershell and clay in 1951-55 (average); 8 plants in 1956; and 9 plants in 1957-60.

TABLE 10.—Raw materials used in producing portland cement in the United States [1]

Raw material	1958	1959	1960
Cement rock thousand short tons	20,799	25,663	19,917
Limestone (including oystershell) do	62,306	65,250	66,823
Marl do	1,487	2,006	1,224
Clay and shale [2] do	9,400	10,363	9,657
Blast-furnace slag do	1,279	1,139	1,269
Gypsum do	2,507	2,770	1,146
Sand and sandstone (including silica and quartz) do	1,121	1,311	2,690
Iron materials [3] do	535	671	774
Miscellaneous [4] do	107	26	66
Total	99,541	109,199	103,566
Average total weight required per barrel (376 pounds) of finished cement pounds	639	644	649

1 Includes Puerto Rico.
2 Includes fuller's earth, diaspore, and kaolin for making white cement.
3 Includes iron ore, pyrite cinders and ore, and mill scale.
4 Includes fluorspar, pumicite, pitch, red mud and rock, hydrated lime, tufa, calcium chloride, sludge, air-entraining compounds, and grinding aids.

FUEL AND POWER

Less fuels of all types (coal, oil, and natural gas) were used in producing cement in 1960 than in 1959. Coal and oil supplied 57 percent of the heat used, compared with 55 percent in 1959. Consumption of natural gas decreased 10 percent compared with that in 1959. The 176 active plants used an average of 1.31 million B.t.u. per barrel of cement produced.

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TABLE 11.—Finished portland cement produced and fuel consumed by the portland-cement industry in the United States,[1] by processes

Year and process	Finished cement produced			Fuel consumed		
	Plants	Thousand barrels	Percent of total	Coal (thousand short tons)	Oil (thousand 42-gallon barrels)	Natural gas (thousand cubic feet)
1959:						
Wet	104	198,427	58.5	4,334	3,686	134,164,350
Dry	68	140,664	41.5	4,334	826	56,355,013
Total	172	339,091	100.0	[2] 8,668	4,512	[3] 190,519,363
1960:						
Wet	107	186,370	58.4	4,138	3,216	110,208,571
Dry	69	132,639	41.6	4,230	816	61,393,837
Total	176	319,009	100.0	[4] 8,368	4,032	[5] 171,602,408

[1] Includes Puerto Rico.
[2] Comprises 158,876 tons of anthracite and 8,508,775 tons of bituminous coal.
[3] Includes 44,584 thousand cubic feet of byproduct gas and 2,144,869 thousand cubic feet of coke-oven gas.
[4] Comprises 151,704 tons of anthracite and 8,216,358 tons of bituminous coal.
[5] Includes 486,957 thousand cubic feet of coke-oven gas.

TABLE 12.—Portland cement produced in the United States,[1] by kinds of fuel

Year and fuel	Finished cement produced			Fuel consumed		
	Plants	Thousand barrels	Percent of total	Coal (thousand short tons)	Oil (thousand 42-gallon barrels)	Natural gas (thousand cubic feet)
1959:						
Coal	61	[2] 112,429	33.2	5,887		
Oil	7	[2] 13,819	4.1		2,547	
Natural gas	35	[2] 67,153	19.8			[3] 85,830,656
Coal and oil	22	48,257	14.2	2,003	1,008	
Coal and natural gas	20	37,195	11.0	568		35,620,667
Oil and natural gas	18	42,614	12.5		931	49,930,537
Coal, oil, and natural gas	9	17,624	5.2	210	26	19,137,503
Total	172	339,091	100.0	[4] 8,668	4,512	190,519,363
1960:						
Coal	61	[2] 107,084	33.6	5,693		
Oil	9	[2] 13,405	4.2		2,491	
Natural gas	37	[2] 57 677	18.1			[5] 69,978,032
Coal and oil	23	47,775	15.0	1,969	851	
Coal and natural gas	21	37,075	11.6	498		36,615,218
Oil and natural gas	18	42,441	13.3		667	51,732,873
Coal, oil, and natural gas	7	13,552	4.2	208	23	13,276,285
Total	176	319,009	100.0	[6] 8,368	4,032	171,602,408

[1] Includes Puerto Rico.
[2] Average consumption of fuel per barrel of cement produced as follows: 1959—coal, 104.7 pounds; oil, 0.1843 barrel; natural gas, 1,278 cubic feet; 1960—coal, 106.3 pounds; oil, 0.1858 barrel; natural gas, 1,213 cubic feet.
[3] Includes 44,584 thousand cubic feet of byproduct gas and 2,144,869 thousand cubic feet of coke-oven gas.
[4] Comprises 158,876 tons of anthracite and 8,508,775 tons of bituminous coal.
[5] Includes 486,957 thousand cubic feet of coke-oven gas.
[6] Comprises 151,704 tons of anthracite and 8,216,358 tons of bituminous coal.

TABLE 13.—Electric energy used at portland cement plants in the United States,[1] by processes

Year and process	Electric energy used						Finished cement produced (thousand barrels)	Average electric energy used per barrel of cement produced (kilowatt-hours)
	Generated at portland cement plants		Purchased		Total			
	Active plants	Million kilowatt-hours	Active plants	Million kilowatt-hours	Million kilowatt-hours	Percent		
1959:								
Wet	27	770	97	3,524	4,294	56.2	198,427	21.6
Dry	32	1,455	61	1,896	3,351	43.8	140,664	23.8
Total	59	2,225	158	5,420	7,645	100.0	339,091	22.5
Percent of total electric energy used		29.1		70.9	100.0			
1960:								
Wet	25	615	100	3,537	4,152	55.9	186,370	22.3
Dry	29	1,222	67	2,052	3,274	44.1	132,639	24.7
Total	54	1,837	167	5,589	7,426	100.0	319,009	23.3
Percent of total electric energy used		24.7		75.3	100.0			

[1] Includes Puerto Rico.

TRANSPORTATION

Shipments of cement in bulk continued to increase, reaching a high of over 82 percent of total shipments in 1960. The quantity shipped by truck had increased every year since 1944, and the percentage of the total shipped by truck had increased from 16 percent in 1944 to 47 percent in 1960. The greatest gains in 1960 were in the Northeastern States where 21 million barrels were shipped by truck compared with 7 million barrels in 1959. Boat shipments had shown little change in 20 years—representing 2 to 3 percent of total shipments each year. Shipments by boat were highest from plants in Northern California, Puerto Rico, and New York. More cement was shipped by barge down the Hudson River in 1960 than in 1959. The tabulations in this chapter represent only shipments from producing companies to consumers and do not include shipments between producing plants or distribution centers.

TABLE 14.—Shipments of portland cement from mills in the United States,[1] in bulk and in containers, by types of carriers

(Thousand barrels)

Year and type of carrier	In bulk		In paper bags [2]		Total shipments	
	Quantity	Percent	Quantity	Percent	Quantity	Percent
1959:						
Truck	103,481	38.2	24,974	38.8	128,455	38.3
Railroad	157,987	58.3	39,333	61.0	197,320	58.8
Boat	9,213	3.4	73	.1	9,286	2.8
Used at the plant	335	.1	56	.1	391	.1
Total	271,016	100.0	64,436	100.0	335,452	100.0
Percent of total	80.8		19.2		100.0	
1960:						
Truck	119,689	46.5	27,515	50.3	147,204	47.1
Railroad	130,416	50.6	27,112	49.5	157,528	50.4
Boat	7,030	2.7	74	.1	7,104	2.3
Used at the plant	417	.2	39	.1	456	.2
Total	257,552	100.0	54,740	100.0	312,292	100.0
Percent of total	82.5		17.5		100.0	

[1] Includes Puerto Rico.
[2] Cloth bags and other containers included with paper bags to avoid disclosing individual company confidential data.

CONSUMPTION

The net shipments of cement into a State are considered to be a fair index of consumption. Shipments into 32 States and the District of Columbia were less than in 1959.

TABLE 15.—Destination of shipments of all types of finished portland and high-early-strength cement from mills in the United States

(Thousand barrels)

Destination	Finished portland		High-early strength	
	1959	1960	1959	1960
Alabama	5,018	4,622	473	289
Alaska [1]	(2)	(2)	(2)	(2)
Arizona	3,860	4,835	11	38
Arkansas	2,624	2,590	24	30
Northern California	15,227	13,307	20	33
Southern California	23,421	22,023	126	185
Colorado	4,316	4,061	14	13
Connecticut [1]	3,141	3,170	310	344
Delaware [1]	1,114	856	110	88
District of Columbia [1]	1,600	1,275	90	83
Florida	[3] 13,550	[3] 12,132	1,162	1,022
Georgia	6,564	5,882	308	245
Hawaii	1,230	1,241	----------	----------
Idaho	1,230	1,351	2	2
Illinois	18,162	18,543	614	589
Indiana	8,697	8,759	437	451
Iowa	7,585	6,940	242	229
Kansas	6,889	5,070	114	101
Kentucky	4,202	3,802	114	105
Louisiana	8,908	8,007	80	74
Maine	1,104	793	90	78
Maryland	5,280	5,478	303	244
Massachusetts [1]	4,598	4,261	439	457
Michigan	15,214	13,887	1,197	816
Minnesota	6,311	6,350	405	345
Mississippi	3,072	3,324	16	34
Missouri	8,825	7,684	236	220
Montana	1,425	1,078	14	14
Nebraska	3,980	4,250	154	166
Nevada [1]	780	839	5	4
New Hampshire [1]	685	722	51	71
New Jersey [1]	8,722	8,016	1,394	1,373
New Mexico	3,087	2,399	111	111
New York	20,563	20,351	1,415	1,466
North Carolina [1]	5,641	5,011	235	239
North Dakota [1]	2,011	1,377	6	2
Ohio	19,339	17,061	461	411
Oklahoma	5,374	4,669	32	25
Oregon	2,913	3,097	7	8
Pennsylvania	15,844	13,721	1,358	1,264
Rhode Island [1]	639	622	57	65
South Carolina	2,613	2,230	41	55
South Dakota	1,666	1,864	45	47
Tennessee	4,983	5,041	146	225
Texas	23,884	20,195	838	1,018
Utah	2,226	2,093	26	36
Vermont [1]	364	438	20	26
Virginia	6,354	6,220	437	451
Washington	5,721	5,643	415	405
West Virginia	2,076	2,306	13	25
Wisconsin	7,530	6,967	95	105
Wyoming	1,100	1,051	6	14
Unspecified	1	60	1	1
Total United States	331,263	307,564	14,320	13,742
Other countries	[4] 4,189	4,728	[5] 43	30
Total shipped from cement plants	335,452	312,292	14,363	13,772

[1] Noncement producer.
[2] Included with "Other countries" to avoid disclosing individual company confidential data.
[3] Includes shipments from Puerto Rican mills.
[4] Direct shipments by producers to foreign countries, the State of Alaska, and to Puerto Rico, including distribution from Puerto Rican mills.
[5] Direct shipments by producers to other countries and the State of Alaska.

TABLE 16.—Cement shipments by types of customers in 1959

District	Number of plants in district	Plants reporting, percent	Building material dealers		Concrete product manufacturers		Ready-mixed concrete	
			Percent	Thousand barrels	Percent	Thousand barrels	Percent	Thousand barrels
Eastern Pennsylvania, Maryland	21	81.0	14.3	5,444	19.3	7,348	56.0	21,319
New York, Maine	12	83.3	13.9	2,595	16.9	3,155	47.2	8,810
Ohio	11	100.0	12.9	2,335	16.0	2,898	51.1	9,274
Western Pennsylvania, West Virginia	6	83.3	15.5	1,803	16.4	1,907	53.2	6,188
Michigan	8	100.0	10.2	2,220	16.4	3,563	47.5	10,294
Illinois	4	100.0	8.3	791	11.8	1,122	68.3	6,475
Indiana, Kentucky, Wisconsin	7	71.4	13.1	2,536	14.4	2,788	60.5	11,713
Alabama	8	87.5	11.0	1,430	19.4	2,521	49.7	6,460
Tennessee	6	100.0	12.1	1,002	19.1	1,600	53.1	4,455
Virginia, South Carolina	4	100.0	10.6	889	19.6	1,647	49.1	4,130
Georgia, Florida	6	100.0	14.1	1,652	21.3	2,498	55.2	6,468
Louisiana, Mississippi	5	100.0	7.7	556	11.7	848	40.0	2,903
Iowa	5	80.0	18.5	2,350	17.4	2,210	44.0	5,589
Eastern Missouri, Minnesota, South Dakota	6	83.3	16.5	2,548	9.1	1,405	44.8	6,918
Kansas	6	83.3	14.0	1,408	5.8	583	52.9	5,320
Western Missouri, Nebraska, Oklahoma, Arkansas	7	71.4	14.2	1,949	5.6	769	47.1	6,464
Texas	15	86.7	13.9	3,783	7.3	1,987	50.2	13,662
Colorado, Arizona, Utah, New Mexico	8	75.0	16.4	1,748	8.6	917	54.8	5,841
Wyoming, Montana, Idaho	3	100.0	15.5	466	8.8	266	54.6	1,647
Northern California	5	80.0	8.5	1,535	6.5	1,174	67.4	12,175
Southern California	8	75.0	11.9	3,043	8.5	2,174	61.8	15,804
Oregon, Washington	9	100.0	8.1	633	10.2	797	60.3	4,711
Puerto Rico	2	50.0	33.5	1,806	11.1	598	47.1	2,540
Total	172	86.6	13.3	44,522	13.3	44,775	53.4	179,160

TABLE 16.—Cement shipments by types of customers in 1959—Continued

District	Highway contractors		Other contractors		Federal, State and other Government agencies		Miscellaneous, including own use		Total
	Percent	Thousand barrels	Percent	Thousand barrels	Percent	Thousand barrels	Percent	Thousand barrels	Thousand barrels
Eastern Pennsylvania, Maryland	7.8	2,969	1.1	419	0.5	190	1.0	381	38,070
New York, Maine	13.8	2,576	5.1	952	2.9	541	.2	37	18,666
Ohio	13.2	2,393	5.9	1,081	.2	36	.7	124	18,141
Western Pennsylvania, West Virginia	12.4	1,442	2.1	244	.1	12	.3	35	11,631
Michigan	21.8	4,729	3.3	715	.1	17	.7	144	21,682
Illinois	10.9	1,032	.5	47	.1	8	.1	11	9,486
Indiana, Kentucky, Wisconsin	10.6	2,052	1.0	194	.1	19	.3	58	19,360
Alabama	13.3	1,729	4.8	624	.9	117	.9	117	12,998
Tennessee	9.3	777	4.4	374	1.2	102	.8	71	8,381
Virginia, South Carolina	16.6	1,392	3.3	279	.7	59	.1	10	8,406
Georgia, Florida	5.3	617	3.0	354	.4	51	.7	83	11,723
Louisiana, Mississippi	21.0	1,520	4.4	322	1.9	135	13.3	963	7,247
Iowa	14.3	1,816	5.3	673	.3	38	.2	25	12,701
Eastern Missouri, Minnesota, South Dakota	18.8	2,903	8.5	1,313	1.0	154	1.3	201	15,442
Kansas	13.6	1,367	8.8	885	.1	10	4.8	483	10,056
Western Missouri, Nebraska, Oklahoma, Arkansas	10.4	1,427	19.0	2,608	.1	14	3.6	494	13,725
Texas	14.6	3,973	3.0	817	5.3	1,442	5.7	1,551	27,215
Colorado, Arizona, Utah, New Mexico	8.8	938	4.2	448	2.0	213	5.2	554	10,659
Wyoming, Montana, Idaho	1.3	39	16.5	497	-----	1	3.3	101	3,017
Northern California	5.9	1,066	9.6	1,734	.7	126	1.4	253	18,063
Southern California	9.6	2,455	2.5	639	.6	153	5.1	1,304	25,572
Oregon, Washington	3.5	276	17.5	1,370	.1	7	.3	25	7,819
Puerto Rico	1.2	65	1.2	65	4.4	237	1.5	81	5,392
Total	11.8	39,553	5.0	16,654	1.1	3,682	2.1	7,106	335,452

TABLE 17.—Cement shipments by types of customers in 1960

District	Number of plants in district	Plants reporting, percent	Building material dealers		Concrete product manufacturers		Ready-mixed concrete	
			Percent	Thousand barrels	Percent	Thousand barrels	Percent	Thousand barrels
Eastern Pennsylvania, Maryland	21	100	14.7	5,081	19.6	6,791	56.1	19,475
New York, Maine	12	100	11.5	2,213	10.5	2,037	57.6	11,122
Ohio	11	100	10.2	1,702	15.8	2,655	54.5	9,139
Western Pennsylvania, West Virginia	6	100	10.5	1,103	16.6	1,748	60.4	6,343
Michigan	9	100	10.0	2,127	16.2	3,425	54.1	11,470
Illinois	4	100	7.4	650	13.0	1,140	59.2	5,189
Indiana, Kentucky, Wisconsin	7	100	12.4	2,341	13.4	2,519	59.7	11,244
Alabama	8	100	9.8	1,118	20.1	2,284	49.8	5,660
Tennessee	6	100	10.2	764	19.0	1,428	56.1	4,219
Virginia, South Carolina	4	100	9.7	691	22.2	1,581	57.0	4,067
Georgia, Florida	6	100	11.9	1,324	20.8	2,304	54.6	6,070
Louisiana, Mississippi	5	100	5.2	372	10.4	752	49.0	3,530
Iowa	5	100	15.4	1,864	15.9	1,921	47.2	5,720
Eastern Missouri, Minnesota, South Dakota	6	100	14.7	2,063	10.1	1,419	49.0	6,864
Kansas	6	100	17.7	1,391	6.8	535	53.2	4,191
Western Missouri, Nebraska, Oklahoma, Arkansas	8	100	13.0	1,723	11.7	1,552	50.2	6,655
Texas	16	100	12.2	2,761	8.7	1,990	54.7	12,426
Colorado, Arizona, Utah, New Mexico	7	100	13.8	1,620	9.6	1,133	57.1	6,702
Wyoming, Montana, Idaho	3	100	15.3	399	7.5	197	61.9	1,615
Northern California	5	100	9.4	1,517	9.1	1,476	65.9	10,652
Southern California	8	100	13.9	3,267	9.2	2,169	65.8	15,497
Oregon, Washington	9	100	7.1	589	9.5	789	54.4	4,522
Hawaii	2	100	13.6	16	11.4	13	51.3	58
Puerto Rico	2	100	45.7	2,487	9.8	536	38.2	2,077
Total	176	100	12.5	39,183	13.6	42,394	55.9	174,507

TABLE 17.—Cement shipments by types of customers in 1960—Continued

District	Highway contractors		Other contractors		Federal, State and other Government agencies		Miscellaneous, including own use		Total
	Percent	Thousand barrels	Percent	Thousand barrels	Percent	Thousand barrels	Percent	Thousand barrels	Thousand barrels
Eastern Pennsylvania, Maryland	6.0	2,075	2.8	990	0.2	64	0.6	203	34,679
New York, Maine	7.6	1,474	12.5	2,409	.1	12	.2	34	19,301
Ohio	16.4	2,743	1.8	303	1.0	166	.3	44	16,752
Western Pennsylvania, West Virginia	9.7	1,018	1.7	181	.4	36	.7	76	10,505
Michigan	15.3	3,250	3.5	740	.1	12	.8	163	21,187
Illinois	19.5	1,712	.5	43	.4	34	----	2	8,770
Indiana, Kentucky, Wisconsin	11.3	2,122	2.2	410	.2	43	.8	153	18,832
Alabama	12.2	1,379	4.3	484	1.9	213	1.9	217	11,355
Tennessee	11.0	825	1.6	125	1.4	102	.7	54	7,517
Virginia, South Carolina	5.8	417	4.6	326	.6	41	.1	7	7,130
Georgia, Florida	9.0	1,005	.8	85	.7	81	2.2	241	11,110
Louisiana, Mississippi	19.5	1,405	4.0	285	2.4	174	9.5	683	7,201
Iowa	16.9	2,046	4.3	520	.3	31	----	3	12,105
Eastern Missouri, Minnesota, South Dakota	16.2	2,281	5.2	738	3.9	555	.9	127	14,047
Kansas	13.6	1,073	4.3	339	.4	34	4.0	314	7,877
Western Missouri, Nebraska, Oklahoma, Arkansas	15.8	2,100	5.2	694	1.6	214	2.5	328	13,266
Texas	10.9	2,474	4.2	947	.3	71	9.0	2,052	22,721
Colorado, Arizona, Utah, New Mexico	9.0	1,055	4.7	557	3.0	352	2.8	326	11,745
Wyoming, Montana, Idaho	3.7	96	8.1	210	.1	2	3.4	88	2,607
Northern California	4.5	734	10.0	1,614	.3	44	.8	133	16,170
Southern California	2.2	524	8.1	1,902	.2	35	.6	148	23,542
Oregon, Washington	11.2	933	15.6	1,297	1.1	95	1.1	94	8,319
Hawaii	----	----	1.2	1	----	----	22.5	25	113
Puerto Rico	1.8	99	.2	10	2.7	146	1.6	86	5,441
Total	10.5	32,840	4.9	15,210	.8	2,557	1.8	5,601	312,292

The 1960 canvass of shipments of cement by type of customers was more successful in securing response from the producing companies than the 1959 canvass. At least an estimate was submitted by each company, whereas only 87 percent of the plants responded to the 1959 canvass.

STOCKS

Stocks of finished portland cement and clinker at portland cement plants on December 31, 1960, were 13 and 27 percent higher, respectively, than on December 31, 1959. Changes in stocks from 1950 to 1960 are shown in figure 1.

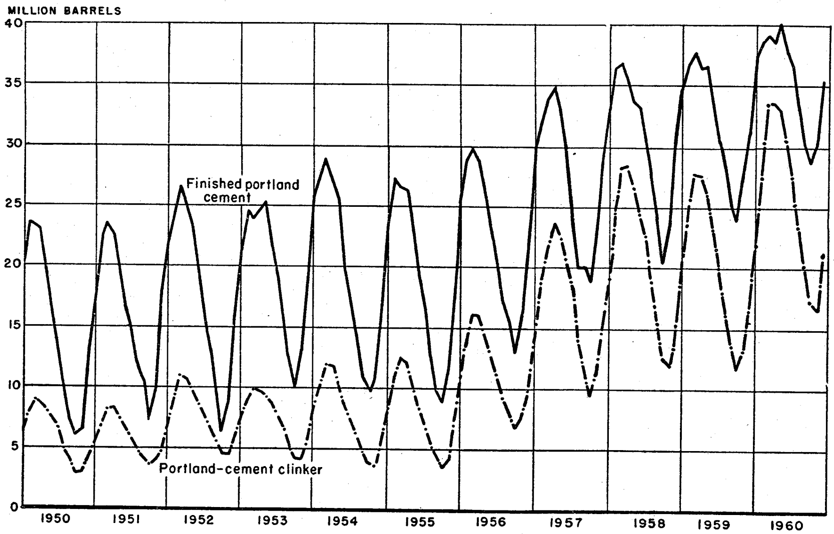

FIGURE 1.—End-of-month stocks of finished portland cement and portland-cement clinker, 1950–60.

TABLE 18.—Stocks of finished portland cement and portland-cement clinker at mills in the United States[1] on Dec. 31, and yearly range in end-of-month stocks

(Thousand barrels)

Year		Dec. 31, quantity	Range: Low, End of month	Range: Low, Quantity	Range: High, End of month	Range: High, Quantity
1956	Cement	22,395	October	13,007	March	29,868
	Clinker	9,443	do	6,874	do	16,151
1957	Cement	28,716	do	19,213	April	34,893
	Clinker	14,853	do	9,444	do	23,620
1958	Cement	30,718	do	20,415	March	36,734
	Clinker	15,505	November	12,124	April	28,409
1959	Cement	[2] 31,465	October	23,913	March	37,711
	Clinker	[2] 16,506	do	11,681	do	27,709
1960	Cement	35,462	do	28,841	May	40,101
	Clinker	20,888	November	16,838	April	33,616

[1] Includes Puerto Rico.
[2] Revised figure.

PREPARED MASONRY CEMENTS

Prepared masonry cements were produced at 135 portland cement plants, 2 natural cement plants, 2 slag-cement plants, and 1 hydraulic-lime cement plant. Production was 10 percent less than in 1959. Shipments were greatest to Ohio, Florida, and North Carolina.

Because prepared masonry cements vary in composition and bulk density, statistics have been converted to equivalent 376-pound barrels for comparison.

TABLE 19.—Shipments of prepared masonry cement from mills in the United States

(Thousand barrels)

Destination	1959	1960	Destination	1959	1960
Alabama	403	358	New Mexico	109	91
Alaska [1]	(2)	(2)	New York	925	822
Arizona	(2)	(2)	North Carolina [1]	986	916
Arkansas	162	162	North Dakota [1]	44	56
Colorado	232	187	Ohio	1,169	1,031
Connecticut [1]	78	74	Oklahoma	212	172
Delaware [1]	21	23	Oregon	2	2
District of Columbia [1]	225	172	Pennsylvania	979	883
Florida	1,246	977	Rhode Island [1]	24	23
Georgia	723	636	South Carolina	466	438
Idaho	16	12	South Dakota	44	39
Illinois	691	578	Tennessee	661	647
Indiana	525	466	Texas	718	604
Iowa	170	154	Utah	14	13
Kansas	194	136	Vermont [1]	25	25
Kentucky	369	367	Virginia	870	738
Louisiana	272	222	Washington	38	35
Maine	53	51	West Virginia	173	160
Maryland	378	333	Wisconsin	425	389
Massachusetts [1]	204	196	Wyoming	10	15
Michigan	990	842	Unspecified	2	4
Minnesota	325	280			
Mississippi	252	227	Total United States	[3] 16,162	14,232
Missouri	172	154	Other Countries [4]	[3] 12	15
Montana	23	23			
Nebraska	70	65	Total shipped from cement plants	16,174	14,247
New Hampshire [1]	39	45			
New Jersey [1]	433	389			

[1] Noncement-producer.
[2] Included with "Other countries" to avoid disclosing individual company confidential data.
[3] Revised figure.
[4] Direct shipments by producers to other countries and to Alaska and Arizona.

TABLE 20.—Prepared masonry cement produced and shipped in the United States, by districts

(Thousand barrels and thousand dollars)

District	Active plants		Production, quantity		Shipments from mills					
					1959			1960		
	1959	1960	1959	1960	Quantity	Value	Average per barrel	Quantity	Value	Average per barrel
Eastern Pennsylvania, Maryland	19	19	1,922	1,735	1,897	$6,929	$3.65	1,687	$6,512	$3.86
New York, Maine	13	12	844	803	851	3,064	3.60	785	2,863	3.65
Ohio	9	9	818	709	853	3,375	3.95	728	3,008	4.13
Western Pennsylvania, West Virginia	6	6	851	917	877	3,406	3.89	862	3,362	3.90
Michigan	5	5	1,349	1,191	1,344	5,126	3.81	1,174	4,612	3.93
Illinois	4	4	432	407	439	1,636	3.73	369	1,411	3.82
Indiana, Kentucky, Wisconsin	6	6	2,115	1,967	2,219	7,792	3.51	1,922	7,298	3.80
Alabama	8	8	1,818	1,608	1,821	6,967	3.83	1,576	6,564	4.16
Tennessee	5	5	763	744	772	2,743	3.55	729	2,696	3.70
Virginia, South Carolina	4	4	967	831	917	3,202	3.49	826	3,127	3.79
Georgia, Florida	5	5	1,112	903	1,107	4,411	3.99	906	3,630	4.00
Louisiana, Mississippi	3	5	202	158	194	708	3.65	168	665	3.98
Iowa	4	4	481	447	469	1,967	4.19	412	1,874	4.54
Eastern Missouri, Minnesota, South Dakota	6	6	534	508	492	2,065	4.19	461	1,977	4.29
Kansas	7	7	348	291	349	1,393	3.99	285	1,179	4.14
Western Missouri, Nebraska, Oklahoma, Arkansas	7	8	454	333	399	1,593	3.99	368	1,570	4.26
Texas	12	13	783	640	776	3,045	3.93	644	2,613	4.06
Colorado, Arizona, Utah, New Mexico	3	4	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Wyoming, Montana, Idaho	2	2	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Northern California	1	1	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Southern California	0	1	----	(1)	----	----	----	(1)	(1)	(1)
Oregon, Washington	5	6	56	48	48	189	3.95	47	186	4.02
Hawaii	----	----	----	----	----	----	----	----	----	----
Undistributed	----	----	356	313	350	1,544	4.42	298	1,338	4.48
Total	134	140	16,205	14,553	16,174	61,155	3.78	14,247	56,485	3.96
Pennsylvania	21	21	2,071	2,039	2,086	7,864	3.77	1,946	7,641	3.93
Missouri	5	5	349	375	364	1,544	4.24	327	1,415	4.33

[1] Included with "Undistributed" to avoid disclosing individual company confidential data.

NATURAL, SLAG, AND HYDRAULIC-LIME CEMENTS

Natural cement was produced at two plants, and slag cement was produced at two other plants. Output was small because the four plants made large quantities of prepared masonry cements. A hydraulic-lime cement plant produced only masonry cement. These five plants reported an annual capacity of approximately 1 million barrels. Producers reported using 82,000 tons of cement rock, 1,300 tons of lime, 1,300 tons of slag, 6,000 tons of coal, and 33 million cubic feet of natural gas in processing these cements. One natural cement plant which formerly made only masonry cement was closed in 1960.

Because masonry cements prepared at these plants contained some portland cement, they are included in the tabulations of masonry cement prepared at portland cement plants (tables 19 and 20). Figures on production of natural and slag cements, 1957 to 1960, are not entirely comparable with figures for preceding years because of changes in the method of reporting by some producers.

TABLE 21.—Natural, slag, and hydraulic-lime cements produced, shipped, and in stock at mills in the United States[1]

(Thousand barrels and thousand dollars)

Year	Production		Shipment		Stocks Dec. 31, quantity
	Active plants	Quantity	Quantity	Value	
1955	6	941	954	$3,019	66
1956	6	1,128	1,074	3,589	116
1957	5	631	662	2,027	79
1958	5	520	492	1,633	107
1959	4	438	441	1,450	[2] 64
1960	4	568	548	1,949	85

[1] Includes Puerto Rico.
[2] Revised figure.

PRICES

The average net value of shipments from all cement plants was $3.37 a barrel, compared with $3.30 in 1959.

Portland cement prices at the plant increased from $3.27 a barrel in the last quarter of 1959 to $3.32, $3.35, and $3.38 in the first, second, and third quarters, respectively, and declined to $3.33 in the fourth quarter. Prices of types I and II portland cement (93 percent of all portland cement produced) increased from $3.26 a barrel in the first quarter to $3.31 and $3.34 in the second and third quarters, respectively, and fell to $3.30 in the fourth quarter.

The average price of high-early-strength cement increased from $3.70 in the last quarter of 1959 to $3.73 through the first and second quarters of 1960, rose to $3.79 in the third quarter, and dropped to $3.74 in the fourth quarter.

The price of prepared masonry cement increased from $3.88 a barrel in the first quarter of 1960 to $3.90 and $3.99 in the second and third quarters, respectively, then declined to $3.94 in the fourth quarter.

The composite wholesale price index of portland cement, f.o.b. destinations, according to the Bureau of Labor Statistics index (1947–49=100), was 155.2, compared with 152.2 in 1959.

TABLE 22.—Average mill value in bulk, of cement in the United States [1]

(Per barrel)

Year	Portland cement	Natural, slag, and hydraulic-lime cements	Prepared masonry cement [2]	All classes of cement [3]
1951–55 (average)	$2.68	$2.95	$3.26	$2.70
1956	3.05	3.34	3.75	3.08
1957	3.18	3.06	3.81	3.21
1958	3.25	3.32	3.77	3.27
1959	3.28	3.28	3.78	3.30
1960	3.35	3.56	3.96	3.37

[1] Includes Puerto Rico.
[2] Includes masonry cements made at portland, natural, and slag cement plants.
[3] Includes shipments of masonry cements for 1956–60.

FOREIGN TRADE [14]

Imports.—Imports of hydraulic cement declined from 5.25 million barrels in 1959 to 4.1 million barrels in 1960. Imports into New England and New York decreased from 2.6 million barrels in 1959 to 2.4 million barrels in 1960 but represented 59 percent of all imports in 1960 compared with 49 percent in 1959. Canada, Colombia, and Belgium supplied 46 percent of the cement imported in 1960. Imports from West Germany decreased from 603,000 barrels in 1959 to 67,000 barrels in 1960.

The largest quantities of white cement (64 percent) came through the Florida customs district, and 60 percent of all white cement imports came from Belgium-Luxembourg and France.

Exports.—Exports of hydraulic cements decreased nearly 33 percent from the 1959 exports.

TABLE 23.—U.S. imports for consumption of cement

(Thousand barrels 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
1951–55 (average)	1,330	[1] $3,899	95	$125	67	$365	1,492	[1] $4,389
1956	3,673	[1] 11,362	483	1,069	300	[1] 1,758	4,456	[1] 14,189
1957	3,856	[1] 11,887	122	221	449	[1] 2,711	4,427	[1] 14,819
1958	3,111	8,060	11	91	268	1,531	3,390	9,682
1959	4,979	12,268	6	47	280	1,458	5,265	13,773
1960	3,816	8,734	(2)	2	282	1,570	4,098	10,306

[1] Data not comparable with other years.
[2] Less than 1,000 barrels.

Source: Bureau of the Census.

[14] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 24.—U.S.[1] imports for consumption of hydraulic cement in 1960, by countries and customs districts

(Barrels)

Customs district	Belgium-Luxembourg	Canada	Colombia	Denmark	France	Germany, West	Israel	Japan	Poland-Danzig	Sweden	United Kingdom	Yugoslavia	Other[2]	Total
Alaska								36,691						36,691
Buffalo		17,108				138								17,246
Connecticut	26,641			53,322	21,008		219,079		13,253				546,327	879,630
Dakota		19,150												19,150
El Paso													2,014	2,014
Florida	352,065		168,721	38,671	58,812	14,568		21,001	67,216	40,908	19,537		6,283	787,782
Galveston											41		29	70
Georgia											3,755			3,755
Hawaii								2,112						2,112
Laredo													18,641	18,641
Los Angeles				3,506	124	3,122		19,049			5,239			31,040
Maine and New Hampshire		26,298												26,298
Massachusetts							39,285		17,388	168,581		41,613	135,391	402,258
Michigan		30,785				8,498								39,283
Montana and Idaho		20,773												20,773
New Orleans	2,074				700	803					1,129			4,706
New York	47,407		99,406		183	30,382					2,994		45,246	225,618
Ohio												300		300
Oregon	2,649	76,707			50			600						80,006
Philadelphia	20,072					8,669	60,889				433	18,777	83,018	191,858
Puerto Rico	1,750		292,834		17,444								65,809	377,837
Rhode Island									145,826	95,928				241,754
Rochester		574,463												574,463
St. Lawrence		35,805				469								36,274
San Diego				1,506				5,045						6,551
San Francisco				2,668	749			617			554			4,588
Vermont		67,515		23										67,538
Total: Barrels	452,658	868,604	560,961	99,696	99,070	66,649	319,253	85,115	243,683	305,417	33,682	60,690	902,758	4,098,236
Value	$1,396,328	$2,394,108	$1,123,755	$210,470	$452,542	$343,686	$626,272	$359,225	$477,878	$587,983	$167,935	$216,087	$1,949,857	$10,306,126

[1] Includes Puerto Rico.

[2] Includes Canary Islands (Philadelphia customs district) 19,982 barrels; Dominican Republic (New York) 45,246 barrels, (Puerto Rico) 65,809 barrels; Italy (Connecticut) 58,379 barrels; Mexico (El Paso) 2,014 barrels, (Laredo) 18,641 barrels; Netherlands (Galveston) 29 barrels; Norway (Connecticut) 310,175 barrels; Portugal (Connecticut) 177,773 barrels, (Massachusetts) 67,733 barrels, (Philadelphia) 45,278 barrels; Tunisia (Massachusetts) 67,658 barrels, (Philadelphia) 17,758 barrels; Union of South Africa (Florida) 6,283 barrels.

Source: Bureau of the Census.

TABLE 25.—U.S. exports of hydraulic cement, by countries

Destination	1958 Barrels	1958 Value	1959 Barrels	1959 Value	1960 Barrels	1960 Value
North America:						
Bermuda	1,725	$10,028	1,040	$8,939	1,363	$7,913
Canada	168,677	730,060	99,093	542,196	55,440	364,976
Central America:						
British Honduras	3,964	18,678	200	814	382	1,717
Canal Zone	------	------	132	957	140	1,227
Costa Rica	25,584	124,324	17,912	58,398	4,557	16,432
El Salvador	149	2,302	------	------	26	560
Guatemala	200	1,989	1,057	7,404	1,026	5,775
Honduras	16,626	66,565	9,980	42,666	9	198
Nicaragua	13,363	55,466	3,804	18,995	7,776	33,915
Panama	1,838	13,588	1,300	5,660	------	------
Greenland	125	500	------	------	------	------
Mexico	221,241	988,608	18,810	107,446	7,344	60,324
West Indies:						
British:						
Bahamas	14,520	84,617	16,910	73,129	14,403	65,265
Barbados	1,500	7,673	------	------	2,024	6,240
Jamaica	383	3,399	727	4,615	537	1,803
Leeward and Windward Islands	9,268	30,582	11,250	37,572	12,241	43,162
Trinidad and Tobago	1,750	8,928	412	2,563	398	2,042
Cuba	6,048	38,827	3,394	23,079	1,157	7,239
Dominican Republic	300	1,496	------	------	94	1,364
French West Indies	6,200	17,160	5,625	15,385	6,455	18,244
Netherlands Antilles	3,082	8,712	600	1,560	640	6,048
Total	496,543	2,213,502	192,246	951,378	116,012	644,444
South America:						
Argentina	------	------	9,285	51,398	10,928	57,747
Bolivia	2,483	14,754	4,477	32,695	2,891	21,093
Brazil	6	104	1,216	13,083	2,004	22,074
Chile	2,110	22,406	5,834	59,556	10,353	64,153
Colombia	12,962	83,540	4,628	31,292	219	3,840
Peru	3,591	11,205	379	8,824	815	8,967
Uruguay	444	9,187	100	1,890	------	------
Venezuela	64,962	205,947	10,201	50,064	287	4,694
Other South America	451	2,774	250	1,125	------	------
Total	87,009	349,917	36,370	249,927	27,497	182,568
Europe:						
Belgium-Luxembourg	815	13,733	533	4,957	264	2,582
France	3,355	21,907	3,900	21,369	21	3,100
Germany, West	124	3,454	639	7,521	191	2,960
Netherlands	213	5,480	65	1,800	88	1,654
Other Europe	726	21,497	589	11,110	258	8,498
Total	5,233	66,071	5,726	46,757	822	18,794
Asia:						
Arabia Peninsular States, N.E.C	3,500	19,267	4,098	31,023	1,250	10,598
India	------	------	697	3,588	55	1,238
Indonesia	4,735	20,819	------	------	750	3,735
Iraq	6,453	34,415	10,750	82,135	8,250	70,010
Japan-Nansei and Nanpo Islands	2,711	82,381	2,918	91,403	1,118	29,576
Korea, Republic of	132	962	740	4,618	------	------
Kuwait	4,750	25,282	2,010	10,261	1,500	6,533
Pakistan	------	------	1,892	11,230	1,366	9,501
Philippines	1,608	14,386	1,807	18,399	751	5,991
Saudi Arabia	2,246	34,672	125	2,300	54	936
Turkey	625	3,269	------	------	187	2,900
Other Asia	50	1,400	352	2,970	2,280	11,327
Total	26,810	236,853	25,389	257,927	17,561	152,345
Africa:						
British West Africa	------	------	4,250	16,585	1,150	5,393
Liberia	14,250	57,400	11,250	46,900	5,500	29,688
Libya	6,612	31,520	1,782	22,003	1,025	8,900
Other Africa	796	5,583	254	3,100	1,179	6,572
Total	21,658	94,503	17,536	88,588	8,854	50,553
Oceania	3,906	14,182	------	------	16,558	85,971
Grand total	641,159	2,975,028	277,267	1,594,577	187,304	1,134,675

Source: Bureau of the Census.

WORLD REVIEW

NORTH AMERICA

Canada.—Completion of the Miron & Freres Ltd. plant at Montreal, Quebec, and expansion of the Inland Cement Co., Ltd., plant at Edmonton, Alberta, raised the annual capacity of the Canadian cement industry to 45 million barrels. Consumption was indicated to be 34 million barrels in 1960.

Plans were announced for constructing new plants near Montreal, Quebec, by Sogemines Ltd., and near Cobourg, Ontario, by British Portland Cement Co.

The manufacture of cement at Regina, Alberta, was described. Limestone was quarried in Manitoba and hauled 275 miles by rail to the plant, and iron oxide tailing was shipped from a copper-leach plant at Fort Saskatchewan.[15]

Cuba.—The cement plant of La Compania Cubana de Cemento Portland, subsidiary of Lone Star Cement Corp. at Mariel, its offices in Havana, and loading facilities at Nuevitas were taken over by the Cuban government.

Dominican Republic.—Exports in 1959 (109,584 barrels), comprised nearly 10 percent of the total sales of Farbrica Dominicana de Cemeto, C. por A., the Republic's only cement producer. Shipments were principally to Caribbean countries.

Panama.—Cemento Atlantico S.A. announced plans to build a 4-million-barrel cement plant in the Las Minas Bay area of Panama. Four vertical kilns, of Swiss manufacture, were included in the design of a dry-process plant using coral as a raw material.

SOUTH AMERICA

Argentina.—Compania Industrial Argentina Loma Negra S.A. began constructing a 3.9-million-barrel plant at Barker, 250 miles south of Buenos Aires. The 18½-foot by 600-foot kiln was shipped from New York in 20 sections, and is the largest kiln in the Western Hemisphere.[16]

Brazil.—A 1-million-barrel plant was opened at Matosinhos, Minas Gerais, and machinery was delivered for a new plant at Capanema, in the Amazon Valley. Shortages of cement were created by Brazil's accelerated building program.

Uruguay.—The Administracion Nacional de Combustibles, Alcohol y Portland, called for bids on plans and equipment to enlarge its cement plant in the Department of Lavalleja.

Venezuela.—Two of the three kilns of the C. A. Venezolana de Cementos plant at Pertigalete, Anzoategui, were shut down part of the year, as demand for cement in construction and the oil industry declined. Efforts were made to increase exports and resulted in a contract to ship 500,000 barrels to Surinam (Dutch Guiana).

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[15] Spector, I., Cement Manufacture in Saskatchewan: Canadian Min. and Met. Bull. (Montreal), vol. 53, No. 582, October 1960, pp. 754–758.
[16] Rock Products, Shipping Kiln to Argentina Is a Mammoth Undertaking: Vol. 63, No. 9, September 1960, p. 44.

TABLE 26.—World production of hydraulic cement by countries[1]

(Thousand barrels)

Country	1951–55 (average)	1956	1957	1958	1959	1960
North America:						
Canada (sold or used by producers)	19,619	26,713	32,178	32,729	33,427	30,307
Cuba	2,416	3,512	3,805	4,192	3,670	[2] 2,345
Dominican Republic	897	1,448	1,642	1,583	1,114	[2] 1,173
Guatemala	387	469	575	692	680	657
Haiti	[3] 152	270	164	211	223	281
Honduras					64	199
Jamaica	451	774	844	1,044	1,155	1,243
Mexico	10,132	13,351	15,010	15,127	15,901	18,153
Nicaragua	135	246	252	235	205	188
Panama	469	410	463	393	569	639
Salvador	[4] 276	405	498	510	487	498
Trinidad	[5] 434	815	780	879	1,055	1,044
United States (including Puerto Rico)	272,114	333,472	313,756	326,352	355,734	334,130
Total	307,482	381,885	369,967	383,947	414,284	390,857
South America:						
Argentina	9,780	12,102	13,861	14,494	13,861	15,479
Bolivia	211	193	141	170	170	223
Brazil	12,166	19,202	19,900	22,222	22,521	26,057
Chile	4,521	4,521	4,263	4,257	4,902	4,855
Colombia	4,960	7,153	7,194	7,200	7,904	8,590
Ecuador	586	891	909	938	921	1,179
Paraguay	[5] 35	82	70	41	76	82
Peru	2,597	3,237	3,195	3,547	3,412	3,524
Uruguay	1,712	1,988	2,445	2,539	2,474	2,433
Venezuela	5,793	8,508	10,243	9,475	10,976	9,029
Total	42,361	57,877	62,221	64,883	67,217	71,451
Europe:						
Albania	129	381	410	457	[2] 440	[2] 469
Austria	9,076	11,351	12,483	12,630	14,172	16,593
Belgium	26,027	27,346	27,587	23,787	26,027	20,545
Bulgaria	4,222	5,037	5,160	5,476	8,402	9,293
Czechoslovakia	14,125	18,458	21,530	24,098	27,815	29,621
Denmark	6,966	6,960	6,825	6,262	8,150	8,408
Finland	5,424	5,629	5,541	5,424	6,860	7,347
France	54,470	67,076	73,930	78,650	82,080	83,083
Germany:						
East	13,761	19,167	20,287	20,862	24,655	29,504
West:[6]	85,258	110,658	110,277	113,689	133,988	} 146,911
Saar	1,542	1,929	2,058	1,718	1,829	}
Greece	4,409	7,259	7,183	7,857	8,349	[2] 9,364
Hungary	6,080	5,834	5,799	7,634	8,402	9,211
Iceland				193	457	428
Ireland	3,072	4,175	3,078	3,055	3,102	3,342
Italy	46,291	66,484	70,072	75,185	83,417	91,233
Luxembourg	827	956	1,114	1,149	1,126	1,231
Netherlands	5,218	7,364	7,740	8,009	9,381	10,542
Norway	4,380	5,248	5,963	6,045	6,631	6,860
Poland	18,610	23,658	26,361	29,657	31,152	38,651
Portugal	4,339	6,004	5,740	6,004	6,045	7,024
Rumania	9,463	12,301	13,808	15,080	16,716	17,907
Spain	20,058	27,710	29,117	31,193	33,591	32,600
Sweden	13,509	14,629	14,365	14,717	16,535	16,452
Switzerland	9,633	13,955	14,723	12,811	15,731	17,824
U.S.S.R.	97,817	145,750	169,426	195,283	227,402	266,663
United Kingdom	67,985	76,065	71,274	69,486	74,992	79,137
Yugoslavia	7,869	9,117	11,627	11,533	13,017	14,060
Total	540,560	700,501	743,478	787,944	890,464	974,303

See footnotes at end of table.

TABLE 26.—World production of hydraulic cement by countries[1]—Continued

(Thousand barrels)

Country	1951–55 (average)	1956	1957	1958	1959	1960
Asia:						
Afghanistan	------	------	------	------	199	205
Burma	258	229	217	211	211	258
Ceylon	410	498	287	469	557	498
China	21,489	37,466	40,222	54,529	71,943	[2] 93,813
Cyprus	------	217	399	487	487	493
Hong Kong	493	709	610	891	833	879
India	23,119	29,363	33,368	36,270	40,662	45,441
Indonesia	838	850	1,472	1,753	2,017	[2] 2,052
Iran	434	1,313	1,835	2,404	3,125	[2] 4,104
Iraq	1,020	2,873	3,541	3,923	3,876	2,855
Israel	3,020	3,594	4,210	4,181	4,579	4,726
Japan	51,210	76,364	88,981	87,862	101,247	132,147
Jordan	[5] 434	463	627	668	645	967
Korea:						
North	903	3,500	5,248	7,177	11,293	[2] 14,658
Republic of	240	270	539	1,736	2,099	2,527
Lebanon	1,970	2,861	3,283	2,973	4,356	[2] 4,397
Malaya	[4] 446	610	668	645	1,132	1,677
Pakistan	3,553	4,609	6,409	6,391	5,875	6,796
Philippines	1,900	2,562	2,996	3,764	4,263	4,661
Taiwan	2,908	3,465	3,541	5,951	6,256	6,936
Thailand	1,800	2,334	2,357	2,674	2,832	2,580
Turkey	3,412	5,687	7,394	8,895	10,167	11,949
United Arab Republic (Syria Region)	1,038	1,911	1,847	2,269	2,621	2,949
Viet-Nam, North	1,266	1,155	967	1,771	2,228	2,380
Total	122,161	182,903	211,018	237,894	283,503	349,948
Africa:						
Algeria	3,242	3,823	4,169	4,937	5,611	6,227
Angola	[4] 276	510	756	973	909	944
Cameroun	[3] 29	76	64	64	[2] 64	[2] 64
Canary Islands	------	------	12	35	293	[2] 293
Congo, Republic of the (formerly Belgian) (Including Ruanda-Urundi)	1,694	2,691	2,721	2,427	2,035	[2] 1,173
Ethiopia	[2] 94	158	147	188	147	164
Kenya	340	1,091	1,208	1,272	1,841	2,070
Morocco:						
Northern zone	[5] 147	[2] 293	[2] 293	[2] 293	[2] 293	} 3,401
Southern zone	3,237	3,436	2,556	2,298	2,943	}
Mozambique	569	885	979	1,055	1,249	[2] 1,249
Nigeria	------	------	------	663	721	[2] 1,190
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia	358	663	} 3,987	4,667	3,489	[2] 3,518
Southern Rhodesia	1,571	2,732	}			
Senegal	481	850	926	874	1,020	985
Sudan	[3] 375	393	352	522	586	709
Tunisia	1,513	2,105	2,351	2,023	2,592	2,380
Uganda	[4] 223	358	504	622	481	416
Union of South Africa	12,424	14,541	14,811	15,960	15,549	15,831
United Arab Republic (Egypt Region)	6,831	7,921	8,596	8,871	10,484	12,313
Total	33,404	42,526	44,432	47,744	50,307	52,927
Oceania:						
Australia	9,493	12,530	13,615	14,418	15,333	16,370
New Zealand	1,689	2,644	3,166	3,289	3,295	3,559
Total	11,182	15,174	16,781	17,707	18,628	19,929
World total (estimate)[1]	1,057,150	1,380,866	1,447,897	1,540,119	1,724,403	1,859,415

[1] This table incorporates some revisions.
[2] Estimate.
[3] Average for 1 year only, as 1955 was first year of commercial production.
[4] Average for 1953–55.
[5] Average for 1954–55.
[6] Excludes clinker.

Compiled by Helen L. Hunt, Division of Foreign Activities.

EUROPE

Member countries of the Organization for European Economic Cooperation (O.E.E.C.) increased cement production, consumption, and exports by 12 percent in 1959 over 1958.[17] Plans for constructing 12 new plants and installing 44 new kilns (40 rotary and 4 vertical) in existing plants in 1960 and 1961 were reported. At the end of 1960, production capacity was estimated to be over 623 million barrels.

Soviet bloc countries, under the Council for Economic Mutual Assistance (C.E.M.A.) Permanent Commission for Construction, held their first meeting on cement-industry development in November 1959. Product standardization, processing, types and sizes of plants, additives, and chemistry were among topics discussed. Plans to improve the quality of cement and to double production of the Soviet member countries by 1965 were revealed.

Belgium.—About 5 million barrels of metallurgical cement was produced in 1958, and output was higher in 1959. Cimenteries et Briquetteries Reunies opened a 1.5-million barrel plant near Lieges in 1959.[18]

Czechoslovakia.—Annual cement production was expected to reach 50 million barrels by 1965. Most of the plants were reported to be converting from coal to oil for fuel, thus permitting more cement to be produced. A cement plant was under construction at Lochkov.

Germany, West.—Exports of cement in 1959 were over 5 million barrels, and sales set a record.

Hungary.—Modernization of the Labatlan plant to provide over 3 million barrels annual capacity was due for completion in 1961. A $10-million reconstruction program was started at Tatabanya in 1959. At Vac, a 6-million-barrel cement plant was under construction.[19]

Portugal.—Extensive pozzolan deposits on the island of Santo Antão, Cape Verde Islands, were developed by the Companhia da Pozolana de Cabo Verde. Plans were to export the material for use with cement.[20]

Sweden.—Exports and imports of cement in 1959 were 1,316,750 and 57,400 barrels, respectively; apparent consumption was 15,275,500 barrels. Skanska Cement, A.B., accounted for over 75 percent of the country's output.[21]

U.S.S.R.—The goal for 1965 cement production was set at 440 million barrels. Plans were announced for constructing 32 new cement plants and for a 15-percent expansion in capacities of older plants by installation of new equipment. About 85 percent of the new plants would use the wet process.[22]

United Kingdom.—Associated Portland Cement Manufacturers, Ltd., planned to add 17-million-barrels capacity to its home plants at a cost of about $42 million. Rebuilding of the company's Plymouth

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[17] Organization for European Economic Cooperation, The Cement Industry in Europe: July 1960, 37 pp.

[18] Pit and Quarry, World-Wide Cement News: Vol. 52, No. 8, February 1960, p. 48.

[19] Cement, Lime, and Gravel (London), Rebuilding the Hungarian Cement Industry: Vol. 35, No. 12, December 1960, p. 369.

[20] Bureau of Mines, Mineral Trade Notes: Vol. 52, No. 1, January 1961, p. 11.

[21] Bureau of Mines, Mineral Trade Notes: Vol. 52, No. 1, January 1961, p. 11.

[22] Nikander, B., Cement Production Skyrockets in Soviet Russia: Rock Products, vol. 63, No. 6, June 1960, pp. 102–108.

plant was started, and a decision was made to build a plant at Westbury, Wiltshire, Scotland.

Yugoslavia.—Capacity of the cement industry was scheduled to increase to 20 million barrels by 1965. An extensive deposit of opal breccia near Kumanovo, northern Macedonia, was mined for pozzolan.

ASIA

Ceylon.—The Ceylon Cement Corp., a State monopoly, advertised for bids on an $8-million expansion program. The annual capacity of the Kankesan Cement Works at Kankesanturai, near Jaffna, would be increased to 1.3 million barrels, and a 600,000-barrel cement grinding and packing plant would be built at Galle.[23] Construction of a $7.6-million plant with annual capacity of 750,000 barrels was started at Puttalam.

China.—A new cement plant was reported in operation in Kiangyu Szechwan Province.

Cyprus.—Cyprus Cement Co., Ltd., mined marl and limestone from quarries near Moni for its Limassol cement plant; iron slags were used from ancient workings in the Kalavassos area.

India.—Cement producing capacity of 36 plants in 1960 was reported to be over 53 million barrels. Associated Cement Companies, Ltd., operated 14 cement plants which accounted for more than half of the Indian production. Expansions at operating plants and new plants under construction were expected to increase capacity to nearly 82 million barrels in 1961.[24] Exports of cement more than tripled in 1959 over 1958.

Kaiser Engineers Overseas Corp. was constructing a 600,000-barrel cement plant for Mysore Cements, Ltd., at Ammasandra, Mysore. Plans were announced for a $½-million cooperative cement plant at Hyderabad and for expanding to 1-million-barrels annual output the Panyam Cements & Minerals Industries, Ltd., plant at Cement Nagar. Vickers, Ltd., and Babcock & Wilcox, Ltd., agreed to build a plant to begin production of cement manufacturing equipment by 1962 in Durgapur, West Bengal.

Iran.—Expansion of the cement plant at Meshed to about 350,000 barrels annual capacity was planned.

Israel.—Addition of a third rotary kiln, to increase capacity 350,000 barrels a year, was planned by the Nesher Cement Co. at Haifa. Long-range plans called for building a new plant at Eilat to supply foreign trade. Exports in 1959 were 1.6-million barrels, nearly double the quantity shipped in 1958. Three plants were operated in 1959.

Japan.—Exports were an important but declining part of the Japanese cement market, with 9,598,000 barrels being shipped abroad in 1958, and 4,409,000 barrels in the first half of 1959. A 60,000-barrel bulk distribution center was opened in 1959 at Singapore by the Onoda Cement Co. and Mitsui Bussan Co.[25]

Jordan.—A ½-million-barrel addition to the Jordan Cement Factories Co. plant near Amman was completed, and another similar increase was planned.

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[23] Foreign Commerce Weekly, Ceylon Plans Expansion of Cement Facilities: Vol. 63, No. 8, Feb. 22, 1960, p. 11.
[24] Bureau of Mines, Mineral Trade Notes: Vol. 51, No. 1, July 1960, pp. 9, 10.
[25] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 3, March 1960, pp. 7–8.

Korea, Republic of.—Cement requirements of Korea were expected to reach nearly 6 million barrels a year by 1963. Need for a new 1-million-barrel plant was indicated.[26]

Nepal.—A 200,000-barrel plant was reported under construction at Hathura, Nepal, with the help of Chinese technicians.

Okinawa.—The Nihon Cement Co. of Tokyo announced plans to build a ½-million-barrel cement plant in the Yabu district of Okinawa.

Pakistan.—Shortages of cement for construction of a new capital at Islamabad spurred planning by the Pakistan Industrial Credit & Investment Corp. for added supplies. New cement plants were proposed for Gharibwal, Jhelum (2.5 million barrels), and Sang Gjai, Rawalpindi. Expansions of the Daudkhel plant of the Maple Leaf Cement Co. to 2.5 million barrels and of the Hyderabad plant of Zeal-Pak Cement Co. to 3 million barrels were announced.

Philippines.—The new 900,000-barrel cement plant of Universal Cement Co., Inc., in Cebu began production. Construction began on a 1-million-barrel cement plant at Iligan City, Mindanao for the Mindanao Portland Cement Co. Other plants under construction were: Atlas Cement Corp., north of Manila; Clep Cement Corp., at Padre Burgos, Quezon Provinces; Filipinas Cement Corp., at Luzon; Luzon Cement Corp., at Ildefonso, north of Manila; San Jose Cement Corp., in Mandaro Province; and Superior Cement Corp., in Rizal Province. By the end of 1962, 13 plants with total annual capacity of 7.8 million barrels were expected to be operating. Imports in 1958 were 158,600 barrels, mainly from Japan; 1959 imports increased to 258,800 barrels, nearly half of which came from Taiwan.[27]

Sarawak.—Limestone deposits in the Kuching area were investigated in connection with possible establishment of a cement plant.[28]

Saudi Arabia.—The Arabian Cement Co. plant at Jidda increased capacity by 800,000 barrels by converting a lime-kiln to portland cement; operations at a new limestone quarry promised improved economies. Depressed construction activity in the Hejaz and Riyadh areas contributed to marketing problems.

Taiwan.—A 4-month ban on cement exports, imposed because of domestic shortages, was lifted. Exports accounted for about one-third of total sales. The new Asia Cement Co. plant began operation, and expansions at five plants were underway. By 1962, total annual capacity was expected to increase 60 percent to over 9 million barrels.[29] Exports of cement to Singapore from the China National Minerals Corp. totaled more than 150,000 barrels in 1959 and were expected to increase in 1960.

Thailand.—Capacity of the Siam Cement Co. plant was increased to 4 million barrels by adding a rotary kiln. Royal Irrigation Cement Co. reportedly planned to double its output.

Turkey.—A list of the 14 cement plants and their capacities, production, and sales for 1958 and 1959 was published.[30] Total capacity in 1959 was 11.5 million barrels, and seven plants under construction were expected to raise the total to 16 million barrels. Imports of

[26] Pit and Quarry, Korea's Cement Shortage, High Demand Hike Price: Vol. 53, No. 5 November 1960, p. 38.
[27] Bureau of Mines, Mineral Trade Notes: Vol. 51, No. 5, November 1960, pp. 9–11.
[28] Canadian Mining Journal, Cement Industry for Sarawaki: Vol. 81, No. 5, May 1960, pp. 118–119.
[29] Pit and Quarry, 60% Formosa Production Hike Paced by Taiwan Cement Co.: Vol. 52, No. 8, February 1960, p. 30.
[30] Bureau of Mines, Mineral Trade Notes: Vol. 51, No. 3, September 1960, pp. 12–14.

cement in 1959 were 12,400 barrels, about 10 percent less than in 1958, and exports, reported for the first time, were 96,600 barrels, supplied to Czechoslovakia and Kuwait.

AFRICA

Algeria.—Imports of cement were 2,609,100 barrels in 1959, up 46 percent from the 1,788,300 barrels imported in 1958.

Ghana.—About 10 percent of the more than 2-million-barrel Ghanaian cement import market was said to have been supplied by the U.S.S.R., Poland, and East Germany.

Ivory Coast.—Increased demand for cement resulted in a search for limestone deposits, and consideration was given to establishing a clinker-grinding plant. Imports in 1959 were 748,600 barrels.[31]

Kenya.—Five kilns were operated at the Bumburi, Mombasa, plant of the British Standard Portland Cement Co., and a sixth kiln, to increase capacity to more than 2 million barrels, was under construction. Most of the production was exported. Dockside bulk handling facilities were installed by the company at Mombasa, Kenya, Dar es Salaam, Tanganyika, and Port Louis, Mauritius. A 2,400-ton ship, the *Southern Baobab*, was converted for bulk cement transport.[32]

Liberia.—Italian interests planned to build a $3-million cement plant in Liberia.

Libya.—Demand for cement was estimated at 600,000 barrels in 1959. Proposals were studied for construction of one or more cement plants.[33]

Malagasy Republic.—Cement and lime imports totaled 467,100 barrels in 1958 and 479,500 barrels in 1959. The Amboaino plant, near Majunga, reportedly was producing about 150,000 barrels per year, and plans for a second cement plant were studied.

Nigeria.—West African Portland Cement Co., Ltd., a subsidiary of Associated Portland Cement Manufacturers, Ltd., opened a new 1-million-barrel plant in Ewekoro, near Lagos. Limestone and shale were supplied from quarries next to the plant.

Rhodesia and Nyasaland, Federation of.—Premier Portland Cement Co. maintained production in Rhodesia, but sales decreased following completion of the Kariba Dam and a general decline of building activity in the Federation.

Tanganyika.—Tanganyika Portland Cement Co. explored the possibility of establishing a cement plant at Dar es Salaam, using limestone deposits in the Bagamoyo district.[34]

United Arab Republic (Egyptian region).—National Cement Co. began operating its new 3-million-barrel plant at Tebbin, south of Cairo, producing cement containing 35 percent blast-furnance slag. The output was intended partly for foreign trade. Exports to hard-currency countries had the advantage of a 17.5-percent premium by the Egyptian Government. Saudi Arabia received 796,700 barrels of the 1,277,600 barrels of cement exported from Egypt in 1958.[35]

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[31] Bureau of Mines, Mineral Trade Notes: Vol. 51, No. 4, October 1960, pp. 24–25.
[32] Bureau of Mines, Mineral Trade Notes: Vol. 52, No. 1, January 1961, pp. 10–11.
[33] Foreign Commerce Weekly, Libyan Businessmen Plan Cement Plants: Vol. 63, No. 4, Jan. 25, 1960, p. 15.
[34] Cement, Lime, and Gravel (London), Tanganyika Portland Cement Company to Build Factory Near Dar es Salaam: Vol. 36, No. 1, January 1961, pp. 13–14.
[35] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 3, March 1960, pp. 8–9.

OCEANIA

Australia.—Plans were announced by the Associated Portland Cement Manufacturers, Ltd., for a new cement plant at Geelong, Australia.

Fiji.—Construction of a cement plant was planned by Fiji Industries, Ltd. The Government granted a 50-year lease on raw materials. Equipment for the plant was ordered from Australia.

TECHNOLOGY

Technicians from 35 countries attended the Fourth International Symposium on Chemistry of Cement, held in early October at two locations, Washington, D.C., and Skokie, Ill. A number of significant papers dealing with the chemistry and hydration of cement were given.[36]

The Portland Cement Association organized an Advanced Engineering group to study new applications and more efficient uses of concrete and merged its Highway-and-Municipal and Soil-Cement Bureaus into a new Paving Bureau.

At the annual meeting of the American Society for Testing Materials new test methods for determining the quantity of water-soluble alkali in masonry cements and for evaluating false set and potential sulfate resistance of portland cement were approved. Specifications were proposed for additives used in processing portland cement.[37] Reports were issued on the accelerated testing of portland cements by autoclave curing in West Germany and the United States.[38]

Many studies were undertaken covering various phases of the hydration of cement: Changes in surface area of a hardened cement paste during hydration; [39] diffusion of alkalies through the liquid phase of hardened cement paste; [40] gradually filling of the capillary space in cement paste; [41] correlation of the final set of a cement paste and changes in the electrical conductivity of the paste; [42] relation of expansion of hardened cement to the potassium content; [43] determination of degree of hydration by measurement of chemically combined water; [44] and determination of the heat of hydration by thermographic methods.[45] The technological behavior of various raw gypsums in portland cement was investigated.[46]

[36] Lerch, W., Fourth International Symposium on Chemistry of Cement: Pit and Quarry, vol. 53, No. 6, December 1960, pp. 99–100.

[37] Rock Products, ASTM Committee Accepts New Cement Specification: Vol. 63, No. 9, September 1960, pp. 67, 70.

[38] Department of Commerce, Technical Translations: Vol. 3, No. 12, June 24, 1960, p. 794.

Wagner, W. K., Accelerated Cement Tests Aid Producer Control: Paper pres. 31st Ann. Conv. of the Nat. Ready Mixed Concrete Assoc., Miami Beach, Fla., January 1961, 12 pp.

[39] Hunt, C. M., Tomes, L. A., and Blaine, R. L., Some Effects of Aging on the Surface Area of Portland Cement Paste: Jour. Res., Nat. Bureau of Standards, A–Physics and Chem., vol. 64A, No. 2, March–April 1960, pp. 163–169.

[40] Hall, R. C., and Rhodes, J. M., Movement of Sodium With Water in Neat Portland Cement: ASTM Bull. 245, April 1960, pp. 66–70.

[41] Department of Commerce, Technical Translations, On the Physical Properties of Hardened Cement: Vol. 3, No. 11, June 8, 1960, p. 731.

[42] Building Science Abstracts (London), Some Phenomena During Setting of Portland Cement: Vol. 33, No. 3, March 1960, p. 67.

[43] Journal of the American Ceramic Society, Ceramic Abstracts, Changes in Size Occurring Early in Setting of Portland Cement: Vol. 43, No. 8, August 1960, p. 185.

[44] Building Science Abstracts (London), Method for Following the Hydration Reaction in Portland Cement Paste: Vol. 33, No. 3, March 1960, p. 68.

[45] Department of Commerce, Technical Translations, Thermographic Method for Determining Hydration Heat of Cement: Vol. 3, No. 12, June 24, 1960, p. 794.

[46] Building Science Abstracts (London), The Suitability of Raw Gypsums for Cement Manufacture: Vol. 33, No. 3, March 1960, p. 67.

Shrinkage and cracking of cement pastes caused by carbonation were studied.[47] Studies of carbonated samples of portland cement mortar indicated that the carbon dioxide gas was chemically bound as calcium carbonate and not as a silicate mineral.[48]

Analytical methods were developed for determining the barium and strontium oxides in cements,[49] and sodium and potassium in raw materials and cement clinker.[50]

Silicate minerals were reported to be more reactive than free quartz in raw-material mixtures for portland cement. Higher kiln temperatures and finer grinding were necessary when free quartz was present in the raw feed.[51]

Exploration for cement raw materials was carried on 5 years in advance of the construction of a cement plant in New Mexico.[52]

Kiln Feed.—Use of a digital computer to solve complex raw mix and other cement manufacturing problems was described. The method was said to allow selection from stockpiles of lowest cost combinations of materials for specified mixes and to contribute to more efficient utilization and, therefore, longer life of deposits.[53] A nuclear density control apparatus for measuring the flow of raw-mix materials into a cement kiln was ordered by a cement company.[54] The largest swing hammer mill ever built in Great Britain, a 72- by 60-inch Pennsylvania-Dixie type, was installed at the Adelaide Cement Co., Ltd., quarry in South Australia.[55]

Carbon dioxide from the stack of a cement plant, when added to the slurry, permitted a decrease in moisture content without increasing viscosity, and resulted in increased production capacity and decreased fuel consumption.[56] A method of lowering moisture content of a slurry by adding 0.1 to 1 percent of a lignin-alkali reaction product was patented in U.S.S.R.[57]

Preheaters.—The problem of alkali buildup in high-efficiency kilns was investigated, and a rearrangement of equipment was suggested to minimize the alkali absorption by raw materials in the preheaters. It was estimated that bypassing the hot kiln gases from the first

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[47] Journal of Applied Chemistry (London), Carbonatation Shrinkage and Crazing; Study of Thin Layers of Hydrated Cement: Vol. 10, pt. 5, May 1960, p. i–439.

[48] Cole, W. F., and Kroone, B., Carbon Dioxide in Hydrated Portland Cement: Jour. Am. Concrete Inst., vol. 31, No. 12, June 1960, pp. 1275–1295.

[49] Ford, C. L., A Gravimetric Method for the Determination of Barium Oxide in Portland Cement: ASTM Bull. 247, July 1960, pp. 77–80.

Ford, C. L., A Gravimetric Method for the Determination of Strontium Oxide in Portland Cement: ASTM Bull. 245, April 1960, pp. 71–75.

[50] Building Science Abstracts (London), Chemical Determination of Sodium and Potassium in Raw Materials and Clinker in Cement Works: Vol. 33, No. 9, September 1960, p. 259.

[51] Building Science Abstracts (London), Determining the Content of Free Silica and the Specific Surface of New Materials for Cement Manufacture: Vol. 33, No. 7, July 1960, p. 197.

[52] Mollette, C. M., Exploration of Cement Raw Materials: Paper pres. at Nat. Western Min. and Energy Conf., Colorado Min. Assoc., Denver, Colo., Apr. 23, 1960, 3 pp.

[53] Utley, H. F., Electronic Computer Controls Cement Production Variables: Pit and Quarry, vol. 52, No. 9, March 1960, pp. 86–91.

Weeks, L. W., Magic Memory Solves Raw Mix Problems: Rock Products, vol. 63, No. 4, April 1960, pp. 85–89.

Nalle, P. B., and Weeks, L. W., The Digital Computer Applications in Mining and Process Control: Min. Eng., vol. 12, No. 9, September 1960, pp. 1001–1004.

[54] Rock Products, Nuclear Density Gauge: Vol. 63, No. 11, November 1960, p. 140.

[55] Chemical Engineering and Mining Review (Melbourne), Swing Hammermill for Adelaide Cement Company, Ltd.: Vol. 52, No. 8, May 16, 1960, pp. 60–61.

[56] Utley, H. F., Carbon Dioxide Gas Used To Thin Slurry in Laramie Cement Plant: Pit and Quarry, vol. 53, No. 1, July 1960, pp. 191–193.

[57] Journal of the American Chemical Society, Chemical Abstracts, Lowering the Moisture Content of Cement Slurries: Vol. 54, No. 16, Aug. 25, 1960, col. 16785f.

stages of the preheaters would prevent condensation of at least half of the volatilized alkali in the kiln gases.[58]

The pelletizing of raw-material mixes for grate-type preheaters was investigated. It was found that production of moist pellets from various mixes was not difficult but that the mineralogical properties of the raw materials affected pellet survival after drying. Chemical additives were necessary with some mixes to prevent disintegration of the pellets while drying and heating on the grate.[59] Patents were issued for a method and apparatus for nodulizing finely ground raw mixtures [60] and for drying and preheating filtercake.[61]

Calcination.—Constant-speed motors for kiln drives were advocated as a means of increasing production and decreasing fuel consumption.[62] The importance of the calcium silicates formed in the firing zone of cement kilns was discussed.[63] Two methods of introducing raw mixtures into rotary kilns were patented, one to reduce dust losses [64] and the other to utilize the maximum heat from the hot gases.[65] Special techniques and equipment were used for installing kiln liners in 16-foot diameter kilns.[66]

A design for an indirectly fired shaft kiln suitable for producing portland cement was patented.[67]

Patents were issued for a stationary reactor chamber to produce clinker in finely divided form [68] and for a moving grate to preheat, sinter, and cool white portland cement.[69]

Clinker Grinding.—Advantages attained by grinding clinker to a wider distribution of particle sizes and greater surface area (3,100 Blaine) included greater uniformity in quality of cement, increased water retention, improved plasticity, increased temperature stability, and higher strength in cases of critical moisture content.[70] A patent was issued for grinding cement clinker to produce cement graded to various particle-size specifications.[71]

Packaging.—An automatic pallet loader was installed in a California cement plant. The loader was adjusted to permit 25 or 40 bags to be loaded on a pallet to meet individual customer requirements. Advantages of the installation included time saved in making up and ship-

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[58] Clausen, C. G., Low-Alkali Cement From High-Efficiency Kilns?: Rock Products, vol. 63, No. 1, January 1960, pp. 148–149, 152, 154, 164.

[59] Tonry, J. R., Pelletizing Characteristics of Raw Mixes: Pit and Quarry, vol. 53, No. 2, August 1960, pp. 102–106; No. 3, September 1960, pp. 117–121, 132.

[60] Keiding, P., and Sylvest, K. J. (assigned to F. L. Smidth & Co.), Method and Apparatus for Nodulization of Pulverulent Materials: U.S. Patent 2,924,847, Feb. 16, 1960.

[61] Davis, G. G. J. (assigned to Associated Portland Cement Manufacturers Ltd.), Apparatus for the Manufacture of Portland Cement, Lime, and the Like: U.S. Patent 2,945,687, July 19, 1960.

[62] Derrom, D. L., Constant-Speed Kilns Pay Off: Rock Products, vol. 63, No. 10, October 1960, pp. 103–104, 108, 148–149.

[63] Derrom, D. L., Let's Scrutinize Silica: Rock Products, vol. 63, No. 12, December 1960, pp. 99–100, 118.

[64] Schoonover, P. L. (assigned to Monolith Portland Cement Co.), Rotary Kiln Construction: U.S. Patent 2,923,538, Feb. 2, 1960.

[65] O'Mara, R. F., and Patterson, R. G., Kiln Process Having Increased Thermal Efficiency: U.S. Patent 2,965,366, Dec. 20, 1960.

[66] Stover, H. M., Lining a 16-ft. 6-in. Diameter Kiln Presents Many Unique Problems: Pit and Quarry, vol. 52, No. 10, April 1960, pp. 114–117.

[67] Ludin, W. (assigned to L. von Roll, A.G.), Shaft Kiln: U.S. Patent 2,960,323, Nov. 15, 1960.

[68] Metcalfe, R. L., and Metcalf, V. E., Heat-Treating Furnace for Particulate Solids: U.S. Patent 2,932,498, Apr. 12, 1960.

[69] Pajenkamp, H., Russ, A., zur Strassen, H., Meyer, K., and Rausch, H. (assigned to Dyckerhoff Zementwerke A.G., and Metallgesellschaft, A.G.), Process for Manufacturing White Cement: U.S. Patent 2,945,688, July 19, 1960.

[70] Stephanson, A. D., Here's a New Approach to Portland Cement: Rock Products, vol. 63, No. 5, May 1960, pp. 161–162, 204, 206.

[71] Claes, G. (assigned to Firma Gebr. Hischmann Maschinenfabrik): Canadian Patent 599,593, June 7, 1960.

ping orders at the cement plant and at the customers' warehouses, less breakage of bags, and less cleanup expense.[72]

Dust Control.—Glass-fiber bags cleaned by ultrasonics were installed in cement plants at Evansville and Northampton, Pa. Collecting efficiency of the system at one plant was claimed to be 99.96 percent; particle sizes handled were nearly 100 percent minus 10 microns and 91.9 percent minus 5 microns.[73] Dust-collecting systems, all employing glass-fiber bags, were planned or being installed at six other plants. A paper was published reviewing dust-collection methods and describing the fabric-type filter equipment employed in the cement industry.[74]

A dilute surface-active chemical spray for control of dust in processing limestone for cement not only reduced the dust lost but also the time lost due to jammed screens.[75]

Additives.—The addition of methylcellulose to portland cement was investigated, and data was given to show the water-retentive properties of mortars containing this additive. Even on dry absorptive tile these mortars retained water and hydrated into a continuous hardened concrete structure.[76]

Tests on colored cements made by adding fine mineral oxides to white portland cement were reported to show the additions had little effect on cracking, shrinkage, swelling, and strength.[77]

Portland Blast-Furnace Slag Cements.—Comparative tests were made on mortars and concretes made from portland cements and portland blast-furnace slag cements. Results indicated differences in strength-producing properties were no greater in the case of the blast-furnace slag cements than usually found in different shipments of regular cement.[78]

Blast-furance slags containing 13 to 20 percent magnesia were used to make portland blast-furnace slag cements, and tests were conducted on concretes made from these cements. Mixtures containing 40 percent or more portland cement developed nearly the same strength as portland cement after 28 days, but less in 1 to 7 days, even when the slag was ground to a fineness (5,000 Blaine) greater than the portland cement (3,200 Blaine). Concrete structures made with this type of portland blast-furnace slag cement in 1953 were found to be as sound as those made with ordinary cement. It was concluded that higher early strengths could be obtained by finer grinding of both the clinker and the slag. The lower cost per ton of granulated slag was said to compensate for the increased cost of grinding.[79]

Reactivity of blast-furnace slags with calcium sulfate solutions was determined, and a method was developed to evaluate the properties of slags suitable for making supersulfated cements.[80] Effects of varied

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[72] Rock Products, Automatic Palletizing Invades the Packhouse: Vol. 63, No. 11, November 1960, pp. 88, 92.

[73] Rock Products, Two Lehigh Valley Cement Plants Lick Air Pollution Problem: Vol. 63, No. 2, February 1960, pp. 104–107.

[74] Building Science Abstracts (London), Present State of Development of Fabric Filters for Dust Collection in the Cement Industry: Vol. 33, No. 8, August 1960, pp. 228–229.

[75] Rock Products, Profit Control Includes Dust Control: Vol. 63, No. 7, July 1960, pp. 87–89.

[76] Wagner, H. B., Methylcellulose in Water-Retentive Hydraulic Cements: Ind. Eng. Chem., vol. 52, No. 3, March 1960, pp. 233–234.

[77] Journal of Applied Chemistry (London), Coloured Cements: Vol. 10, pt. 5, May 1960, p. 1–439.

[78] Rock Products, Study Compares Portland and Blast-Furnace Slag Cements: Vol. 63, No. 2, February 1960, pp. 60, 64.

[79] Stutterheim, N., Properties and Uses of High-Magnesia Portland Slag Cement Concretes: Jour. Am. Concrete Inst., vol. 31, No. 10, April 1960, pp. 1027–1045.

[80] Building Science Abstracts (London), On the Reactivity of Blastfurnace Slag for Supersulphated Cement: Vol. 33, No. 2, February 1960, p. 36.

curing and mixing proportions on permeability of mortars made with portland blast-furnace slag cements containing 30 percent portland cement were investigated. Increases in the ratio of sand to cement had more effect on increased permeability of mortars made with portland cement than with portland blast-furnace slag cements.[81] A patent was issued for making cement from high-magnesia water-granulated blast-furnace slag including grinding to an optimum fineness.[82]

Pozzolanic Concrete.—The importance of uniformity and dependability of the source of a pozzolanic material was discussed.[83] Selective quarrying and separation processes to reject unsuitable material were emphasized, and various milling circuits were suggested. Heat-activating techniques and pyroprocessing equipment were described. The optimum pozzolanic reactivity to alkalies and for chemical buffering purposes was reported to be dependent on exposure to different temperatures and for different times for various pozzolanic materials.

The use of pumicite as a pozzolan in the concrete for Glen Canyon Dam was reported to improve the workability of the fresh concrete and reduce the heat of hydration and permeability.[84]

Heavy Concrete.—Boron salts added to cements used with heavy aggregates for nuclear shielding increased the ability of the cement paste to capture thermolized neutrons. The boron salts prolonged the setting time of the concrete but decreased the heat of hydration.[85]

Soil Cement.—Laboratory and field tests showed that fly ash with 10 percent cement could be used satisfactorily for soil stabilization.[86]

High-alumina Cements.—Tests were conducted on concretes made from Thames Valley gravel and high-alumina cement; from the results the properties of concretes made with other types and sizes of aggregates were estimated.[87] Tests in New Zealand showed concrete made of high-alumina cement deteriorated during prolonged exposure to warm and humid conditions.[88] A high-temperature insulating refractory was developed utilizing the foaming reaction of acid and aluminum powder in high-alumina cement.[89] Russian patents were issued for use of glauconite and hydroboracite, or other borate ore, as additives to alumina cements to reduce exothermic effects during setting.[90] A process for counteracting the generation of hydrogen sulfide during the hydration of alumina cement was patented.[91]

[81] Building Science Abstracts (London), Water Permeability of Portland Blastfurnace Slag Content Containing a Large Amount of Slag: Vol. 33, No. 3, March 1960, p. 67.
[82] Kamlet, J., Hydraulic Cements: U.S. Patent 2,947,643, Aug. 2, 1960.
[83] Bauer, W. G., The Coming Role of Pozzolans: Pit and Quarry, vol. 52, No. 10, April 1960, pp. 132, 134, 136, 148; No. 12, June 1960, pp. 95–99, 134.
[84] Price, W. H., Witte, L. P., and Porter, L. C., Concrete and Concrete Materials for Glen Canyon Dam: Jour. Am. Concrete Inst., vol. 32, No. 6, December 1960, pp. 629–648.
Utley, H. F., 10,000,000 Tons of Aggregates: Pit and Quarry, vol. 52, No. 10, April 1960, pp. 138–145, 148.
[85] Campbell-Allen, P., Thorne, C. P., Malinowski, R., and Henrie, J. O., Discussion of Properties of Nuclear Shielding Concrete: Jour. Am. Concrete Inst., vol. 9, No. 13, March 1960, pp. 923–928.
[86] Building Science Abstracts (London), Laboratory and Field Tests on Cement-Stabilized Pulverized-Fuel ash: Vol. 33, No. 8, August 1960, p. 228.
[87] Building Science Abstracts (London), The Design of Concrete Mixes With High-alumina Cement: Vol. 33, No. 8, August 1960, p. 228.
[88] Building Science Abstracts (London), Tests on the Strength of High-alumina Cement Concrete: Vol. 33, No. 6, June 1960, p. 166.
[89] Building Science Abstracts (London), Development of a Foamed Alumina Cement: Vol. 32, No. 11, November 1959, p. 323.
[90] Kuratsyov, M. S., Zhuravlev, F. F., and Novikov, P. I.: Russian Patent 127,602, Mar. 25, 1960.
Levin, N. I., Il'na, N. V., and Telegina, A. S.; Russian Patent 127,603, Mar. 25, 1960.
[91] Zehrlaut, H. A. R. (assigned to Zeco Research Corp., Tallahassee, Fla.), Process of Treating Aluminous Cement and Product: U.S. Patent 2,919,997, Jan. 5, 1960.

Chromium

By Wilmer McInnis [1] and Hilda V. Heidrich [2]

ALTHOUGH domestic consumption and imports of chromite ores declined from 1959, estimated world production increased because of improved foreign demand, mainly in Western Europe. Domestic producers of chromium ferroalloys operated at less than half capacity during the last 6 months of 1960, whereas producers of chromite refractories and chromium chemicals operated at a slightly higher level than in 1959.

LEGISLATION AND GOVERNMENT PROGRAMS

The General Services Administration (GSA) offered for sale approximately 1,600 long tons of chromite ore and about 100 long tons of nodulized chromite concentrate that had been declared in excess of defense requirements on August 14, 1959. However, no acceptable bids were received for the material, and GSA announced plans to negotiate its disposal. In September 1960, GSA announced plans to dispose of an additional 89,750 long tons of domestic chromite ore and 151,000 long tons of chromium ferroalloys that were declared in excess of stockpile needs.

All three grades of chromite (chemical, metallurgical, and refractory) were eligible for acquisition under the agricultural barter pro-

TABLE 1.—Salient chromite statistics

	1951-55 (average)	1956	1957	1958	1959	1960
United States:						
Production (shipments) short tons	80,800	[1] 207,700	166,200	143,800	[2] 105,000	[2] 107,000
Value thousands	$3,906	$8,715	$7,815	$6,187	[3] $3,765	[3] $3,813
Imports for consumption short tons	1,733,000	2,175,000	2,283,000	1,263,000	1,554,000	1,387,000
Exports do	1,400	1,700	800	700	[4] 11,000	5,000
Consumption do	1,247,000	1,847,000	1,760,000	1,221,000	1,337,000	1,220,000
Stocks Dec. 31: Consumer do	957,000	1,227,000	1,619,000	1,537,000	1,800,000	1,707,000
World: Production do	3,890,000	4,565,000	5,110,000	4,165,000	4,350,000	4,920,000

[1] Includes 45,710 short tons of concentrate produced in 1955 and 1956 from low-grade ore and concentrate stockpiled near Coquille, Oreg., during World War II.
[2] Produced for Federal Government only.
[3] Estimated by Bureau of Mines.
[4] Revised figure.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

gram. The Commodity Credit Corporation (CCC), U.S. Department of Agriculture, exchanged surplus agricultural products for chromite ore, chromium ferroalloys, and chromium metal as a result of contracts signed during 1960 and in prior years.

Government financial assistance for exploring domestic chromite deposits was available upon approval by the Office of Minerals Exploration (OME), but no contracts were entered into during 1960.

DOMESTIC PRODUCTION

All chromite produced in the United States was from the Stillwater complex in Montana. American Chrome Co. produced over 200,000 tons of ore, averaging about 20 percent Cr_2O_3, from the Mouat mine at Nye, Mont. The ore was beneficiated in the firm's mill near the mine site to a concentrate containing approximately 38.5 percent Cr_2O_3. A total of 107,000 short tons of chromite concentrate was shipped to the Federal Government stockpile, and more was consumed in the firm's ferrochromium pilot plant. No other domestic chromite was reported consumed in the production of chromium ferroalloys.

American Chrome Co. installed another electric furnace during 1960 for use in studies on refining charge ferrochromium.

TABLE 2.—Chromite production (mine shipments) in the United States, by States

(Short tons, gross weight)

State	1956	1957	1958	1959		1960	
				Shipments	Value	Shipments	Value
Alaska	7,193	4,207					
California	27,082	34,901	20,588	(1)			
Montana	118,780	119,149	119,057	[2] 105,000	[3] $3,765,000	[2] 107,000	[3] $3,813,000
Oregon	[4] 54,577	7,900	4,133				
Washington	30		17				
Total	[4] 207,662	166,157	143,795	[2] 105,000	[3] 3,765,000	[2] 107,000	[3] 3,813,000

[1] Small quantity produced; Bureau of Mines not at liberty to publish.
[2] Dry weight; excludes quantity consumed by American Chrome Co.
[3] Estimate.
[4] Includes 45,710 short tons of concentrate produced in 1955 and 1956 from low-grade ore and concentrate stockpiled near Coquille, Oreg., during World War II.

CONSUMPTION AND USES

Domestic consumption of chromite ores and concentrates declined 9 percent because of decreased demand for chromium ferroalloys in the last three quarters of the year. The metallurgical industry consumed 17 percent less chromite ores and concentrates, but the refractory and chemical industries consumed 3 and 2 percent more, respectively.

The metallurgical industry used 652,000 short tons of chromite containing about 207,000 tons of chromium in producing 280,000 tons of chromium ferroalloys and chromium metal. In addition, 13,000 tons of chromite ore containing 4,300 tons of chromium was used directly in alloying steel. Of the 652,000 tons of chromite consumed in making chromium ferroalloys and metal, 82 percent (47.3 percent Cr_2O_3) was metallurgical-grade ore, 14 percent (44.7 percent Cr_2O_3) chemical-grade ore, and 4 percent (33.7 percent Cr_2O_3) refractory-grade ore. Sixty-seven percent of the metallurgical-grade ore had a Cr/Fe ratio of 3:1 and above, 29 percent a ratio between 2:1 and 3:1, and 4 percent a ratio of less than 2:1.

Chromium ferroalloy plants were operated well below capacity during the last three quarters of 1960. Production of chromium ferroalloy products declined from about 110,000 short tons in the first quarter to 43,000 tons in the fourth quarter. Vanadium Corporation of America closed its ferroalloy plant at Niagara Falls, N.Y. The plant had been in operation since 1925, and about 320 persons were employed when its closure was announced.[3] Metal & Thermit Corp. suspended indefinitely the production of aluminothermic chromium metal at its Carteret, N.J., plant.

Ticromet, Inc. produced high-purity chromium crystals by a fused-salt electrolytic process for use in making high-temperature and other special alloys where low interstitial content is desired.

Although the chormium content of the ferrochromium produced ranged from about 50 percent chromium in charge ferrochromium to approximately 72 percent chromium in some grades of low-carbon ferrochromium, the average chromium content was 64 percent in high-carbon ferrochromium, and 67 percent in low-carbon ferrochromium. Some producers discontinued some grades of chromium ferroalloys, whereas others changed the specifications of their products in order to standardize on fewer grades. The production of all grades of chromium ferroalloys and chromium metal declined 14 percent.

Consumption of chromium ferroalloys and chromium metal during the first quarter of 1960 totaled 97,000 short tons, but consumption declined sharply during the remainder of the year when the production of alloy steel, in which 94 percent of the chromium contained in products is used, was reduced. Many small consumers were not canvassed, and the data in table 5 represent about 90 percent of the total chromium ferroalloys and chromium metal consumed in the United States during 1960.

TABLE 3.—Consumption of chromite and tenor of ore used by primary consumer groups in the United States

(Thousand short tons)

Year	Metallurgical		Refractory		Chemical		Total	
	Gross weight	Average Cr_2O_3 (percent)	Gross weight	Average Cr_2O_3 (percent)	Gross weight	Average Cr_2O_3 (percent)	Gross weight	Average Cr_2O_3 (percent)
1951-55 (average)	698	46.9	396	34.2	153	44.5	1,247	42.7
1956	1,212	46.8	475	34.4	160	45.4	1,847	43.5
1957	1,177	47.1	435	34.8	148	45.0	1,760	43.9
1958	778	46.9	312	35.2	131	45.6	1,221	43.8
1959	796	46.7	379	35.0	162	45.4	1,337	43.2
1960	665	46.4	391	34.9	164	45.3	1,220	42.6

[3] American Metal Market, Vanadium Plans to Shut Niagara Plant: Vol. 67, No. 88, May 9, 1960, p. 1.

Consumption of chromite ores and concentrates by the producers of chromite-bearing refractories was the highest since 1957. The increased consumption was attributed mainly to greater use of basic refractories in roofs of open-hearth steel furnaces. The open-hearth furnaces reportedly operating with basic roofs increased from 1 in 1954 to over 200 at the start of 1960.[4] Chrome-magnesite and magnesite-chrome compositions made from coarse chromite grains mixed with coarse and fine or all-fine grains of high-quality magnesite were said to have been used in making the most successful brick used in the basic roofs of open-hearth furnaces.

The producers of chromium chemicals consumed more chromite ores and concentrates than in any year since 1951. Production of chromium chemicals totaled 122,000 short tons, sodium bichromate equivalent. Columbia-Southern Chemical Corp., a subsidiary of Pittsburgh Plate Glass Co., announced plans to build a multimillion dollar chromium chemicals plant at Corpus Christi, Tex. Solvay Process

TABLE 4.—Production, shipments, and stocks of chromium ferroalloys and chromium metal in 1960

(Short tons, gross weight)

Alloy	Net production	Chromium contained	Shipments	Producers stocks, Dec. 31
Low-carbon ferrochromium	99,271	67,152	101,531	25,279
High-carbon ferrochromium	94,517	60,707	93,234	32,559
Ferrochromium silicon	60,034	25,539	56,338	14,283
Other [1]	26,421	12,656	26,197	3,892
Total	280,243	166,054	277,300	76,013

[1] Includes chromium briquets, chromium metal, exothermic chromium additives, and other miscellaneous chromium alloys.

TABLE 5.—Consumption of chromium ferroalloys and metal in the United States in 1960, by major end uses, and consumer stocks Dec. 31

(Short tons)

	Low-carbon ferro-chromium	High-carbon ferro-chromium	Ferro-chromium silicon	Exothermic ferro-chromium silicon	Chromium briquets	Other [1]	Total
Stainless steels	49,617	28,827	17,530	6	[2] 5,249	43	101,272
High-speed steels	271	494					765
Other tool steels	498	974	3			3	1,478
Other alloy steels [3]	7,681	18,581	1,900	2,119	244	7,530	38,055
Gray and malleable iron	315	2,010		60	202	200	2,787
High-temperature alloys	3,264	196	49		5	995	4,509
Nickel-base alloys	249	28	3	6		62	348
Other alloys	239	704	5			547	1,495
Total (contained chromium)	62,134	51,814	19,490	2,191	5,700	9,380	150,709
Total (gross weight)	92,026	82,000	43,636	5,613	9,682	19,155	252,112
Stocks on hand (gross weight)	5,125	5,427	3,061	771	695	1,451	16,530

[1] Includes exothermic high- and low-carbon ferrochromium, chromium metal, and other chromium alloys
[2] Believed to be low-carbon ferrochromium.
[3] Includes quantities that were believed used in producing high-speed and other tool steels and stainless steels because some firms failed to specify individual uses.

[4] Fay, Mervin A., Basic Roof Performance in American Open Hearth Furnaces, Blast Furnace and Steel Plant: Vol. 48, No. 4, April 1960, pp. 372–376, 386–387.

TABLE 6.—End use of individual chromium ferroalloys and chromium metal in the United States in 1960

(Percent in contained weight)

Alloy	Stainless steels	High-speed steels	Other tool steels	Other alloy steels	Gray and malleable castings	High temperature alloys	Nickel base alloys	Other alloy
Low-carbon ferrochromium	79.9	0.4	0.8	12.4	0.5	5.2	0.4	0.4
High-carbon ferrochromium	55.6	1.0	1.9	35.9	3.9	.4	----	1.3
Ferrochromium-silicon	90.0	----	----	9.7	----	.3	----	----
Chromium briquets	[1] 92.1	----	----	4.3	3.6	----	----	----
Exothermic ferochromium-silicon	.3	----	----	96.7	2.7	----	.3	----
Low-carbon exothermic ferrochromium	----	----	----	97.4	.2	2.4	----	----
High-carbon exothermic ferrochromium	----	----	----	97.0	2.0	----	----	1.0
Chromium metal	2.5	----	.2	10.4	.5	56.1	3.5	26.8
Other chromium alloys	----	----	----	----	100.0	----	----	----

[1] Believed to be low-carbon ferrochromium.

Division, Allied Chemical Corp. was reported to have started expanding its research and technical service laboratory at Syracuse, N.Y., to provide additional space for studies on chromium chemicals and other products.[5] MacDermid, Inc., was reported to have started expanding its research and development laboratory at Waterbury, Conn., to provide additional space for research on chromate conversion coating, a copper plating process, cleaners, and other metal finishing compounds.[6]

STOCKS

The stocks of chromite ores and concentrates given in table 7 include industry stocks at all locations but do not include Government stockpiles.

Compared with 1959, stocks of chromium ferroalloys and chromium metal at producer plants increased 5 percent, but stocks at consumer plants decreased 43 percent.

Chromium chemicals at producer plants at the end of 1960 amounted to 19,417 short tons, sodium bichromate equivalent.

TABLE 7.—Stocks of chromite at consumer plants, Dec. 31

(Thousand short tons)

Industry	1956	1957	1958	1959	1960
Metallurgical	640	849	749	[1] 955	[1] 863
Refractory	432	610	612	730	719
Chemical	155	160	176	115	125
Total	1,227	1,619	1,537	[1] 1,800	[1] 1,707

[1] Includes stocks at locations other than consumer plants.

[5] Chemical Engineering: Vol. 67, No. 23, Nov. 14, 1960, p. 122.
[6] Steel, New Plants: Vol. 146, No. 16, Apr. 18, 1960, pp. 118, 122.

PRICES

Prices quoted by E&MJ Metal and Mineral Markets increased slightly for most grades of chromite ores and concentrates.

Some grades of chromium ferroalloys were reduced in price by 10 to 15 percent during the first half of 1960.[7] The yearend prices quoted by E&MJ Metal and Mineral Markets for lump material in bulk carload lots, delivered, per pound of contained chromium were: High-carbon ferrochromium (4–9 percent carbon, 65 to 70 percent chromium), 28.75 cents; low-carbon ferrochromium (0.10 percent carbon, 65 to 71 percent chromium), 33.75 cents; special low-carbon ferrochromium (0.25 percent carbon, 63 to 66 percent chromium), 35 cents; charge ferrochromium, 22.50 cents; and refined ferrochromium, 26 cents.

Electrolytic chromium metal (99.8 percent pure) and aluminothermic chromium metal (98.5 percent chromium, 0.05 percent carbon) were quoted at $1.15 to $1.19 per pound delivered, depending on size of lot. Vacuum grade electrolytic chromium was quoted at $1.19 to $1.23 cents per pound.

TABLE 8.—Price quotations for various grades of foreign chromite in 1960

Source	Cr_2O_3 (percent)	Cr/Fe ratio	Price per long ton [1]	
			Jan. 1	Dec. 31
Rhodesia [2]	48	3:1	$34.00–35.00	$35.75–36.25
Do	48	2.8:1	30.00–32.00	32.00–33.50
Do	48		25.00–26.00	27.00–28.00
Union of South Africa	48		24.00–26.00	25.50–27.00
Do	44		18.25–19.00	19.75–20.50
Turkey	48	3:1	36.00–37.00	36.00–38.00
Do	46	3:1	33.50–34.00	33.50–34.00

[1] Quotations are on a dry basis, subject to penalties if guarantees are not met, f.o.b. cars, east coast ports.
[2] Term contract.

Source: E&MJ Metal and Mineral Markets.

FOREIGN TRADE [8]

Imports.—Imports of chromite ores and concentrates declined 11 percent. Metallurgical-grade ore (46.0 percent Cr_2O_3) consisted of 39 percent of the imports, refractory-grade (33.4 percent Cr_2O_3) 34 percent, and chemical-grade (44.1 percent Cr_2O_3), 27 percent. Of the 1.4 million tons imported, 36 percent was from the Union of South Africa, 23 percent from the Federation of Rhodesia and Nyasaland, 28 percent from the Philippines, 9 percent from Turkey, and 4 percent from five other countries.

Chromium metal imports totaled 908 short tons valued at $1,645,432; 514 tons was from the United Kingdom, 208 tons from France, 64 tons from West Germany, and 122 tons from Japan. Of the 908 short tons, 673 tons valued at $1,273,140 entered duty free for the U.S. Government. Of the ferrochromium imports given in table 10, 94 percent

[7] American Metal Market, Ferroalloy Prices Reported Being Cut: Vol. 67, No. 49, Mar. 14, 1960, pp. 1, 8.
[8] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

of the quantity containing 3 percent or more carbon, and 68 percent of the quantity containing less than 3 percent carbon entered duty free for the U.S. Government. Sodium chromate and sodium bichromate imports totaled 1,902 tons valued at $370,146.

Exports.—Exports of chromium products included 15,588 short tons of ferrochromium valued at $5,248,750, 982 tons of chromic acid valued at $545,728, and 9,595 tons of sodium bichromate and chromate valued at $2,214,125. Reexports of chromium and chromium-bearing alloys in crude form and scrap totaled 60 tons valued at $16,215, and chromium and chromium alloys in semifabricated forms totaled 2 tons valued at $12,970.

Tariff.—There were no import duties on chromite ores and concentrates. Duties on chromium products, under various trade agreements to the Tariff Act of 1930, from all countries except the U.S.S.R. and other designated Communist countries and areas were: Chromium metal, and ferrochromium containing under 3 percent carbon, 10½ percent ad valorem; ferrochromium containing 3 percent or more carbon, ⅝ cent per pound of contained chromium; and chromium-carbide, chromium-nickel, chromium-silicon, chromium-vanadium, chrome green, and other colors containing chromium, 12½ percent ad valorem.

Duties on imports from all countries for other products were: Chrome brick and shapes, 25 percent ad valorem; sodium chromate and bichromate, 1¾ cents per pound; and potassium chromate and bichromate, 2¼ cents per pound.

WORLD REVIEW

World production of chromite ores and concentrates during 1960 rose 13 percent, mainly because of increased European demand and U.S. barter contracts.

NORTH AMERICA

Cuba.—The Cuban Government reportedly signed trade agreements with East Germany, Rumania, and Poland involving the exchange of chromite ore and concentrate for products from those Communist nations.

EUROPE

Finland.—Preliminary drilling of a chromite deposit in north Finland indicated an ore reserve of more than 15 million tons averaging about 20 percent Cr_2O_3. Samples of the chromite mineral analyzed by the Finnish State Geological Research Institute contained 44 to 47.5 percent Cr_2O_3, 18 to 27 percent Fe, and 6.5 to 9 percent MgO.[9]

Greece.—Large deposits of metallurgical-grade chromite reportedly were discovered in the Kozani area.[10] The Greek firm, Hellenic Mines, S.A., and the French firm, Compagnie de Produits Chimiques et Electro-Metallurgiques (Pechiney), were considering the development of the deposits and the construction of a ferrochromium plant.

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[9] Bureau of Mines, Mineral Trade Notes: Vol. 51, No. 4, October 1960, pp. 25–26.
[10] U.S. Embassy, Athens, Greece, State Department Dispatch 415: Nov. 8, 1960, p. 2.

TABLE 9.—U.S. imports for consumption of chromite, by grades and countries

Year and country	Metallurigical grade			Refractory grade			Total		
	Short tons		Value	Short tons		Value	Short tons		Value
	Gross weight	Cr_2O_3		Gross weight	Cr_2O_3		Gross weight	Cr_2O_3	
1959:									
North America:									
Cuba	36,876	15,985	[1] $910,466	6,856	2,423	$166,695	43,732	18,408	[1] $1,077,161
Guatemala	1,500	720	75,000				1,500	720	75,000
Total	38,376	16,705	[1] 985,466	6,856	2,423	166,695	45,232	19,128	[1] 1,152,161
Europe:									
Greece	7,871	3,918	310,064				7,871	3,918	310,064
U.S.S.R.	63,143	30,579	2,196,437				63,143	30,579	2,196,437
Total	71,014	34,497	2,506,501				71,014	34,497	2,506,501
Asia:									
India	8,437	4,005	283,769				8,437	4,005	283,769
Iran	3,360	1,613	123,000				3,360	1,613	123,000
Philippines	47,366	21,594	965,135	310,912	101,276	5,684,950	358,278	122,870	6,650,085
Turkey	159,082	73,737	4,681,158				159,082	73,737	4,681,158
Total	218,245	100,949	6,053,062	310,912	101,276	5,684,950	529,157	202,225	11,738,012
Africa:									
Rhodesia and Nyasaland, Federation of	429,630	200,001	[1] 10,192,440	20,700	7,495	479,355	450,330	207,496	[1] 10,671,795
Union of South Africa	81,008	36,540	1,143,748	62,752	26,080	717,414	[2] 444,000	[2] 194,937	[2] 5,478,544
Total	510,638	236,541	[1] 11,336,188	83,452	33,575	1,196,769	[2] 894,330	[2] 402,433	[1,2] 16,150,339
Oceania: New Caledonia [3]	13,813	7,180	378,900				13,813	7,180	378,900
Grand total	852,086	395,872	[1] 21,260,117	401,220	137,274	7,048,414	[2] 1,553,546	[2] 665,463	[1,2] 31,925,913
1960:									
North America: Cuba				32,774	10,968	722,704	32,774	10,968	722,704
Europe:									
Greece	2,352	1,279	80,102				2,352	1,279	80,102
Latvia	71	29	2,450				71	29	2,450
U.S.S.R.	7,148	3,288	150,994				7,148	3,288	150,994
Total	9,571	4,596	233,546				9,571	4,596	233,546

Asia:									
India	4, 520	2, 486	176, 188				4, 520	2. 486	176, 188
Philippines	16, 878	7, 332	305, 260	376, 282	120, 371	7, 059, 806	393, 160	127, 703	7, 365, 066
Turkey	122, 665	56, 660	2, 891, 536				122, 665	56, 660	2, 891, 536
Total	144, 063	66, 478	3, 372, 984	376, 282	120, 371	7, 059, 806	520, 345	186, 849	10, 432, 790
Africa:									
Mozambique				1, 122	489	11, 530	1, 122	489	11, 530
Rhodesia and Nyasaland, Federation of	307, 142	141, 705	7, 078, 820	15, 693	6, 391	338, 584	[2] 323, 218	[2] 148, 250	[2] 7, 424, 336
Union of South Africa	80, 556	36, 102	982, 835	52, 049	21, 478	481, 417	[2] 499, 592	[2] 219, 487	[2] 5, 414, 155
Total	387, 698	177, 807	8, 061, 655	68, 864	28, 358	831, 531	[2] 823, 932	[2] 368, 226	[2] 12, 850, 021
Grand total	541, 332	248, 881	11, 668, 185	477, 920	159, 697	8, 614, 041	[2] 1, 386, 622	[2] 570, 639	[2] 24, 239, 061

[1] Revised figure.
[2] Includes chemical grade 1959: Union of South Africa 300, 240 short tons, gross weight, 132,317 short tons Cr_2O_3, valued at $3,617,382; 1960: Federation of Rhodesia and Nyasaland 383 short tons, gross weight, 154 short tons Cr_2O_3, valued at $6,932; Union of South Africa 366,987 short tons, gross weight, 161,907 short tons Cr_2O_3, valued at $3,949,903.
[3] Assumed source; classified in import statistics under "French Pacific Islands".

Source: Bureau of the Census.

TABLE 10.—U.S. imports for consumption of ferrochromium, by countries

Year and country	Low-carbon ferrochromium (less than 3 percent carbon)			High-carbon ferrochromium (3 percent or more carbon)		
	Short tons		Value	Short tons		Value
	Gross weight	Chromium content		Gross weight	Chromium content	
1959:						
North America: Canada	30	22	$10,763	3,995	2,706	$1,063,281
Europe:						
France	9,813	6,900	3,680,531	2,254	1,546	762,038
Germany, West	4,706	3,364	1,715,135	10,288	7,272	2,779,491
Italy				9,192	6,159	2,326,337
Norway	3,780	2,602	1,467,487	8,728	5,982	2,280,485
Sweden	5,753	4,007	2,190,389	2,543	1,735	623,984
United Kingdom				5,237	3,597	1,443,290
Yugoslavia	1,858	1,315	620,049			
Total	25,910	18,188	9,673,591	38,242	26,291	10,215,625
Asia: Japan	9,536	6,322	3,776,561	8,070	5,430	2,562,601
Africa:						
Rhodesia and Nyasaland, Federation of	1,680	1,190	528,641			
Union of South Africa				5,868	3,917	1,918,925
Total	1,680	1,190	528,641	5,868	3,917	1,918,925
Grand total	37,156	25,722	13,989,556	56,175	38,344	15,760,432
1960:						
North America: Canada				1,115	752	289,235
Europe:						
France	2,493	1,782	916,264	4,508	3,111	1,164,177
Germany, West	2,355	1,693	794,416	5,732	4,117	1,546,541
Italy				7,041	4,731	1,694,147
Norway	4,764	3,270	1,783,423	4,422	3,036	1,129,856
Sweden	1,805	1,289	650,848	1,385	940	348,018
United Kingdom				7,180	4,974	1,929,920
Yugoslavia	614	435	218,953			
Total	12,031	8,469	4,363,904	30,268	20,909	7,812,659
Asia: Japan	2,725	1,828	938,957	2,077	1,394	551,573
Africa:						
Rhodesia and Nyasaland, Federation of	1,106	790	334,776			
Union of South Africa				65	44	21,539
Total	1,106	790	334,776	65	44	21,539
Grand total	15,862	11,087	5,637,637	33,525	23,099	8,675,006

Source: Bureau of the Census.

TABLE 11.—U.S. exports of chromite ore and concentrates

Year	Exports [1]		Reexports [2]	
	Short tons	Value	Short tons	Value
1951–55 (average)	1,386	$79,961	9,182	$413,747
1956	1,727	99,169	12,990	501,938
1957	837	52,579	4,872	193,546
1958	717	48,829	52,303	2,157,966
1959	[3] 11,080	[3] 530,714	[4] 26,591	[3] 1,064,612
1960	5,184	320,179	19,927	720,575

[1] Material of domestic origin or foreign material that has been ground, blended, or otherwise processed in the United States.
[2] Material that has been imported and later exported without change of form.
[3] Revised figure.
[4] Adjusted by Bureau of Mines.

Source: Bureau of the Census.

TABLE 12.—World production of chromite by countries [1] [2]

(Short tons)

Country [1]	1951-55 (average)	1956	1957	1958	1959	1960
North America:						
Cuba	78,281	59,248	127,126	[3] 82,800	[4] 43,732	[4] 32,774
Guatemala	439	979	[3] 1,100	1,168	452	200
United States	80,759	[5] 207,662	166,157	143,795	[6] 105,000	[6] 107,000
Total	159,479	267,889	294,383	227,763	149,184	139,974
South America: Brazil	3,235	4,536	8,748	6,336	6,177	5,233
Europe:						
Albania	87,500	145,500	184,000	221,800	272,300	[3] 330,700
Greece	32,261	86,920	80,020	72,217	88,185	[3] 110,200
Portugal	36	----------	----------	----------	----------	----------
U.S.S.R. [3] [7]	685,000	815,000	850,000	880,000	940,000	1,010,000
Yugoslavia	128,862	130,913	132,570	125,188	117,965	111,170
Total [1] [3]	955,000	1,200,000	1,270,000	1,320,000	1,440,000	1,590,000
Asia:						
Cyprus (exports)	11,521	5,858	5,678	13,260	13,637	15,702
India	56,564	59,009	87,968	70,500	93,936	110,354
Iran [8]	23,468	36,156	42,549	[3] 38,600	[3] 55,000	[3] 55,000
Japan	40,787	43,947	51,216	46,155	63,578	74,398
Pakistan	24,329	25,487	18,114	26,935	17,662	19,945
Philippines	536,024	781,598	799,733	458,903	720,345	809,579
Turkey	773,887	918,305	1,052,665	574,194	427,324	528,690
Total [7]	1,466,580	1,870,360	2,057,923	1,228,547	1,391,482	1,613,668
Africa:						
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	509,511	448,965	654,072	618,841	543,104	668,401
Sierra Leone	23,194	21,929	17,602	15,944	19,974	6,023
Union of South Africa	668,598	690,851	733,612	696,057	749,873	850,916
United Arab Republic, (Egypt Region)	348	281	114	----------	275	----------
Total	1,201,651	1,162,026	1,405,400	1,330,842	1,313,226	1,525,340
Oceania:						
Australia	2,344	6,828	3,415	869	134	----------
New Caledonia	99,014	53,932	70,768	52,249	48,463	43,211
Total	101,358	60,760	74,183	53,118	48,597	43,211
World total (estimate) [1]	3,890,000	4,565,000	5,110,000	4,165,000	4,350,000	4,920,000

[1] In addition to countries listed, Bulgaria and Rumania produce chromite, but data on output are not available; estimates by senior author of chapter included in total.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Estimate.
[4] United States imports.
[5] Includes 45,710 short tons of concentrates produced in 1955-56 from low-grade ores and concentrates stockpiled near Coquille, Oregon during World War II.
[6] Produced for Federal Government only; excludes quantity consumed by American Chrome Company.
[7] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.
[8] Year ended March 20 of year following that stated.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

Yugoslavia.—Geological prospecting in Kosovo and Mehohiya in southwest Serbia was reported to have resulted in the discovery of new reserves of chromite.[11]

ASIA

Iran.—Chromite was produced in the northeast and southwest parts of Iran during 1960. In the northeast the major deposits were near the village of Forumad. Deposits in the southeast were in the area

[11] Mining World, Europe: Vol. 22, No. 6, May 1960, p. 99.

of Esfandeqeh, northeast of the port of Bandar-Abbas. The chromite resources in Iran, the history of mining, mining methods, and mining costs were the subject of a paper delivered during a symposium on chromite held in Ankara, Turkey.[12] According to that report, potential reserves of chromite in northeast Iran were estimated at 1 million tons, and those in the southeast part of the country were believed to be considerably more than 1 million tons.

The Iranian Foreign Investments Board approved an investment of $522,666 by Philipp Brothers Ore Corp. to explore and exploit the Shahriar and Shahine chromite mines, north of Bandar-Abbas.

Pakistan.—The Government of Pakistan sponsored additional exploration for chromite in west Pakistan and reported that high-grade chromite deposits found in the Kharean and Ras Koh Mine areas were likely to be developed in the near future.[13] A plan to increase chromite production from 18,000 tons to 50,000 tons a year by 1964 was reported to have been finalized by the Government of Pakistan.

Philippines.—Refractory-grade chromite ore consisted of about 82 percent of the total chromite produced in the Philippines during 1960. Exports of refractory-grade ore totaled 658,000 short tons; 53 percent was shipped to the United States, 26 percent to the United Kingdom, and 21 percent to six other countries. Virtually all exports of metallurgical-grade chromite went to Japan.

Exploratory diamond drilling and geological mapping on the Insular Chromite Reservation Number One, Zambales Range, in Western Luzon located three main ore bodies with total indicated reserves of about 670,000 short tons of ore similar in physical and chemical characteristics to the chromite ore in the Coto deposit.[14]

Turkey.—Production and exports of chromite were at a low level during the early part of 1960, but improved European demand and a barter contract with the U.S. Department of Agriculture involving the exchange of wheat for chromite stimulated both production and exports during the last half of the year. The ore produced contained 247,000 short tons of Cr_2O_3. Exports of ore to all countries totaled 426,000 tons compared with approximately 337,000 tons in 1959.

Considerable technical data on the Guleman, Kavak, and Sazak chromite mines and other chromite deposits and operations in Turkey were made available during a symposium held in Ankara during September 26–29, 1960. The symposium was organized under the auspices of the United States Economic Coordinator for the Central Treaty Organization (CENTO). About 40 government and private representatives of the chromite ore industry from the CENTO area and from the United States and the United Kingdom attended the meetings. Twenty-two technical papers were delivered during the proceedings.

A plant capable of producing 8,000 tons of ferrochromium and 4,000 tons of calcium carbide annually was being constructed near Antalya. The plant, being constructed by Elecktrometalurji Sanayii Anonim

[12] Central Treaty Organization, The CENTO Symposium on Chromite, Chromite in Iran: Ankara, Turkey, September 1960, 25 pp.

[13] Mining Journal (London), Expansion of Pakistan's Chromite Output: Vol. 255, No. 6524, Sept. 2, 1960, p. 265.

[14] Rossman, Dorwin L., Fernandez, Norberto S., Fontanos, Conrado A., and Zepeda, Zoilo C., Chromite Deposits on Insular Chromite Reservation Number One, Zambales, Philippines: Bureau of Mines, Republic of the Philippines (Manila), 1959, 12 pp.

Sirketi (ESAS) was 60-percent owned and controlled by Etibank (State agency), and 40 percent owned by a French combine consisting of Pechiney and Compagnie Pour l'Etude de Developpment des Eschanges Commerciaux (Compadec).[15] It was said that the French group would supervise equipment installations and provide technical assistance in operating the plant upon its completion. The planned production schedule was for 6,000 tons of low-carbon ferrochromium and 2,000 tons of high-carbon ferrochromium annually; about half would be marketed in Europe by Pechiney.

AFRICA

Malagasy Republic (formerly Madagascar and Dependencies).—Société Electro-Chimie d'Electro-Metallurgie et des Acieries Electriques d'Ugine (Ugine) planned to develop chromite deposits in the Andriamena-Teleomita region of Malagasy. It was reported that exploration had disclosed an ore reserve of about 700,000 tons and a probable reserve of 2 million tons. The ore averaged 30 to 35 percent Cr_2O_3 with a Cr/Fe ratio ranging from about 1.7:1 to 2.9:1.

Rhodesia and Nyasaland, Federation of.—In 1960, chromite production in Southern Rhodesia was higher than in any prior year. Considerable information on chromite occurrences, geology, reserves, mining methods, names and addresses of producers, and the history of chromium in the Federation of Rhodesia and Nyasaland was published.[16] Chromite ore reserves were estimated at 608 million tons; the reserves consisted of about 50 percent metallurgical-grade ore and 50 percent chemical- and refractory-grade ores combined. All three grades were produced during 1960, and it was estimated that the ratio of production was metallurgical-grade ore 55 percent, chemical-grade ore 28 percent, and refractory-grade ore 17 percent.

A number of small mines closed because of increased costs and decreased demand. Nearly 70 percent of the total output was reported produced by Rhodesia Chrome Mines, Ltd. in the Northern area of the Great Dyke, 15 percent by Rhodesian Vanadium Corp. in the Great Dyke area, and about 15 percent by all other producers. The first two firms operated at about 100 percent capacity; all other firms operated at 50 percent or less capacity at yearend.[17]

Rhodesian Alloys, Inc., announced plans to expand its ferrochromium plant at Gwelo, Southern Rhodesia. The decision to expand the plant was said to have been due to a forecast by the Federal Power Board that the cost of electrical power would be reduced substantially within a few years.

Union of South Africa.—Production of chromite ores and concentrates in the Union of South Africa was higher during 1960 than in any prior year. Approximately 92 percent of the 865,000 tons shipped was exported, and about 8 percent was sold locally for producing chromium chemicals and other chromium products.

[15] U.S. Embassy, Ankara, Turkey, State Department Dispatch 489: Encl. 1, Mar. 20, 1961, pp. 1–2.
[16] Stanley R., Chromium in Southern Rhodesia: Mines Department, Southern Rhodesia Government, undated, 21 pp.
[17] American Consulate, Salisbury, Southern Rhodesia: State Department Dispatch 475: Jan. 6, 1961.

The National Science Foundation granted $29,000 for continued basic research on chromite in the Bushveld complex.[18]

TECHNOLOGY

Federal Bureau of Mines research on chromium during 1960 was directed mainly toward beneficiating low-grade chromite-bearing materials by flotation and gravity methods, extracting chromium directly from chromite concentrate by electrolytic techniques, and improving the efficiency of pyrometallurgical techniques for recovering chromium during electric-furnace smelting. Results of studies by Bureau of Mines researchers on the beneficiation and utilization of low-grade domestic chromite materials, preparation of high-purity chromium by the electrolysis of chromium trioxide, fused-salt electrorefining chromium, and the measurement of heats of combustion and formation of chromium subnitride were published.[19]

The ferroalloy industry started using oxygen top-blowing techniques to refine ferrochromium. The new process was said to be less costly than the second-stage furnace operation used previously in reducing the carbon and silicon contents of ferrochromium.

Literature published on the technology of chromium contained information on the mineralogy and types of geologic occurrence of chromite, a high tension and magnetic process for beneficiating chromiferous sands, the effect of fluoride or fluosilicate on current efficiency in electrodepositing high-purity chromium from fluoride-containing electrolytes, and chemical equilibrium studies of the iron-chromium-oxygen, and chromium-iron-sulfur systems.[20] The corrosion resistance and other properties of chromate conversion coatings were published.[21] Chromium compounds were used experimentally to reduce the nitric oxides expelled by automobile exhausts.[22] Research to improve chromium plating processes reportedly resulted in the development of a process for depositing chromium free from pores over a two-layered nickel plate on die-cast zinc automobile parts.[23]

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[18] Skillings' Mining Review, South Africa Chromite Deposit Under Study: Vol. 49, No. 31, Oct. 29, 1960, p. 16.

[19] Sullivan, G. V., and Stickney, W. A., Flotation of Pacific Northwest Chromite Ores: Bureau of Mines Rept. of Investigations 5646, 1960, 14 pp.

Hunter, W. L., and Sullivan, G. V., Utilization Studies on Chromite From Seiad Creek, Calif.: Bureau of Mines Rept. of Investigations 5576, 1960, 37 pp.

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Cattoir, F. R., and Baker, D. H., Jr., Electrorefining Chromium: Bureau of Mines Rept. of Investigations 5682, 1960, 15 pp.

Mah, Alla D., Heats of Combustion and Formation of Molybdenum Subnitride and Chromium Subnitride: Bureau of Mines Rept. of Investigations 5529, 1960, 7 pp.

[20] Heiligman, Harold A., and Mikami, Harry M., Chromite: Ind. Minerals and Rocks, third ed., 1960, pp. 243–257.

Hunt, J. F., Beneficiation of Southwest Oregon Beach Sands by High Tension and Magnetic Dry Processing: Pacific Northwest Metals and Minerals Conf., Apr. 29, 1960, 11 pp.

Ryan, N., Electrodeposition of High-Purity Chromium from Electrolytes containing Fluoride or Fluosilicate: Jour. Electrochem. Soc., vol. 107, No. 5, May 1960, pp. 397–404.

Seybolt, A. U., Observations of the Fe-Cr-O System: Jour. Electrochem. Soc., vol. 107, No. 3, March 1960, pp. 147–156.

Griffing, N. R., and Healy, G. W., The Effect of Chromium on the Activity of Sulfur in Liquid Iron: Trans. of the Metallurgical Soc. of AIME, vol. 218, No. 5, October 1960, pp. 849–854.

[21] Ostrander, C. W., Chromate Conversion Coatings for . . . Materials in Design Engineering: Vol. 52, No. 2, August 1960, pp. 116–120.

[22] Chemistry, Chromite Cuts Smog Exhausts: Vol. 33, No. 5, January 1960, p. 41.

[23] Chemical and Engineering News, Battelle Develops Better Chrome Plate: Vol. 38, No. 30, July 25, 1960, pp. 48–49.

Clays

By Taber de Polo [1] and Betty Ann Brett [2]

Contents

TOTAL CLAYS sold or used by producers in 1960 decreased less than 1 percent in tonnage, but increased 2 percent in value. Exports increased 8 percent. Only kaolin and fire clay registered tonnage increases over 1959, and fuller's earth tonnage was almost equal to the 1959 figure with a minor increase in value.

The 100 leading firms supplied 15 percent of clay production; the other 1,300 firms supplied 85 percent.

TABLE 1.—Salient clays and clay products statistics in the United States

(Thousand short tons and thousand dollars)

	1951–55 (average)	1956	1957	1958	1959	1960
Domestic clays sold or used by producers	[1] 43,624	50,774	45,622	43,750	49,383	49,054
Value	[1] $129,394	$163,048	$155,805	$143,487	$159,659	$162,372
Imports for consumption	160	176	162	162	176	[2] 160
Value	$2,312	$2,969	$2,940	$2,900	$3,288	[2] $3,103
Exports	333	511	485	450	489	529
Value	$8,146	$12,593	$13,528	$12,129	[3] $13,490	$13,708
Clay refractories, shipments (value)	[4] $160,401	$208,608	$207,640	$162,887	[3] $178,632	$179,874
Clay construction products,[5] shipments (value)	[6] $445,400	$503,400	$437,000	$453,000	$521,500	$487,300

[1] Includes Puerto Rico 1953–54.
[2] Adjusted by Bureau of Mines.
[3] Revised figure.
[4] Does not include value of shipments of ground crude fire clay, high-alumina, and silica fire clay for 1954.
[5] Principal products only.
[6] Average for 1954–55 only.

Trends in the clay industry were toward continued research on upgrading and improving raw materials, especially for specialty uses and improved products; new plant construction and expansion; efforts to combat imports, especially of whiteware; and a more varied color line.

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.

The market for lightweight aggregate continued strong and was one of the few classifications that registered an increase. Much interest was shown in structural clay panels and prefabricated expanded-clay lightweight concrete units.

The results of the 1958 Census of Mineral Industries were issued in 1960. Statistics on production, employment, shipments, and values for bentonite, fire clay, fuller's earth, kaolin, and ball clay were given.[3]

TABLE 2.—Value of clays produced in the United States, by States

(Thousand dollars)

State	1959	1960	Kinds of clay produced in 1960
Alabama	[1] $2,089	[1] $2,170	Kaolin, fire clay, miscellaneous clay.
Arizona	[2] 179	[2] 260	Bentonite, miscellaneous clay.
Arkansas	2,406	2,456	Fire clay, miscellaneous clay.
California	5,646	5,663	Kaolin, ball clay, fire clay, bentonite, fuller's earth, miscellaneous clay.
Colorado	1,160	1,424	Fire clay, bentonite, miscellaneous clay.
Connecticut	368	308	Miscellaneous clay.
Florida	[1 3] 6,171	[1 3] 6,357	Kaolin, fuller's earth, miscellaneous clay.
Georgia	36,232	40,160	Do.
Idaho	[4] 33	[2 4] 29	Fire clay, bentonite, miscellaneous clay.
Illinois	4,950	5,479	Fire clay, miscellaneous clay.
Indiana	2,915	3,396	Do.
Iowa	1,168	1,345	Do.
Kansas	1,271	1,224	Do.
Kentucky	3,595	[5] 2,646	Ball clay, fire clay, miscellaneous clay.
Louisiana	[2] 904	749	Miscellaneous clay.
Maine	26	50	Do.
Maryland	[5] 944	[5] 853	Ball clay, fire clay, miscellaneous clay.
Massachusetts	229	71	Miscellaneous clay.
Michigan	1,937	1,904	Do.
Minnesota	267	[4] 163	Fire clay, miscellaneous clay.
Mississippi	4,064	4,786	Ball clay, fire clay, bentonite, fuller's earth, miscellaneous clay.
Missouri	6,898	7,207	Fire clay, miscellaneous clay.
Montana	[2 4] 48	[4] 77	Do.
Nebraska	133	109	Do.
New Hampshire	26	27	Miscellaneous clay.
New Jersey	1,895	1,597	Fire clay, miscellaneous clay.
New Mexico	[4] 77	[4] 132	Do.
New York	1,714	1,717	Miscellanoeus clay.
North Carolina	[1] 1,522	[1] 1,548	Kaolin, miscellaneous clay.
North Dakota	[2] 79	[2 4] 129	Fire clay, bentonite, miscellaneous clay.
Ohio	15,346	14,325	Fire clay, miscellaneous clay.
Oklahoma	[2] 970	[2] 739	Fire clay, bentonite, miscellaneous clay.
Oregon	308	370	Bentonite, miscellaneous clay.
Pennsylvania	17,196	[1] 16,536	Fire clay, kaolin, miscellaneous clay.
South Carolina	5,920	6,201	Kaolin, miscellaneous clay.
South Dakota	[2] 227	[2] 202	Bentonite, miscellaneous clay.
Tennessee	4,952	4,537	Ball clay, fuller's earth, miscellaneous clay.
Texas	[6] 5,703	[6] 5,058	Fire clay, bentonite, fuller's earth, miscellaneous clay.
Utah	[1] 484	[1] 416	Kaolin, fire clay, bentonite, fuller's earth, miscellaneous clay.
Virginia	1,396	1,395	Miscellaneous clay.
Washington	[4] 171	[4] 162	Fire clay, bentonite, miscellaneous clay.
West Virginia	2,492	2,639	Fire clay, miscellaneous clay.
Wisconsin	192	156	Miscellaneous clay.
Wyoming	[3 4] 9,449	[3] 9,571	Fire clay, bentonite, miscellaneous clay.
Other	[7] 5,907	[7] 6,029	
Total	159,659	162,372	
Puerto Rico	83	102	

[1] Value of kaolin included with "Other" to avoid disclosing individual company confidential data.
[2] Value of bentonite included with "Other" to avoid disclosing individual company confidential data.
[3] Value of miscellaneous clay included with "Other" to avoid disclosing individual company confidential data.
[4] Value of fire clay included with "Other" to avoid disclosing individual company confidential data.
[5] Value of ball clay included with "Other" to avoid disclosing individual company confidential data.
[6] Value of fuller's earth included with "Other" to avoid disclosing individual company confidential data.
[7] Includes Alaska, Delaware, District of Columbia, Hawaii, Nevada, and Vermont; values indicated by footnotes 1 through 6.

[3] Bureau of the Census, U.S. Census of Mineral Industries: 1958, Clay, Ceramic, and Refractory Minerals, Industry Report MIC 58(1)-14D, 1960, 28 pp.

REVIEW OF DOMESTIC PRODUCTION, PRICES, AND FOREIGN TRADE BY TYPE OF CLAY

CHINA CLAY OR KAOLIN

For the second successive year there was a substantial increase in the total tonnage and value of domestic kaolin sold or used. The 8-percent volume and 10-percent value rises established new highs for the industry. The paper, rubber, refractories, and pottery industries continued to be the principal consumers, accounting for 80 percent. The remainder was consumed for a variety of purposes, including cement, floor and wall tile, fertilizers, chemicals, insecticides, paint filler or extender, and linoleum. Refractories, paper coating, paints, and exports accounted for the bulk of the increase.

Georgia continued to be the major producer, with 78 percent of the tonnage and 83 percent of the value.

In December, the Oil, Paint and Drug Reporter quoted prices for Georgia kaolin as follows: Dry ground, air floated, 99 percent through 325-mesh, in bags, carlots, f.o.b. plants, $11 to $17 a short ton; same, less than carlots, $13.50 to $22.50 a ton.

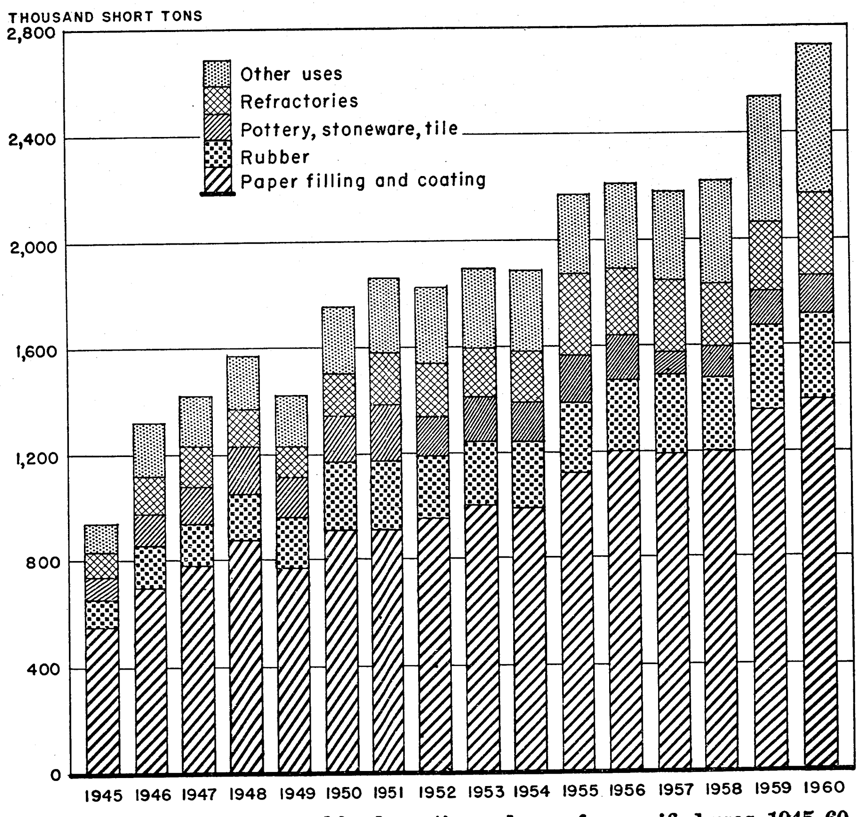

FIGURE 1.—Kaolin sold or used by domestic producers for specified uses, 1945–60.

Prices for imported china clay in December were quoted by Oil, Paint and Drug Reporter as follows: White, lump, carlots, ex dock (Philadelphia, Pa., and Portland, Maine), $23 to $35 a long ton; powdered, ex dock, in bags, $50 a ton; less than carlots, ex warehouse, $60 to $70 a ton.

TABLE 3.—Kaolin sold or used by producers in the United States

Year and State	Sold by producers		Used by producers		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1951–55 (average)	1,761,059	$26,332,510	162,696	$1,172,447	1,923,755	$27,504,957
1956	2,003,087	31,829,389	246,833	2,674,327	2,249,920	34,503,716
1957	1,941,801	33,072,638	241,884	2,525,143	2,183,685	35,597,781
1958	2,003,526	33,991,313	218,659	2,429,884	2,222,185	36,421,197
1959:						
California	12,959	203,028			12,959	203,028
Florida and North Carolina	29,288	706,359			29,288	706,359
Georgia	1,809,883	32,919,921	130,396	1,045,108	1,940,279	33,965,029
Pennsylvania	29,607	168,150			29,607	168,150
South Carolina	(1)	(1)	(1)	(1)	446,086	5,292,097
Other States [2]	423,397	5,270,379	99,944	1,369,009	77,255	1,347,291
Total	2,305,134	39,267,837	230,340	2,414,117	2,535,474	41,681,954
1960:						
California	14,247	212,120			14,247	212,120
Florida and North Carolina	29,760	663,604			29,760	663,604
Georgia	1,942,745	36,915,750	178,492	906,505	2,121,237	37,822,255
South Carolina	(1)	(1)	(1)	(1)	446,620	5,502,342
Other States [2]	446,166	5,626,115	119,041	1,353,001	118,587	1,476,774
Total	2,432,918	43,417,589	297,533	2,259,506	2,730,451	45,677,095

[1] Included with "Other States."
[2] Includes States indicated by footnote 1, and Alabama, Pennsylvania (1960), and Utah.

TABLE 4.—Georgia kaolin sold or used by producers, by uses

(Thousand short tons and thousand dollars)

Year	China clay, paper clay, etc., quantity	Refractory uses, quantity	Total kaolin		
			Quantity	Value	
				Total	Average per ton
1951–55 (average)	1,196	162	1,358	$20,213	$14.88
1956	1,456	208	1,664	26,605	15.99
1957	1,414	245	1,659	28,210	17.01
1958	1,510	187	1,697	29,348	17.30
1959	1,751	189	1,940	33,965	17.51
1960	1,861	260	2,121	37,822	17.83

Imports of kaolin were 127,000 short tons, down 10 percent from 1959. Almost 99 percent of the imports came from the United Kingdom, and the remainder came from Canada, Mexico, and Netherlands.

Exports of kaolin or china clay increased 7 percent over 1959; 67 percent went to Canada, 14 percent to Mexico, 5 percent to Japan, and 3 percent each to Cuba, Italy, and Venezuela. Small tonnages also went to other countries in Central and South America, Europe, Africa, and Asia.

A detailed article on kaolin appeared, including mineralogy, history and development of the industry, locations of domestic deposits, exploration, mining and processing, uses, and outlook.[4]

An occurrence of halloysite in commercial quantities was described.[5]

Bell Kaolin Co. increased storage facilities at Batesburg, S.C.[6]

BALL CLAY

Ball clay sold or used by producers decreased 6 percent in tonnage and 7 percent in value compared with 1959. Tennessee continued to be the major producer, accounting for 64 percent of the domestic tonnage and value; Kentucky was second. Most of the loss in tonnage was due to decreased demand in the pottery and floor and wall tile industries, which in 1960 consumed 56 percent and 22 percent, respectively of the total. A three fold increase was reported in ball clay consumed for heavy clay products.

Quotations on domestic ball clay in Oil, Paint and Drug Reporter for December 1960 were: Crushed, shed moisture, bulk, carlots, f.o.b. plant (Tennessee), $8 to $11.25 a short ton; air floated, in bags, carlots, f.o.b. plant (Tennessee), $17.50 to $21.50 a ton. In 1960 the average value per short ton for ball clay, as reported by producers, was $13.45, compared with $13.59 in 1959.

Prices for imported ball clay in December 1960 were quoted by Oil, Paint and Drug Reporter as follows: Air floated, in bags, carlots, Atlantic ports, $43 to $47 a short ton; lump, bulk, Atlantic ports, $31.50 to $37.50 a ton.

Imports of common blue and ball clay decreased 29 percent in tonnage and 28 percent in value compared with 1959, according to Bureau of Mines figures based on data supplied by the Bureau of the Census. Unmanufactured blue and ball clays represented the major share of the imports; the United Kingdom supplied 99 percent of this classification and most of the imports of manufactured blue and ball clay. The remainder of the unmanfactured blue and ball clays came from Canada. Imports of Gross Almerode clays, including fuller's earth, totaled 5,705 short tons. Greece accounted for 80 percent, and Canada, the United Kingdom, Netherlands, and West Germany for the remainder.

TABLE 5.—Ball clay sold or used by producers in the United States

Year	Short tons	Value	Year	Short tons	Value
1951-55 (average)	338,073	$4,125,180	1958	396,949	$5,502,986
1956	458,806	6,081,318	1959	475,235	6,459,902
1957	408,286	5,521,195	1960	444,369	5,977,963

FIRE CLAY

Fire clay sold or used by producers in the United States increased less than 1 percent in quantity and value compared with 1959. Small

[4] Agnello, L. A., Morris, H. H., and Gunn, F. A., Kaolin: Ind. Eng. Chem., vol. 52, No. 5, May 1960, pp. 370–376.

[5] Loughnan, F. C., and Craig, D. C., An Occurrence of Fully-Hydrated Halloysite at Muswellbrook, N.S.W.: Am. Mineral., vol. 45, Nos. 7–8, July–August 1960, pp. 783–790.

[6] American Ceramic Society Bulletin, Kaolin: Vol. 39, No. 5, May 1960, p. 5.

increases for refractories, heavy clay products, and chemicals, and a decrease for floor and wall tile use were registered.

Of the three major producing States—Ohio, Pennsylvania, and Missouri—only Pennsylvania showed an increase. Together, these States accounted for 58 percent of the total U.S. fire-clay production, and 64 percent of the value. Increases and decreases for the other States were about equally divided.

The principal uses of fire clay were for the manufacture of refractories, which consumed 54 percent of the total output (same as in 1959), and heavy clay products, including terra cotta, which consumed 43 percent (42 percent in 1959). About 1 percent was used in floor and wall tile, 1 percent in chemicals, and 1 percent in a variety of applications.

The average value per short ton of fire clay sold by producers (as reported to the Bureau of Mines) was $3.55, compared with $3.47 in 1959, and $3.24 in 1958. The average value of all fire clay, including both sales and captive tonnage, was $4.56, compared with $4.58 in 1959.

The following quotations on firebrick manufactured from fire clay were reported in September by E&MJ Metal and Mineral Markets: Superduty, $185 per thousand; high duty, $140; low duty, $103.

Exports of fire clay increased 29 percent in quantity to 177,578 short tons, and 33 percent in value compared with 1959. The average value was $18.60 a short ton, compared with $18.06 (revised figure) in 1959. Of the larger consumers, Japan accounted for the highest revenue per ton. Canada received 44 percent, Mexico 27 percent, Japan 19 percent, Italy and United Kingdom 2 percent each, and Belgium-Luxembourg, West Germany, and Cuba 1 percent each of the exports. The remaining 3 percent comprised small tonnages to many destinations in Central and South America, Europe, Asia, and Africa.

A report described an extensive fire-clay prospecting program being conducted in many countries by North American Refractories Co., Cleveland, Ohio.[7]

BENTONITE

Bentonite sold or used by producers declined 8 percent in tonnage and 5 percent in value compared with 1959, principally because of a 16-percent decline in use for drilling mud for oil exploration, the largest consuming industry in 1959.

The foundry, petroleum, and filtering industries consumed 83 percent of the total tonnage, the same as for the year before. Wyoming, the largest producer, accounted for 62 percent of total production and 64 percent of the total value. Mississippi and Texas accounted for substantial production with 19 percent and 9 percent, respectively. Mississippi output increased 19 percent.

The price of bentonite was given in Oil, Paint and Drug Reporter for December 1960 as follows: 200-mesh, in bags, carlots, f.o.b. mines (Wyoming), $14 a short ton; imported, Italian, white, high gel, in bags, 5-ton lots, ex warehouse, $95.20 a ton and 1-ton lots $99 a ton; Italian, low gel, in bags, 5-ton lots, ex warehouse, $93.40 a ton and 1-ton lots $97.16 a ton.

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[7] Haines, J. D., and Hudson, J. R., Jr., Fire Clay Prospecting With Back-Hoe and Core Drill: Brick and Clay Record, vol. 135, No. 7, January 1960, pp. 95–96.

TABLE 6.—Fire clay, including stoneware clay, sold or used by producers in the United States[1]

Year and State	Sold by producers		Used by producers		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1951–55 (average)	2,971,441	$9,496,035	7,636,938	$32,708.236	10,608,379	$42,204,271
1956	3,542,541	10,149,016	8,260,552	43,600,870	11,803,093	53,749,886
1957	2,947,798	9,431,240	7,857,301	41,879,524	10,805,099	51,310,764
1958	2,276,745	7,369,379	6,531,430	33,050,861	8,808,175	40,420,240
1959:						
Alabama	185,296	455,735	92,348	281,367	277,644	737,102
Alaska			180	1,458	180	1,458
Arizona			50	50	50	50
Arkansas			398,799	2,022,918	398,799	2,022,918
California	90,681	271,502	345,812	1,296,745	436,493	1,568,247
Colorado	193,339	550,355	77,244	346,560	270,583	896,915
Illinois	(2)	(2)	(2)	(2)	321,593	2,157,582
Indiana	(2)	(2)	(2)	(2)	365,662	564,782
Iowa	(2)	(2)	(2)	(2)	15,820	42,635
Kansas			266,930	516,711	266,930	516,711
Kentucky	78,624	309,986	168,800	947,351	247,424	1,257,337
Maryland	(2)	(2)	(2)	(2)	58,265	235,809
Mississippi			70,000	140,000	70,000	140,000
Missouri	228,861	540,913	1,428,222	5,379,678	1,657,083	5,920,591
Nebraska			2,450	2,450	2,450	2,450
New Jersey	(2)	(2)	(2)	(2)	126,943	947,659
Ohio	568,066	2,296,240	1,790,434	9,649,080	2,358,500	11,945,320
Oklahoma			325	3,250	325	3,250
Pennsylvania	357,465	1,029,239	1,445,704	11,054,956	1,803,169	12,084,195
Texas	25,991	64,570	696,109	1,531,224	722,100	1,595,794
Utah	(2)	(2)	(2)	(2)	37,198	96,145
West Virginia	(2)	(2)	(2)	(2)	328,792	2,178,974
Other States[3]	544,128	2,358,486	805,828	4,140,012	95,683	274,912
Total	2,272,451	7,877,026	7,589,235	37,313,810	9,861,686	45,190,836
1960:						
Alabama	197,468	504,903	93,776	248,468	291,244	753,371
Arkansas			427,042	2,068,717	427,042	2,068,717
California	95,568	314,629	319,091	1,060,944	414,659	1,375,573
Colorado	210,048	651,940	80,876	389,429	290,924	1,041,369
Illinois	(2)	(2)	(2)	(2)	359,357	2,378,344
Indiana	(2)	(2)	(2)	(2)	347,706	635,268
Iowa	(2)	(2)	(2)	(2)	13,599	37,172
Kansas			285,635	616,177	285,635	616,177
Kentucky	83,480	390,488	223,288	1,455,161	306.768	1,845,649
Maryland	(2)	(2)	(2)	(2)	26,468	144,633
Mississippi			129,161	258,322	129,161	258,322
Missouri	218,385	526,650	1,322,763	5,681,657	1,541,148	6,208,307
Nebraska			900	900	900	900
New Jersey	(2)	(2)	(2)	(2)	127,099	938,215
Ohio	562,932	2,153,245	1,739,544	8,765,109	2,302,476	10,918,354
Oklahoma			510	5,100	510	5,100
Pennsylvania	(2)	(2)	(2)	(2)	1,857,981	11,640,393
Texas	(2)	(2)	(2)	(2)	715,491	1,668,337
Utah	(2)	(2)	(2)	(2)	27,567	78,778
West Virginia	(2)	(2)	(2)	(2)	346,053	2,328.865
Wyoming			6,308	12,616	6,308	12,616
Other States[3]	1,122,064	4,298,749	2,796,533	15,827,657	97,276	276,401
Total	2,489,945	8,840,604	7,425,427	36,390,257	9,915,372	45,230,861

[1] Includes stoneware clay as follows: 1951–55 (average), 66,152; 1956, 74,143; 1957, 30,089; 1958, 26,429; 1959, 27,418; 1960, 27,470 tons.
[2] Included with "Other States."
[3] Includes States indicated by footnote 2 and Alaska (1960), Idaho, Minnesota, Montana, Nevada, New Mexico, North Dakota (1960), Washington, and Wyoming (1959).

The average value per short ton, as reported to the Bureau of Mines, was $11.83, compared with $11.54 in 1959.

Exports of bentonite increased 23 percent from 47,256 short tons in 1959 to 58,091 tons in 1960, according to reports received by the Bureau of Mines.

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An article reviewed the history of bentonite, and data were presented on properties, production and processing, and uses.[8]

The geology of the Otay bentonite deposit in California was described.[9]

Discovery of a large deposit of bentonite was reported north of Tonopah, Nev., by Nevada Clay Products Co.,[10] and the Illinois State geologist reported that a deposit of bentonite estimated to contain over 700,000 tons was discovered near Homer, Ill.[11]

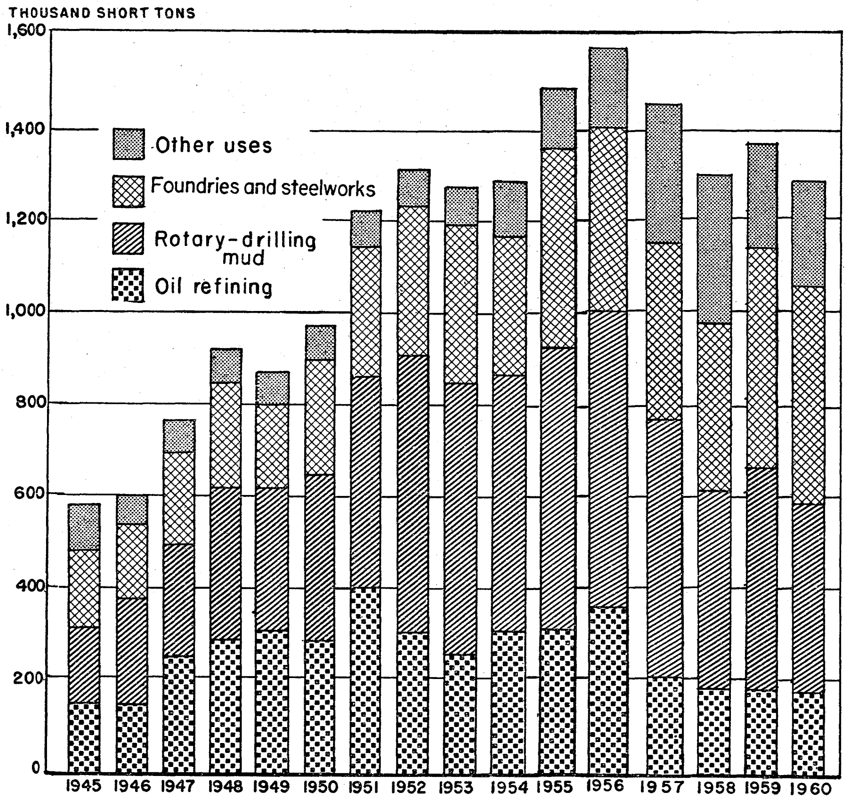

FIGURE 2.—Bentonite sold or used by domestic producers for specified uses, 1945–60.

[8] Chisholm, Fred, Bentonite in Industry: Mines Mag., vol. 50, No. 7, July 1960, pp. 30–35, 42.

[9] Cleveland, G. B., Geology of the Otay Bentonite Deposit, San Diego County, California: California Div. of Mines Special Report 64, San Francisco, 1960, 16 pp.

[10] Mining World, Nevada: Vol. 22, No. 6, May 1960, p. 89.

[11] Rock Products, Louisiana Geological Survey Confirms Rich Bentonite Find: Vol. 63, No. 3, March 1960, p. 40.

TABLE 7.—Bentonite sold or used by producers in the United States

Year and State	Short tons	Value
1951–55 (average)	1,313,083	$15,183,943
1956	1,570,610	18,414,807
1957	1,450,867	17,806,546
1958	1,291,414	15,317,250
1959:		
California	5,979	123,047
Idaho	140	1,400
Mississippi	200,256	2,494,325
Oregon	148	3,000
Texas	133,317	946,588
Utah	6,703	81,029
Washington	50	300
Wyoming	763,834	9,449,024
Other States [1]	261,859	2,742,742
Total	1,372,286	15,841,455
1960:		
California	10,664	$231,717
Colorado	1,000	9,930
Mississippi	237,564	2,899,847
Oregon	600	7,320
Texas	115,587	872,940
Utah	6,255	85,247
Washington	78	440
Wyoming	782,168	9,558,969
Other States [1]	114,884	1,338,347
Total	1,268,800	15,004,757

[1] Includes Arizona, Idaho (1960), Louisiana (1959), Montana (1959), Nevada, North Dakota, Oklahoma, and South Dakota.

FULLER'S EARTH

The tonnage of fuller's earth sold or used by producers declined only a fraction of 1 percent, while the value increased a little over 1 percent compared with 1959. Florida continued to be the leading State in production, accounting for 62 percent of the tonnage and 69 percent of the value. Georgia was second, with 23 percent of the tonnage and 19 percent of the value. Over 45 percent of the ouput was for absorbents, the largest single use. Other uses were: Insecticides and fungicides, 24 percent; rotary-drilling mud, 14 percent; and mineral and vegetable oil refining, 5 percent each.

The average value per short ton of fuller's earth reported sold or used in the United States was $22.44, compared with $22.04 in 1959.

The last 1960 quotations on fuller's earth, published in the Oil, Paint and Drug Reporter for February, were: Insecticide grade, dried, powdered, in bags, carlots, Georgia or Florida mines, $17.50 a short ton; oil-bleaching grade, 100-mesh, in bags, carlots, f.o.b. Georgia and Florida mines, $16.30 to $17 a short ton; and 200-mesh, same basis, $17.50 to $18.

Effective January 1, 1955, fuller's earth import statistics were not classified separately but were included under "Other clay." Exports

TABLE 8.—Fuller's earth sold or used by producers in the United States

Year and State	Short tons	Value
1951–55 (average)	417,671	$7,420,785
1956	417,715	8,879,324
1957	366,101	8,056,841
1958	357,883	7,609,049
1959:		
Florida	245,288	6,171,076
Georgia	99,212	1,719,182
Tennessee	30,028	456,504
Utah	2,818	38,700
Other States [1]	32,276	641,597
Total	409,622	9,027,059
1960:		
Florida	252,106	$6,357,173
Georgia	93,689	1,777,051
Tennessee	21,319	316,466
Utah	3,238	43,645
Other States [1]	37,973	667,323
Total	408,325	9,161,658

[1] Includes California, Mississippi, Nevada, and Texas.

are not given separately in official foreign-trade statistics; however, 12,035 short tons (a 21-percent increase over 1959) was exported, according to reports made by producers to the Bureau of Mines.

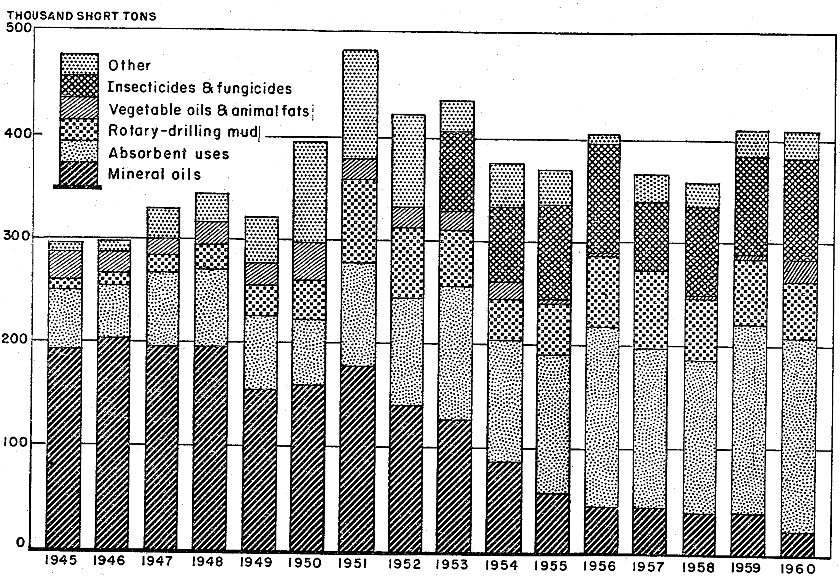

FIGURE 3.—Fuller's earth sold or used by producers for specified uses, 1945–60.

MISCELLANEOUS CLAY

This section presents statistics for the large-tonnage clays and shales—other than those discussed in the preceding pages—used in manufacturing heavy clay products, portland cement, and lightweight aggregate. With these are grouped small tonnages of slip clay, oil-well drilling mud, pottery clay, and clays that cannot clearly be identified with one of the types discussed separately in this chapter.

Miscellaneous clay sold or used by producers remained within 1 percent of the 1959 record high in tonnage and within a fraction of a percent in value. The quantity of miscellaneous clay used in heavy clay products remained approximately the same, that used for cement declined 8 percent and that used in lightweight aggregate increased 5 percent. Captive tonnage—clay produced by mine operators for their own use in manufacturing brick, tile, cement, and lightweight aggregate and other minor products and marketed for the first time as such—was almost 96 percent of the miscellaneous clay sold or used in 1960. About half the States showed increases and half decreases in production. Ohio, North Carolina, Texas, and California reported tonnages exceeding 2 million short tons.

The average reported value of miscellaneous clay sold as crude or prepared clay was $1.44 a short ton, compared with $1.84 (revised) in 1959. There was a 71-percent quantity increase in this clay classification. Some special types of clay included under the miscellaneous-clay classification, however, sold at much higher prices. The value of captive tonnage was computed from individual estimates averaging slightly over $1 a short ton.

According to figures compiled by the Bureau of the Census, exports of clays not elsewhere classified were 271,956 short tons valued at $8,359,682, a decrease of approximately 2 percent in tonnage and 5 percent in value from 1959. Some countries of destination with percentages received were: Canada, 38 percent; Mexico and United Kingdom, 8 percent each; Australia, 6 percent; Netherlands, 4 percent; West Germany, 3 percent; Argentina, Belgium-Luxembourg, Brazil, Colombia, Italy, Japan, Sweden, Switzerland, and Venezuela, approximately 2 percent each; and Kuwait and Union of South Africa, 1 percent each. Smaller amounts were shipped to other countries in Central and South America, Europe, Asia and Africa.

A major new deposit of brick clay was opened 15 miles northwest of Evanston, Wyo., providing the area with its first raw material source for production of white brick.[12]

Extensive clay deposits of possible commercial interest were discovered on the north slope of the San Gabriel Mountains, Calif.[13]

TABLE 9.—Miscellaneous clay, including shale and slip clay sold or used by producers in the United States

Year and State	Sold by producers		Used by producers		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1951-55 (average) [1]	1,540,416	$2,883,643	27,482,837	$30,071,584	29,023,253	$32,955,227
1956	1,487,222	2,044,557	32,786,954	39,374,481	34,274,176	41,419,038
1957	1,097,620	1,588,484	29,310,775	35,923,688	30,408,395	37,512,172
1958	979,565	1,687,185	29,693,948	36,529,282	30,673,513	38,216,467
1959:						
Alabama	—	—	1,508,336	1,351,583	1,508,336	1,351,583
Arizona	—	—	119,488	179,233	119,488	179,233
Arkansas	—	—	383,445	383,445	383,445	383,445
California	[2] 250,384	[2] 787,813	[2] 1,991,710	[2] 2,808,849	2,242,094	3,596,662
Colorado	(3)	(3)	(3)	(3)	146,898	263,094
Connecticut	35,485	26,614	244,452	341,037	279,937	367,651
Georgia	—	—	1,312,749	547,831	1,312,749	547,831
Idaho	—	—	39,250	31,850	39,250	31,850
Illinois	28,803	54,906	1,879,008	2,737,358	1,907,811	2,792,264
Indiana	87,735	116,375	1,238,143	2,233,299	1,325,888	2,349,674
Iowa	(3)	(3)	(3)	(3)	895,518	1,125,387
Kansas	—	—	753,630	753,630	753,630	753,630
Kentucky	—	—	625,237	818,370	625,237	818,370
Louisiana	—	—	904,149	904,149	904,149	904,149
Maine	—	—	25,104	26,232	25,104	26,232
Maryland	(3)	(3)	(3)	(3)	602,516	709,092
Massachusetts	—	—	101,124	228,736	101,124	228,736
Michigan	(3)	(3)	(3)	(3)	1,770,685	1,936,842
Mississippi	—	—	430,549	432,169	430,549	432,169
Missouri	—	—	977,636	977,812	977,636	977,812
Montana	(3)	(3)	(3)	(3)	46,023	47,730
Nebraska	—	—	128,834	130,385	128,834	130,385
New Hampshire	—	—	26,150	26,150	26,150	26,150
New Jersey	—	—	573,343	946,932	573,343	946,932
New Mexico	(3)	(3)	(3)	(3)	45,388	77,541
New York	2,269	29,487	1,307,256	1,684,140	1,309,525	1,713,627
North Carolina	—	—	2,523,631	1,522,423	2,523,631	1,522,423
North Dakota	—	—	61,381	78,648	61,381	78,648
Ohio	171,207	206,365	2,948,889	3,194,158	3,120,096	3,400,523
Oklahoma	—	—	966,370	966,770	966,370	966,770
Oregon	(3)	(3)	(3)	(3)	293,904	305,050
Pennsylvania	105,859	32,699	1,527,726	4,910,981	1,633,585	4,943,680

See footnotes at end of table.

[12] Brick and Clay Record, White-Burning Clay Deposit in Wyoming: Vol. 138, No. 1, January 1961, p. 32.

[13] Davis, F. F., and Staff, The California Minerals Industry in 1960: Mineral Infor. Service, California State, Div. of Mines, vol. 14, No. 3, March 1960, p. 6.

TABLE 9.—Miscellaneous clay, including shale and slip clay sold or used by producers in the United States—Continued

Year and State	Sold by producers		Used by producers		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1959:						
South Carolina	----	----	714,081	$628,489	714,081	$628,489
South Dakota	----	----	227,118	227,118	227,118	227,118
Tennessee	----	----	812,683	331,388	812,683	331,388
Texas	9,548	$25,891	3,004,890	3,134,029	3,014,438	3,159,920
Utah	(3)	(3)	(3)	(3)	137,877	267,826
Virginia	----	----	1,346,014	1,396,433	1,346,014	1,396,433
Washington	(3)	(3)	(3)	(3)	179,820	170,668
West Virginia	----	----	266,932	312,970	266,932	312,970
Wisconsin	----	----	178,363	192,229	178,363	192,229
Undistributed [4]	159,716	282,402	4,732,207	5,454,276	773,294	833,448
Total	[2] 851,006	[2] 1,562,552	[2] 33,879,888	[2] 39,893,102	34,730,894	41,455,654
1960:						
Alabama	----	----	1,548,673	1,416,739	1,548,673	1,416,739
Arizona	----	----	173,272	259,908	173,272	259,908
Arkansas	----	----	387,633	387,633	387,633	387,633
California	211,864	613,048	2,216,159	3,057,733	2,428,023	3,670,781
Colorado	38,000	76,000	159,838	296,940	197,838	372,940
Connecticut	45,188	35,891	162,270	271,867	207,458	307,758
Georgia	----	----	1,304,044	560,527	1,304,044	560,527
Idaho	----	----	36,250	29,450	36,250	29,450
Illinois	(3)	(3)	(3)	(3)	1,997,499	3,100,860
Indiana	85,061	114,298	1,388,720	2,646,874	1,473,781	2,761,172
Iowa	3,823	14,012	1,004,256	1,294,459	1,008,079	1,308,471
Kansas	----	----	607,541	607,541	607,541	607,541
Kentucky	----	----	644,388	799,513	644,388	799,513
Louisiana	----	----	749,432	749,432	749,432	749,432
Maine	----	----	41,114	49,917	41,114	49,917
Maryland	(3)	(3)	(3)	(3)	585,694	707,975
Massachusetts	----	----	83,221	70,724	83,221	70,724
Michigan	(3)	(3)	(3)	(3)	1,737,588	1,904,389
Minnesota	----	----	125,387	162,997	125,387	162,997
Mississippi	----	----	597,694	599,156	597,694	599,156
Missouri	----	----	998,533	998,709	998,533	998,709
Montana	----	----	63,248	77,167	63,248	77,167
Nebraska	----	----	106,870	108,243	106,870	108,243
New Hampshire	----	----	27,260	27,260	27,260	27,260
New Jersey	(3)	(3)	(3)	(3)	536,619	659,059
New Mexico	1,647	12,926	54,840	118,616	56,487	131,542
New York	(3)	(3)	(3)	(3)	1,172,492	1,716,704
North Carolina	----	----	2,476,170	1,547,680	2,476,170	1,547,680
North Dakota	----	----	102,044	128,444	102,044	128,444
Ohio	156,424	206,100	2,705,800	3,200,576	2,862,224	3,406,676
Oklahoma	----	----	733,900	734,400	733,900	734,400
Oregon	(3)	(3)	(3)	(3)	316,900	362,720
Pennsylvania	(3)	(3)	(3)	(3)	1,699,447	4,895,957
South Carolina	----	----	850,254	698,727	850,254	698,727
South Dakota	----	----	201,970	201,970	201,970	201,970
Tennessee	(3)	(3)	(3)	(3)	965,908	373,449
Texas	14,266	27,253	2,456,691	2,489,866	2,470,957	2,517,119
Utah	6,623	8,824	99,681	199,467	106,304	208,291
Virginia	----	----	1,347,766	1,394,665	1,347,766	1,394,665
Washington	(3)	(3)	(3)	(3)	169,370	162,115
West Virginia	----	----	279,570	310,341	279,570	310,341
Wisconsin	----	----	144,358	156,018	144,358	156,018
Undistributed [4]	894,491	993,498	8,949,065	13,570,570	662,039	680,840
Total	1,457,387	2,101,850	32,827,912	39,224,129	34,285,299	41,325,979

[1] Includes Puerto Rico 1953–54.
[2] Revised figure.
[3] Included with "Undistributed."
[4] Includes States indicated by footnote 3 and Alaska (1960), Delaware, District of Columbia, Florida, Hawaii, Minnesota (1959), Nevada, Vermont, and Wyoming.

CONSUMPTION AND USES—ALL CLAYS

Heavy clay products (building brick, structural tile, and sewer pipe) comprised 48 percent of the total clay used in 1960.

The total tonnage of clay consumed remained within 1 percent of the 1959 figure; the value increased almost 2 percent. Some increases for individual classifications were: Stoneware, 143 percent; filtering and decolarizing for vegetable and animal oils, 42 percent; paint, 35 percent; paper coating, 8 percent; chemicals, 6 percent; lightweight aggregate, 5 percent; total refractories, and art pottery, 3 percent each; and firebrick and block, 2 percent each. Some decreases in consumption were: Fire-clay mortar, 43 percent; mineral oils and greases, 18 percent; rotary-drilling mud, 16 percent; floor and wall tile, and cement, 8 percent each; whiteware, 7 percent; foundries and steelworks and insecticides and fungicides, 3 percent each; paper filler, 2 percent.

Refractories.—The value of clay-refractories shipments increased 1 percent, and nonclay-refractories shipments increased 3 percent in value from 1959.

The trend in the refractories industry was towards improving products through more accurate quality control and better manufacturing techniques. There was increased interest in new lines of firebrick, in new lines of insulating and lightweight refractories, and in improved refractory mortars and castables. The industry recognized the need for products capable of withstanding higher temperatures. New refractories plants were built or started, mergers took place, and market surveys became the order of the day. Mining operations and materials handling became further mechanized. Research facilities were expanded. The trend toward greater use of basic refractories continued.

An article was published forecasting the role of refractories in the steel industry. Changes in steelmaking processes will affect the types of refractories needed.[14]

The new Garber Research Center of Harbison-Walker Refractories Co., Pittsburgh, Pa., had fully instrumented firing equipment for precise research laboratory studies.[15]

The Bureau of Mines released a report covering sources and market information of refractory raw materials in the South Central United States.[16]

Detailed cost-saving figures resulting from careful control of maintenance costs in the firebrick industry were presented.[17]

A complete resume of the operations of the A. P. Green Fire Brick Co., and its subsidiaries was given.[18]

A number of plants announced sizable expansions to their refractories plants: At Pueblo, Colo., Standard Fire Brick Division, of A. P. Green Fire Brick Co., planned a $500,000 expansion; W. S. Dickey Clay Manufacturing Co. planned a $1.5 million expansion of its plant in Bessemer, Ala., now under construction; H. K. Porter Co.,

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[14] Debenham, W. S., The Role of Refractories in Steel's Future: Brick and Clay Record, vol. 136, No. 2, February 1960, pp. 47–50.

[15] Ceramic Age, Instrumentation Versatility for Laboratory Kilns: Vol. 75, No. 3, March 1960, pp. 16–20.

[16] Rollman, H. E., and Eng, Harvard, Sources of Refractory Raw Materials and Refractories Markets in South Central United States: Bureau of Mines Inf. Circ. 7950, 1960, 54 pp.

[17] Seifriz, R. S., Control Over Maintenance Costs in the Fire Brick Industry: Brick and Clay Record, vol. 137, No. 1, July 1960, pp. 50–53, 56, 62.

[18] Brick and Clay Record, A. P. Green Fire Brick Co.: Vol. 136, No. 6, 1960, pp. 49–80, 101.

Inc., started a $4 million construction and expansion program at the Bessemer, Ala., and Wellsville, Ohio, plants of its Refractories Division.

TABLE 10.—Clay sold or used by producers in the United States in 1960, by kinds and uses

(Short tons)

Use	Kaolin	Ball clay	Fire clay and stoneware clay	Bentonite	Fuller's earth	Miscellaneous clay including slip clay	Total
Pottery and stoneware:							
Whiteware, etc	107,751	243,878					351,629
Stoneware, including chemical stoneware		2,455	14,762			45,520	62,737
Art pottery, flower pots, and glaze slip	10,780	3,731	12,708			67,372	94,591
Total	118,531	250,064	27,470			112,892	508,957
Floor and wall tile	20,515	98,342	129,844			145,625	394,326
Refractories:							
Firebrick and block	268,009	18,001	4,257,844			56,698	4,600,552
Bauxite, high-alumina brick			55,447				55,447
Fire-clay mortar	1,268		103,024			6,512	110,804
Clay crucibles			25,520				25,520
Glass refractories		30,156	10,754				40,910
Zinc retorts and condensers			54,072				54,072
Foundries and steelworks			600,851	464,090		9,095	1,074,036
Saggers, pins, stilts, and wads		9,765	100,709				110,474
Other refractories	82,350	9,480	186,776	10		556	279,172
Total	351,627	67,402	5,394,997	464,100		72,861	6,350,987
Heavy clay products; Building brick, paving brick, drain tile, sewer pipe, and kindred products		12,629	4,221,884			19,125,899	23,360,412
Architectural terra cotta			5,721				5,721
Lightweight aggregates						5,504,367	5,504,367
Filler:							
Paper filling	586,660						586,660
Paper coating	810,136						810,136
Rubber	321,188						321,188
Linoleum and oilcloth	13,459		6,640				20,099
Paint	69,803						69,803
Fertilizers	12,886					5,900	18,786
Insecticides and fungicides	69,150		1,425	26,761	96,793	485	194,614
Plaster and plaster products	2,765						2,765
Plastics, organic	9,915						9,915
Other fillers	57,372	4,120	2,440	685	3,802	2,345	70,764
Total	1,953,334	4,120	10,505	27,446	100,595	8,730	2,104,730
Portland and other hydraulic cements	76,005					9,224,941	9,300,946
Miscellaneous:							
Enameling	2,280			720			3,000
Filtering and decolorizing (raw and activated earths):							
Mineral oils and greases				106,051	21,198		127,249
Vegetable or animal oils and fats				73,595	20,662		94,257
Other filtering and clarifying				3,275	1,416		4,691
Rotary-drilling mud			1,880	404,980	55,791	10,121	472,772
Chemicals	28,291		103,710				132,001
Absorbent uses					186,829		186,829
Exports	75,209		6,675	58,091	12,035		152,010
Other uses	104,659	11,812	12,686	130,542	9,799	79,863	349,361
Total	210,439	11,812	124,951	777,254	307,730	89,984	1,522,170
Grand total:							
1960	2,730,451	444,369	9,915,372	1,268,800	408,325	34,285,299	49,052,616
1959	2,535,474	475,235	9,861,686	1,372,286	409,622	34,730,894	49,385,197

Plans for new plants were announced by North American Refractories Co., for a basic refractory brick plant at Womelsdorf, Pa.; by Refractories Co., of Louisville, Ky. (a subsidiary of Corning Glass Works), for a refractory products plant at Buckhannon, W. Va.; by Super Minerals for a firebrick operation in the Clatskanie, Oreg., area; and by the refractories division of Ferro Corporation, for refractory specialty items, in the Los Angeles, Calif., area.

Kaiser Refractories & Chemical Division, Kaiser Aluminum & Chemical Corp., announced that it would build a new technical center at Mexico, Mo., for testing and evaluating material of all types in connection with development of fire-clay, silica, and high-alumina refractories.

TABLE 11.—Shipments of refractories in the United States, by kinds

Product	Unit of quantity	Shipments 1959 Quantity	Shipments 1959 Value (thousands)	Shipments 1960 Quantity	Shipments 1960 Value (thousands)
Clay refractories:					
Fire-clay brick, standard and special shapes, except superduty.	1,000 9 inch equivalent.	330,199	$51,486	341,177	$55,167
Superduty fire-clay brick and shapes	do	73,630	18,649	70,310	18,679
High-alumina brick and shapes (50 percent Al_2O_3 and over) made substantially of calcined diaspore or bauxite.[1]	do	20,031	8,919	21,962	9,978
Insulating firebrick and shapes	do	44,596	10,672	47,250	11,681
Ladle brick	do	[2] 200,094	[2] 21,175	193,290	20,438
Sleeves, nozzles, runner brick, and tuyeres	do	[2] 46,309	[2] 9,553	35,133	7,804
Glasshouse pots, feeder parts and upper structure shapes used only for glass tanks.[1]	Short ton	15,098	4,065	18,792	5,254
Hot-top refractories	do	[2] 112,768	[2] 6,964	83,322	5,346
Clay-kiln furniture, radiant-heater elements, potters' supplies, and other miscellaneous shaped refractory items.			6,026		5,345
Refractory bonding mortars, air-setting (wet and dry types).[3]	Short ton	57,986	6,842	52,553	6,168
Refractory bonding mortars, except air-setting types.[3]	do	9,472	994	11,239	1,038
Ground crude fire clay, high-alumina clay, and silica fire clay.[4]	do	595,961	4,838	513,006	5,809
Plastic refractories and ramming mixes[1]	do	137,076	11,606	128,122	10,392
Castable refractories (hydraulic setting)	do	[2] 95,146	[2] 9,419	92,523	9,217
Insulating castable refractories (hydraulic setting).	do	18,292	2,277	23,492	2,546
Other clay refractory materials sold in lump or ground form.[4] [5]	do	232,811	5,147	241,396	5,012
Total clay refractories			[2] 178,632		179,874
Nonclay refractories:					
Silica brick and shapes	1,000 9 inch equivalent.	200,566	40,905	183,297	39,069
Magnesite and magnesite-chrome (magnesite predominating) brick and shapes (excluding molten cast).	do	53,549	43,591	52,815	45,493
Chrome and chrome-magnesite (chrome ore predominating) brick and shapes (excluding molten cast).	do	47,106	35,472	44,330	35,742
Graphite crucibles, retorts, stopper heads, and other shaped refractories, excluding those containing natural graphite.	Short ton	21,191	12,328	11,360	8,785
Mullite brick and shapes made predominantly of kyanite, sillimanite, andalusite, or synthetic mullite (excluding molten cast).	1,000 9 inch equivalent.	4,429	5,657	5,559	6,748

See footnotes at end of table.

TABLE 11.—Shipments of refractories in the United States, by kinds—Continued

Product	Unit of quantity	Shipments 1959 Quantity	Shipments 1959 Value (thousands)	Shipments 1960 Quantity	Shipments 1960 Value (thousands)
Nonclay refractories—Continued					
Extra-high-alumina brick and shapes made predominantly of fused bauxite, or fused or dense-sintered alumina (excluding molten cast).	1,000 9 inch equivalent.	2,338	$3,679	3,134	$4,937
Silicon carbide brick and shapes made substantially of silicon carbide.	do	4,315	9,933	3,991	9,389
Zircon and zirconia brick and shapes made predominantly of either of these materials.	do	899	3,017	1,150	4,510
Forsterite, pyrophyllite, molten-cast, and other nonclay brick and shapes.			[2] 18,041		23,237
Nonclay refractory bonding mortars, air-setting (wet and dry types).	Short ton	89,793	9,549	99,680	10,816
Nonclay refractory bonding mortars, except air-setting types.	do	16,921	1,254	14,039	1,262
Nonclay refractory castables (hydraulic setting).	do	7,671	1,072	7,789	1,105
Nonclay plastic refractories and ramming mixes (wet and dry types).	do	188,283	21,873	156,986	18,967
Dead-burned magnesia or magnesite [4]	do	156,346	9,295	13,143	8,367
Carbon refractories; brick, blocks, and shapes, excluding those containing natural graphite.	do	223,214	12,769	208,302	16,223
Other nonclay gunning mixes	do				
Other nonclay refractory materials sold in lump or ground form.[5]	do				
Total nonclay refractories			[2] 228,435		234,650
Grand total refractories			[2] 407,067		414,524

[1] Excludes data for mullite or extra-high alumina refractories. These products are included with mullite and extra-high-alumina brick and shapes in the nonclay refractories section.
[2] Revised figure.
[3] Includes data for bonding mortars that contain up to 60 percent Al_2O_3, dry basis. Bonding mortars that contain more than 60 percent Al_2O_3, dry basis, are included in the nonclay-refractories section.
[4] Represents only shipments by establishments classified in "manufacturing" industries, and excludes shipments to refractory producers for the manufacture of brick and other refractories.
[5] Includes data for calcined clay, ground brick, and siliceous and other gunning mixes.

Source: Bureau of the Census.

Heavy Clay Products.—After an initial slow start in 1960 the clay-industry economy picked up somewhat, but not enough to offset the earlier lag. Most segments of the heavy clay products business declined for the year.

Some new products were placed on the market, changes in production methods aimed at cost cutting were instituted, and some equipment was replaced in old plants. New plants were built or planned, and much emphasis was placed on automation and research of both raw materials and product properties to reduce labor costs while improving quality in an effort to meet competition from alternate materials and meet demands of architects and customers. Producers of clay products continued to work more closely with architects and engineers on color, shape, and design. Clay-bonded block continued to arouse much interest but only a few companies had reached commercial production. Reinforced brick masonry also drew attention.

Articles described new brick plants of Builders Brick Co., New Castle, Wash., stressing modern assembly line production techniques;[19] of Jenkins Brick Co. at Montgomery, Ala.;[20] and of Woodbridge Clay Products Co., Manassas, Va.[21] In Mississippi the new $700,000 brick plant of Atlas Tile and Brick Co. at Shuqualak, went into production in May.

Webster Brick Co., Somerset, Va., doubled its capacity with a new $300,000 tunnel kiln.[22]

The new clay-pipe plant of Dic-Kota Clay Products Co., at Dickinson, N. Dak., added 12-inch pipe to its line of products.[23]

Other new plants completed and in operation were: An electronically controlled brick plant in Nebraska City, Nebr., by Nebraska City Brick and Tile Co., with an ultimate capacity of 80,000 brick a day; and the plant of W. G. Bush & Co., at Gleason, Tenn.

Atlas Brick & Tile Co. shipped machinery to Anchorage, Alaska, for a plant, and plans to produce 80,000 brick a day as well as building, sewer, and patio tile.[24]

Work started on new plants by Delta-Macon Brick and Tile Co., at Macon, Miss., and Rio Brick Co. near El Paso, Tex.

New clay products plants were planned by Mississippi Clay Products Co., for making brick at Yazoo City, Miss.; Glen-Gery Brick Co. for brickmaking at Ephrata, Pa., to replace a plant destroyed by fire; Universal Sewer Pipe Corp., in Ocala, Fla.; United States Concrete Pipe Co., a $2.5 million vitrified-clay pipe plant in Ocala, Fla.; Boron Clay Products Co., at Pleasant Garden, N.C.; and Delta Brick & Tile Co., Indianola, Miss., a $625,000 brick plant near Macon, Miss., with a daily capacity of 60,000 brick.

Plant expansions were announced by Key James Brick Co., Chattanooga, Tenn., to increase production from 15 to 21 million brick a year,[25] and by Cherokee Brick Co., increasing production facilities at Moncure, N.C., from 75,000 to 130,000 brick a day.[26] Cunningham Brick Co., Thomasville, N.C., announced plans for a $1.3 million expansion to double capacity from 100,000 to 200,000 brick daily.[27]

Other expansion programs were underway by Merry Brothers Brick and Tile Co., Augusta, Ga., on a $4 million improvement project involving two new kilns that would give the company an ultimate capacity of 36 million brick a year; Mountain Brick and Supply Co., Inc., at Loveland, Colo., on a $200,000 improvement of facilities; Texas Clay Products, at Malakoff, Tex.; and Bridgewater Brick Co., at East Bridgewater, Mass.

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[19] Ceramic Age, Northwest's Newest Brick Plant: Vol. 75, No. 2, February 1960, pp. 30–31.

[20] Brick and Clay Record, Latest Methods Up Capacity 60%: Vol. 135, No. 7, January 1960, pp. 84–88.

[21] Mohler, Neal, Woodbridge Completes First Year of Operation: Brick and Clay Record, vol. 136, No. 3, March 1960, pp. 39–41, 70.

[22] Brick and Clay Record, News of the Industry: Vol. 137, No. 3, September 1960, p. 31.

[23] Brick and Clay Record, Dic-Kota Builds Modern Compact Plant for Manufacturing Clay Pipe: Vol. 136, No. 3, March 1960, pp. 42–43, 59.

[24] Brick and Clay Record, Machinery Sent to Alaskan Brick Plant: Vol. 136, No. 5, May 1960, p. 23.

[25] Brick and Clay Record, Key James to Add Second Kiln: Vol. 136, No. 3, March 1960, p. 24.

[26] Brick and Clay Record, Cherokee Brick Co. Expands: Vol. 136, No. 5, May 1960, p. 25.

[27] Brick and Clay Record, New Million Dollar Plant for North Carolina: Vol. 137, No. 3, September 1960, p. 31.

Details were published on the expanded facilities of Columbia Brick and Tile Co., and on completion of a modernization program and a fifth tunnel kiln by Chattahoochee Brick Co., Atlanta, Ga.[28]

Introduction of modern materials handling equipment and conversion to natural gas for firing greatly increased capacity at Metropolitan Brick Co.'s Bessemer, Pa., plant.[29]

Production details of the John A. Denie's Sons Co. two adjacent plants producing brick and lightweight aggregate from the same deposit were reported.[30] Another article described the operations of Southwest Concrete Materials Corp. at Poyen, Ark., where sand, gravel, and clay for lightweight aggregate were produced from the same deposit.[31] Some details of production of new lightweight aggregate operations were presented.[32]

It was announced that a new expanded shale aggregate plant would be erected by Buildex, Inc., near Marquette, Kans.

A review of the status of clay-bonded block (lightweight) and predictions for favorable acceptance by the building industry were presented. It was reported that eight ventures into the clay-block industry were in various stages of development.[33]

A grant was established under the guidance of the National Bureau of Standards by the Expanded Shale, Clay and Slate Institute for a comprehensive study of creep and shrinkage of expanded-shale lightweight concrete.[34]

Based on data compiled by the U.S. Department of Commerce, the value of clay construction products was $487.3 million, a 7-percent decrease from the 1959 value of $521.5 million. Shipments of the principal clay product, unglazed brick, were approximately 6.5 billion brick with a value of $223.5 million, compared with 7.3 billion valued at $241.4 million in 1959.

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[28] Mohler, Neal, Columbia Brick and Tile Co. Now Producing 73 million Brick a Year From Two Tunnel Kilns: Brick and Clay Record, vol. 137, No. 1, July 1960, pp. 37–40, 66.
Brick and Clay Record, Chattahoochee Lights Fifth Tunnel Kiln, Ups Production 30%: Vol. 136, No. 4, April 1960, pp. 74, 75, 95, 109.

[29] Ceramic Age, Modern Touches Step-Up Production: Vol. 75, No. 1, January 1960, pp. 27–29.

[30] Brick and Clay Record, Denie's Brick and L. W. Aggregate Operation Functioning Side by Side at Frayser, Tenn. Locale: Vol. 137, No. 4, October 1960, pp. 56–57, 79, 84, 92.

[31] Herod, B. C., Standard and Lightweight Aggregates From Materials in Single Pitt: Pit and Quarry, vol. 53, No. 5, November 1960, pp. 118–120, 123–125.

[32] Wright, C. E., Solite Didn't Spare the Spadework: Rock Products, vol. 63, No. 4, April 1960, pp. 144, 146.
Torgerson, R. S., Choice Shales Fine to Premium Aggregates: Rock Products, vol. 63, No. 11, November 1960, pp. 81–83.

[33] Svec, J. J., Clay Bonded Block: Brick and Clay Record, vol. 137, No. 4, October 1960, pp. 49–50, 83.

[34] Pit and Quarry, E.S.C.S.I. Grant Setup for Light Aggregate Study on Creep and Shrinkage: Vol. 52, No. 8, February 1960, p. 32.

TABLE 12.—Shipments of principal structural clay products in the United States[1]

Product	Unit of quantity	Shipments			
		1959		1960	
		Quantity	Value (thousands)	Quantity	Value (thousands)
Unglazed brick (building)	1,000 standard brick.	7,258,000	$241,400	6,502,200	$223,500
Unglazed structural tile	Short tons	521,300	8,000	488,200	7,800
Vitrified clay sewer pipe and fittings	do	1,973,100	98,300	1,854,500	94,800
Facing tile, ceramic glazed, including glazed brick.	1,000 brick, equivalent.	369,600	30,100	369,500	29,100
Facing tile, unglazed and salt glazed	1,000 tile, 8- by 5- by 12-inch equivalent.	14,300	2,600	12,300	2,600
Clay floor and wall tile and accessories, including quarry tile.	1,000 square feet.	252,500	141,100	233,000	129,500
Total			521,500		487,300

1 Bureau of the Census, U.S. Department of Commerce.

WORLD REVIEW

NORTH AMERICA

Canada.—Reviews of bentonite[35] and clays and clay products[36] in Canada in 1959 were published. The occurrence, use, and export-import information on bentonite, miscellaneous clay and shale, stoneware clay, fire clay, ball clay, and kaolin were reported.

Large-scale production of swelling bentonite was achieved in Canada for the first time with the construction of two new plants in Alberta. The value of clay products made in Canada from domestic and imported clays during 1959 was Can.$66.7 million, Can.$1.9 million more than the 1958 revised figure. Production from domestic clays reached a value of Can.$44.5 million. The value of domestic clays including bentonite, not used in clay products, Can.$700,000.

The value of imports of clay and clay products was $48.1 million, and of exports $5.1 million.

An article described the operations of Lafarge Cement of North America, Ltd., which operated a clay plant along with its other activities. The clay is transported from the pit to the plant by pipeline.[37]

A revised list of ceramic plants in Canada appeared. Included was information on location, management, kind and source of raw materials used, processes, number and type of kilns, fuel, products, and plant capacity.[38]

A geological report on the Chaste-Magarin area was published covering 550 square miles in the clay belt of the Abitibi region.[39]

35 Buchanan, R. M., Bentonite in Canada, 1959: Dept. of Mines and Tech. Surveys, Ottawa, Canada, Review 31, June 1960, 4 pp.

36 Brady, J. G., Clays and Clay Products, 1959: Dept. of Mines and Tech. Surveys, Ottawa, Canada, Review 33, July 1960, 8 pp.

37 Utley, H. F., Lafarge's Vancouver Plant: Pit and Quarry, vol. 53, No. 2, August 1960, pp. 126–129.

38 Department of Mines and Technical Surveys, Ottawa, Ceramic Plants in Canada: Ind. Min. Div. Operation List 6, June 1959, 29 pp.

39 Precambrian Mining in Canada (Winnipeg), Announce Geological Report on Chaste-Magarin, Quebec: Vol. 33, No. 5, May 1960, p. 43.

Cooksville-Laprairie Brick, Ltd., Toronto, announced plans to construct a new tunnel-kiln brick plant on the outskirts of Ottawa, with an ultimate annual capacity of 50 million brick.[40]

Jamaica (British).—Jamaica Pottery, Ltd. planned to build a plant to make fine china and tile from clays in newly discovered deposits.[41]

SOUTH AMERICA

Chile.—The Government reduced import deposit requirements. The deposit on refractory materials and brick was lowered from 50 percent of the value to 20 percent, and the deposit was returned in 30 instead of 90 days.[42]

EUROPE

Germany, West.—Production of crude kaolin in 1959 amounted to 1.6 million short tons, of which 45,860 tons was marketed at a value of US $169,524.[43]

Italy.—According to the Ministry of Industry and Commerce, revised production figures of kaolin and bentonite in 1959 totaled 180,997 short tons, 52 percent more than the 119,220 tons produced in 1958. Exports of bentonite were approximately 12,910 tons valued at US $310,789 in 1959, compared with 9,802 tons valued at US $233,495 in 1958.[44]

A résumé of the Italian Pottery Industry appeared, giving details of import-export figures for several years.[45]

Poland.—It was announced that a large experimental plant near Poznan would soon begin to produce aluminum oxide from local clay.[46]

Spain.—Output of bentonite and kaolin in 1958 and 1959, in short tons, was reported as follows:[47]

	1958	*1959 (preliminary)*
Bentonite	5,162	4,503
Kaolin	99,221	115,560

United Kingdom.—The relaxation in credit restrictions toward the end of 1958 resulted in a record demand for brick for construction. Brick deliveries in the first 11 months of 1959 reached 6.6 billion, compared with 6.3 billion in the first 11 months of 1958.[48]

ASIA

Hong Kong.—Fire clay, nonstructural clay products, and other ceramic raw materials and products were freed from import license restrictions.[49]

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[40] Brick and Clay Record, Cooksville-Laprairie Expanding: Vol. 137, No. 5, November 1960, p. 39.
[41] Ceramic Industry, To Make Tableware in New Jamaica Plant: Vol. 74, No. 5, May 1960, p. 50.
[42] U.S. Embassy, Santiago, Chile, State Department Dispatch 560, June 22, 1960, p. 1.
[43] U.S. Consulate Düsseldorf, Germany, State Department Dispatch 316, Feb. 19, 1960, p. 2.
[44] Bureau of Mines, Mineral Trade Notes: Vol. 51, No. 4, October 1960, p. 26.
[45] Ceramic Age, Italian Pottery Industry: Vol. 75, No. 1, January 1960, pp. 34–35, 43.
[46] U.S. Embassy, Warsaw, Poland, State Department Dispatch 467, May 25, 1960, encl. 5, pp. 1–2.
[47] Bureau of Mines, Mineral Trade Notes: Vol. 52, No. 2, February 1961, p. 9.
[48] Foreign Commerce Weekly, Industry News From Britain: Vol. 63, No. 15, Apr. 11, 1960, p. 32.
[49] Ceramic Age, License Restrictions Removed: Vol. 75, No. 3, March 1960, p. 15.

India.—The Indian refractories industry had grown substantially in recent years. A breakdown by types of the 1960 annual production capacity is: Fire-clay refractories, 582,400 short tons; silica refractories, 87,400 tons; basic refractories, 49,280 tons; high-alumina refractories, 11,200 tons; miscellaneous (insulating, etc.), 7,168 tons; dead-burned magnesite, 72,038 tons; fire cement and mortar, 96,096 tons. Production of refractories in India during the fiscal year April 1, 1959, to March 31, 1960, was 571,200 tons, valued at $18.5 million.[50]

The Central Road Research Institute, New Delhi, was surveying and testing clay deposits suitable for making pozzolonic cement.[51]

The Indian government approved the establishment of a washing plant for plastic fire clay, kaolin, and ball clay at Neyveli.[52]

Israel.—Production of flint clay in Israel increased from 4,254 short tons valued at US$82,592 in 1958, to 11,020 tons valued at US$213,889 in 1959. Exports increased from 551 tons in 1958 (to Italy, West Germany, France, Holland, and Scandinavia) to 7,053 tons in 1959 (mainly to West Germany, England, Japan, and Poland).[53]

The Israel Mining Industries announced that US$15.4 million was to be spent in exploitation of shale deposits in the Makhtesh Ramon area of the Negev desert.[54]

Japan.—In 1959 the Chubu District produced 351,000 tons of kebushi clay, a fire clay, for use in the tile industry (65 percent of the national output), and 517,000 tons of gairome clay, a variety of kaolin (100 percent of the national output). These figures represented increases of 24 percent and 12 percent, respectively, over 1958 production.[55]

Korea, Republic of.—Production of clay in 1959 was 47,180 short tons.[56]

Pakistan.—Deposits of china clay were reported to have been found along the Salt Range in West Pakistan.[57]

Philippines.—In 1959, 2,005,750 pieces of refractory ceramic and other clay products were produced, with a value of US$111,715.[58]

The Philippines Bureau of Mines published a report on white-burning clays. Details were given on the location, geology, description of deposits, chemical analyses, results of physical tests, and estimated tonnage.[59]

Taiwan.—Production of clay in 1959 amounted to 156,374 short tons with a value of US$56,762. Most of the clay was valued at 25 cents per ton and used for the manufacture of cement. Clay for the paper industry sold for almost US$9 a ton. Approximately 15,500 tons of brick and pottery clay also was produced.[60]

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[50] Foreign Commerce Weekly, Production of Refractories Offers Investment Opportunity in India: Vol. 63, No. 25, June 20, 1960, p. 33.

[51] U.S. Embassy, New Delhi, India, State Department Dispatch 1203, June 8, 1960, p. 6.

[52] Ceramic Age, Indian Clay Washing Plant: Vol. 75, No. 1, January 1960, p. 12.

[53] Bureau of Mines, Mineral Trade Notes: Vol. 51, No. 3, September 1960, p. 17.

[54] Mining Journal (London), Mining Miscellany: Vol. 255, No. 6538, Dec. 2, 1960, p. 635.

[55] U.S. Consulate, Nagaya, Japan, State Department Dispatch 29, Jan. 18, 1961, p. 1.

[56] U.S. Embassy, Seoul, Korea, State Department Dispatch 560, Apr. 21, 1960, p. 2.

[57] Mining World (London), Far East: Vol. 102, No. 2, February 1960, p. 110.

[58] U.S. Embassy, Manila, Philippines, State Department Dispatch 560, Apr. 29, 1960, p. 1.

[59] Cruz, Amable, and de la Cruz, Juan, Clay Deposits of Siruma Peninsula, Camarines Sur (Manila), pts. 1–2: Republic of the Philippines, Department of Agriculture and Nat. Res., Rept. of Investigation No. 24, June 1960, 26 pp.

[60] U.S. Embassy, Taipei, Taiwan, State Department Dispatch 600, May 3, 1960, p. 1.

AFRICA

Egypt.—Production of kaolin in 1959 was 12,366 short tons, compared with 10,040 tons in 1958; output of common clay was 332,729 tons, compared with 533,325 tons in 1958. Clay imports for the pottery industry were 9,974 short tons, and clay exports were 3,358 tons in 1959.[61]

Morocco.—Production of fuller's earth (smectite and ghassoul) totaled 28,591 short tons in 1959, compared with 22,932 tons in 1958. The 1959 value was US$297,170. Exports went to Algeria, France, Spain, and Tunisia.[62]

Rhodesia and Nyasaland, Federation of.—Production of fire clay and kaolin in Southern Rhodesia in 1959 and the first 6 months of 1960 was as follows:

Type	*1959* Short tons	*1959* Value	*1960 (6 months)* Short tons	*1960 (6 months)* Value
Fire clay	13,588	$19,303	3,886	$6,070
Kaolin	([1])	([1])	1,202	336

[1] Data not available.

Small quantities of these clays were exported to the Republic of the Congo, Kenya, Mozambique, and Union of South Africa.

Reportedly, raw materials for the glass and ceramic industries were being developed.[63]

Union of South Africa.—A bentonite deposit 15 feet thick was discovered near Parys.[64]

OCEANIA

Australia.—Clay production figures for 1958 and 1959 in short tons were as follows:[65]

	1958	*1959*
Bentonite and bentonitic clays	153	([1])
Brick clay and shale	3,829,263	4,133,528
Fuller's earth	120	([1])
Kaolin and ball clay	37,099	([1])
Other clays	737,027	([1])

[1] Data not available.

The brick-making industry in Australia is reported to be booming, with numerous small plants having started in 1960.

New Zealand.—Production of bentonite in New Zealand totaled 2,407 short tons valued at US $81,293 in 1959, compared with 2,017 tons valued at US$67,945 in 1958.[66] The production of other clays, exclusive of common brick clay, in 1959 was 7,486 short tons valued at US$29,242.[67]

TECHNOLOGY

State publications dealing with clays and issued during 1960 included: A survey of Montana's clay and shale resources, including results of tests for ceramic and expanded lightweight aggregate uses

[61] U.S. Embassy, Cairo, Egypt, State Department Dispatch 525, Jan. 11, 1961, p. 1.
[62] Bureau of Mines, Mineral Trade Notes: Vol. 51, No. 6, December 1960, pp. 6–7.
[63] Bureau of Mines, Mineral Trade Notes: Vol. 52, No. 3, March 1961, pp. 10–11.
[64] Mining World, Union of South Africa: Vol. 13, No. 10, September 1960, p. 73.
[65] U.S. Embassy, Canberra, Australia, State Department Dispatch 32, July 18, 1960, p. 1.
[66] Bureau of Mines, Mineral Trade Notes: Vol. 52, No. 1, January 1961, p. 12.
[67] U.S. Embassy, Wellington, New Zealand, State Department Dispatch 9, July 9, 1960, p. 1.

and as possible sources of aluminum; [68] a circular presenting detailed basic data on the composition, properties, and uses of clays; [69] the results of tests on clays and shales of Illinois; [70] and a discussion of the characteristics and stratigraphic and geographic distribution of Indiana's clays and shales, and their production and uses.[71]

The proceedings of the Seventh National Conference on Clays and Clay Minerals, held in Washington, D.C., in 1958, and sponsored by the Committee on Clay Minerals of the National Academy of Sciences-National Research Council, were published in 1960. Selected papers from this volume were of special interest to the clay industry.[72]

Existing methods for determining modulus of rupture of unfired clay and recommendations for improved testing were reviewed,[73] and data were presented on the results of experiments to show the advantages of using precalcined shale.[74]

Clay-mineral associations with iron ores in the Lake Superior area were studied to determine if a key exists to the origin of the ore.[75]

Work was conducted on the relationship of clay particle size to analysis [76] and expansion [77] of clays.

High-pressure compaction studies were conducted on kaolinite, illite, and montmorillonite.[78]

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[68] Sahinan, U. M., Smith, R. I., and Lawson, D. C., Progress Report on the Clays and Shales of Montana: Montana Bureau of Mines and Geol., Bull. 13, January 1960, 83 pp.

[69] Newton, Joseph, Clay—Its Composition, Properties, and Uses: Idaho Bureau of Mines and Geol., Inf. Circ. No. 5, 1960, 35 pp.

[70] Parham, W. E., Lower Pennsylvanian Clay Resources of Knox County, Illinois: Div. Illinois State Geol. Survey, Circ. 302, 1960, 19 pp.

White, W. A., and Lamar, J. E., Ceramic Tests of Illinois Clays and Shales: Div. Illinois State Geol. Survey, Circ. 303, 1960, 72 pp.

[71] Directory of Producers and Consumers of Clay and Shale in Indiana: Directory No. 7, 1960, Indiana Dept. of Conserv. Geol. Survey, 38 pp.

[72] Seventh National Conference of Clays and Clay Minerals, Nat. Acad. Sci.-Nat. Res. Council, Washington, D.C., pub. by Pergamon Press, Inc., 1960, 369 pp. Specifically the following papers:

Whitehouse, U. Grant, Jeffrey, Lela M., and Debbrecht, James D., Differential Settling Tendencies of Clay Minerals in Saline Waters, pp. 1–79.

Nelson, Bruce W., Clay Mineralogy of the Bottom Sediments, Rappahannock River, Virginia, pp. 135–147.

Heron, S. Duncan, Jr., Clay Minerals of the Outcropping Basal Cretaceous Beds Between the Cape Fear River, North Carolina, and Lynches River, South Carolina, pp. 148–161.

Pinsak, Arthur P., and Murray, Haydn H., Regional Clay Mineral Patterns in the Gulf of Mexico, pp. 162–177.

Patterson, Sam H., and Hosterman, John W., Geology of the Clay Deposits in the Olive Hill District, Kentucky, pp. 178–194.

Ross, Clarence S., Review of the Relationships in the Montmorillonite Group of Clay Minerals, pp. 225–229.

Parrish, William, Advances in X-Ray Diffractometry of Clay Minerals, pp. 230–259.

Hosterman, John W., Geology of the Clay Deposits in Parts of Washington and Idaho, pp. 285–292.

Keller, W. D., Clay Minerals in the Morrison Formation on the Colorado Plateau, pp. 293–294.

Stubičan, V., Clay Mineral Research at the Institute for Silicate Chemistry, Zagreb, pp. 295–302.

Nash, V. E., Role of Exchangeable Cations in Viscosity of Clay Suspensions, pp. 328–342.

[73] McDowall, I. C., Testing Clay Strength: Am. Ceram. Soc. Bull., vol. 39, No. 9, Sept. 15, 1960, pp. 443–447.

[74] Brick and Clay Record, Allied Engineering Reports Further on Precalcined Clay: Vol 136, No. 4, April 1960, pp. 24–25.

[75] Taylor, S. A., and Bailey, S. W., Clay Minerals Associated With the Lake Superior Iron Ores: Econ. Geol., vol. 55, No. 1, January–February 1960, pp. 150–175.

[76] Phelps, G. W., Practical Grain Size Analysis of Clays: III Log Probability Data Plotting: Am. Ceram. Soc. Bull., vol. 39, No. 5, May 1960, pp. 267–269.

[77] Jonas, E. C., and Roberson, H. E., Particle Size as a Factor Influencing Expansion of the Three-Layer Clay Minerals: Am. Mineral., vol. 45, Nos. 7–8, July–August 1960, pp. 828–838.

[78] Chilingar, G. V., and Knight, Larry, Relationship Between Pressure and Moisture Content of Kaolinite, Illite, and Montmorillonite Clays: Bull. Am. Assoc. Petrol. Geol., vol. 44, No. 1, January 1960, pp. 101–106.

Examples were presented of the application of mineralogy in determining various useful properties of clays.[79]

Results of a detailed study of the clays of Japan were published.[80]

A systematic study was made of the relationship of mineralogy and ceramic properties of fired quartz-kaolinite-mica bodies to composition and firing temperature,[81] and the reactions of the mixtures were compared with equilibrium diagrams.[82]

Reports were published on results of studies made on the catalytic properties of kaolinite clays,[83] on the properties of bauxitic kaolins,[84] and on properties and analyses of some kaolins.[85]

The results of a study of clay-water systems of domestic kaolin suggest that exchange behavior in kaolinites is primarily a surface phenomenon and does not depend on isomorphous substitutions.[86]

Studies were made on the effects of concentration methods [87] and drying [88] on the properties of kaolin.

Results of rheological studies of kaolins were published.[89]

A method was developed for determining the quantity of montmorillonites in kaolin clays.[90]

A new mill suitable for ultrafine grinding of kaolin and other ceramic materials was described.[91]

Another article described results achieved in the particle size reduction of kaolinite clays using a new fine-grinding mill developed in Japan.[92]

Articles described the economical mining of Missouri fire-clay deposits, giving graphical information on time cycles [93] and methods of fire-clay analysis.[94]

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[79] Grim, R. E., Some Applications of Clay Mineralogy: Am. Mineral., vol. 45, Nos. 3–4, March–April, 1960, pp. 259–269.

[80] Sudo, Toshio, Mineralogical Study on Clays of Japan: Maruzen Co., Ltd. (Tokyo), 1959, 328 pp.; Ceram. Abs., vol. 43, No. 4, April 1960, p. 104.

[81] Brindley, G. W., and Udagawa, S., High-Temperature Reactions of Clay Mineral Mixtures and Their Ceramic Properties, I, Kaolinite-Mica-Quartz Mixtures With 25 Weight Percent Quartz: Jour. Am. Ceram. Soc., vol. 43, No. 2, February 1960, pp. 59–65.

[82] Brindley, G. W., and Maroney, D. M., II, Reactions of Kaolinite-Mica-Quartz Mixtures Compared With the K_2O–Al_2O_3–SiO_2 Equilibrium Diagram: Jour. Am. Ceram. Soc., vol. 43, No. 10, November 1960, pp. 511–516.

[83] Nikulina, S. Ye, and Larina, V. A., The Investigation of the Calalytic Properties of Clays of Eastern Siberia and the Methods of Their Industrial Utilization: Referativnyy Zhurnal. Khimiga, (U.S.S.R.), 1959, No. 16, p. 286.

[84] Pigott, P. G., and Tyrrell, M. E., Refractory Properties of Alabama Bauxitic Kaolins: Bureau of Mines Rept. of Investigations 5491, 1959, 18 pp.

[85] Rybnikov, V. A., Possibility of Using Nev'yansk Kaolins With Low Sintering Temperatures: Steklo i Keram., vol. 13, No. 6, 1956, pp. 15–18; Ceram. Abs., vol. 43, No. 1, January 1960, p. 17.

[86] Ormsby, W. C., and Shartsis, J. M., Surface Area and Exchange Capacity Relation in a Florida Kaolinite: Jour. Am. Ceram. Soc., vol. 43, No. 1, January 1960, pp. 44–47.

[87] Lednik, V. N., The Effect of Various Concentration Methods on the Properties of Kaolin: Referativnyy Zhurnal Khimiga (U.S.S.R.), No. 11, 1959, pp. 304–305.

[88] Lekareva, T. S., The Effect of Drying on the Properties of Prosyanovo Kaolin: Referativnyy Zhurnal, Khimiga (U.S.S.R.), No. 11, 1959, p. 305.

[89] Ormsby, W. C., and Shartsis, J. M., Clay Mineral Content of Two Domestic Kaolins: Jour. Am. Ceram. Soc., vol. 43, No. 6, June 1960, p. 335.

[90] Hinckley, D. N., and Bates, T. F., An X-Ray Fluorescence Method for the Quantitative Determination of Small Amounts of Montmorillonite in Kaolin Clay: Am. Mineral., vol. 45, Nos. 1–2, January–February 1960, pp. 239–241.

[91] Pearce, E. W. J., The "Vibro-Energy" Mill: Ceram. News, vol. 9, No. 1, January 1960, pp. 15, 19.

[92] Robertson, R. H. S., Purifying Kaolinite Clays With the Hosokawa Fine Grinding Mill: Chem. Age (London), vol. 83, No. 2135, June 11, 1960, p. 953.

[93] McDonald, M. H., Low Cost Overburden Stripping of Missouri Fire Clay Deposits: Brick and Clay Record, vol. 136, No. 3, March 1960, pp. 44–47, 50.

[94] Worrall, W. E., Rational Analysis of Fire Clays: Trans. Brit. Ceram. Soc., vol. 58, No. 3, March 1959, pp. 145–147; Ceram. Abs., vol. 43, No. 7, July 1960, p. 178.

Swelling bentonite was used in a slurry to stabilize walls of trenches up to 80 feet deep, as a means of eliminating costly shoring.[95]

The Colorado State University Research Foundation reported favorable results in experiments with the use of low-swell (calcium) bentonites for sealing irrigation canals and farm reservoirs.[96]

A paper described the use of fuller's earth for purifying heavy liquids.[97]

Ninety samples of Illinois shales were tested for bloating, and testing procedures, chemical characteristics, and the effects of weathering were discussed.[98]

Data were presented on the bloating characteristics of Maryland, New Jersey, and Virginia clays having favorable possibilities for use as lightweight aggregate.[99]

The American Society for Testing Materials released a number of updated tentative specifications on vitrified clay pipe in 1960. They were: Standard Strength Unglazed Clay Pipe, C271–60T; Extra Strength Unglazed Clay Pipe, C278–60T; Testing Clay Pipe, C301–60T; Vitrified Clay Pipe Joints Using Materials Having Resilient Properties, C425–60T; Standard Strength Ceramic Glazed Pipe, C462–60T; and Extra Strength Ceramic Glazed Clay Pipe. C463–60T.

The first two articles of a series on firing heavy clay products appeared. The first dealt with basic steps in firing and of the problems involved, and the second dealt primarily with design and operation of the kiln.[1]

A report compared old and new methods of glazing sewer pipe.[2]

Intensified basic and applied research was conducted by a sewer pipe manufacturer.[3]

Results of several series of laboratory tests to determine the resistance of brick masonry to driving rain were published.[4]

High-intensity dispersion of clays for use in plastic whiteware batches improved their working properties for extruding and jiggering.[5]

A British tile-making firm marketed prefabricated ceramic tile partitions, 1¼ to 1¾ inches thick.[6]

The need increased for new and improved kilns to meet demands of new industries and higher firing temperatures.[7]

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[95] Engineering News-Record, Bentonite Slurry Stabilizes Trench: Vol. 164, No. 6, Feb. 11, 1960, pp. 42–44, 46.

[96] Engineering News-Record, Calcium Bentonite Slurry Seals Canals: Vol. 165, No. 19, Nov. 10, 1960, p. 53.

[97] Griffitts, W. R., and Marronzino, A. P., Fuller's Earth as an Agent for Purifying Heavy Organic Liquids: Am. Mineral., vol. 45, Nos. 5–6, May–June 1960, pp. 739–741.

[98] White, W. A., Lightweight Aggregate From Illinois Shales: Illinois State Geol. Survey Circ. 290, 1960, 29 pp.

[99] Knechtel, M. M., and Hosterman, J. W., Bloating Clay in Miocene Strata of Maryland, New Jersey, and Virginia: Geol. Survey Prof. Paper 400–B, 1960, pp. B59–B62.

[1] Seator, J. G., Firing Heavy Clay Products, pt. 1, Four Basic Steps in Firing Detailed: Brick and Clay Record, vol. 136, No. 6, June 1960, pp. 111–112, 114, 116, 118, 120; pt. 2, Specific Factors in Kiln Design and Operation: No. 7, July 1960, pp. 46–47.

[2] Brick and Clay Record, The Ceramic Glazing of Clay Pipe: Vol. 136, No. 3, March 1960, pp. 66, 72.

[3] Ceramic Age, Three-Way Research Program Builds Quality for W. S. Dickey: Vol. 75, No. 2, February 1960, pp. 14–18.

[4] Amrin, E., Penetration of Brick Masonry Walls by Driving Rain: Ziegelindustrie vol. 12, No. 24, pp. 726–730; Bldg. Sci. Abs. (London), vol. 33, No. 12, December 1960, p. 357.

[5] West, Richard, and Coffin, Leon, Casting of Ware With Highly Dispersed Clay Bodies: Am. Ceram. Soc. Bull., vol. 39, No. 9, Sept. 15, 1960, pp. 462–464.

[6] Ceramic Age, Ceramic Tile Partitions: Vol. 75, No. 3, March 1960, pp. 46–47.

[7] Brick and Clay Record, Tunnel Kiln Requirements Move Up Constantly: Vol. 135, No. 7, January 1960, pp. 48–49.

Technical details on a rotary kiln for producing lightweight aggregate were presented.[8]

The use of multicored dies reduced the weight of brick 17.5 to 18.5 percent compared with that of standard three-core brick, without reducing its physical properties.[9]

A résumé of past performance and present practices in the refractories industry and predictions of future needs for refractories were reported in a special issuse of a trade journal. Details of steel industry requirements, kiln requirements, new refractories, changing trends, and other details also were presented.[10]

The Bureau of Mines published the results of an investigation of the refractory clay deposits of Wyoming.[11]

The physical and mechanical properties of 35 plastic refractories were studied in detail, and the general characteristics that a plastic refractory should have were given.[12]

Experiments were conducted on the low-temperature formation of mullite from kaolin.[13]

Solutions to some of the problems in the silica brick industry, such as spalling of silica open-hearth roof brick,[14] and conveying batched mixes from a central mixing unit to multiple distribution points,[15] were presented.

The use of a cellular silica lightweight refractory reduced heating costs.[16]

Patents were issued for methods of activating kaolin and other clays for use in petroleum refining.[17]

Other patents were issued for increasing the usefulness of kaolin by reducing viscosity,[18] increasing its brightness,[19] and coating kaolin particles to improve certain surface characteristics.[20]

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[8] Parsons, M. F., A Basic Rotary Kiln Design for Lightweight Aggregate: Pit and Quarry, vol. 52, No. 9, March 1960, pp. 100–104.

[9] Clark, J. L., Multicored Die Cuts Brick Weight: Brick and Clay Record, vol. 137, No. 1, July 1960, pp. 48–49.

[10] Brick and Clay Record, Refractories Progress in '60's: Vol. 135, No. 7, January 1960, pp. 41–63.

[11] Van Sant, J. N., Refractory-Clay Deposits of Wyoming: Bureau of Mines Rept. of Investigations 5662, 1960, 105 pp.

[12] Eusner, G. R., and Hubble, D. H., 35 Super-Duty Plastic Refractories: Am. Ceram. Soc. Bull., vol. 39, No. 7, July 1960, pp. 349–353.

[13] Okuda H., Formation of Mullite From Kaolin Minerals at Low Temperature: Bull. Ceram. Soc. Japan, vol. 32, 1960, pp. 560–561; Bldg. Sci. Abs. (London), vol. 33, No. 12, December 1960, p. 367.

[14] Eusner, R. G., and Kappmeyer, K. K., Spalling Parameters of Silica Open-Hearth Roof Brick Determined by Hot-Plate Test: Am. Ceram. Soc. Bull., vol. 39, No. 9, Sept. 15, 1960, pp. 448–452.

[15] Baker D. J., Air Transport of Silica Batch: Ceram. Age, vol. 75, No. 6, June 1960, pp. 31–36.

[16] Iron and Steel Engineer, Silica Refractory in Furnaces Reduces Production Costs: Vol. 37, No. 6, June 1960, p. 151.

[17] Gary, W. W. (assigned to Minerals & Chemicals Corp. of America, Menlo Park, N.J.), Activation of Clay by Acid Treatment, Aging in Inhibited Oil, and Calcination: U.S. Patent 2,925,393, Feb. 16, 1960.

Greene, E. W., and Allegrini, A. P. (assigned to Minerals & Chemicals Corp. of America, Menlo Park, N.J.), Activation of Clay by Acid Treatment, Sand Aging, and Calcination: U.S. Patent 2,941,959, June 21, 1960.

Robinson, A. J. (assigned to Minerals & Chemicals Phillip Corp., Menlo Park, N.J.), Process for Simultaneously Producing Pelleted and Fluid Cracking Catalysts From Clay: U.S. Patent 2,960,478, Nov. 15, 1960.

Mills, I. W. (assigned to Sun Oil Co., Philadelphia, Pa.), Preparation and Use of Acid Activated Clay: U.S. Patent 2,949,421, Aug. 16, 1960.

[18] Rowland, B. W. (assigned to Georgia Kaolin Co., Elizabeth, N.J.), Clay Products and Method of Reducing Clay Viscosity: U.S. Patent 2,950,983, Aug. 30, 1960.

[19] Maloney, W. T., Treatment of Clays and Products Produced Thereby: U.S. Patent 2,955,051, Oct. 4, 1960.

[20] Albert, C. G., and Wilcox, J. R. (assigned to Minerals & Chemicals Corp. of America, Menlo Park, N.J.), Surface Modified Kaolin Clay: U.S. Patent 2,948,632, Aug. 9, 1960.

Patents were issued for a more efficient spray dryer,[21] and a pelletizer for making spherical masses of activated kaolin.[22]

Patents were issued on the use of bentonite as a major ingredient in a preparation for packing walls in coal mines to prevent mine fires,[23] as a cation-modified thickener for lubricants,[24] and as a constituent of foundry molding sand,[25] and on a method of beneficiating certain bentonites to improve their usefulness as drilling muds.[26]

Patents were issued for the use of fuller's earth (attapulgite) as an additive to smoking tobacco to absorb tars,[27] and as a coating for pellets of resins, ammonium nitrate, and other materials.[28]

An improved method and kiln for producing lightweight aggregate was patented.[29] The kiln was designed to prevent sticking of the material being bloated. Another patent was issued for a process using alkali nitrate liquor additive to produce a more uniform expanded clay or shale product and increase sintering efficiency.[30]

Other patents involving lightweight aggregate were for an improved method and apparatus for pelletizing a continuous clay strip for making a lightweight product;[31] for a flotation method and apparatus for separating lightweight aggregate from unbloated clay or other heavy material;[32] and for a process for reducing agglomeration of pellets of lightweight aggregate in firing, by controlling rate of travel in the preheat section of the kiln, and by directing the gases in the firing zone counter to the movement of the pellets.[33]

A patent was issued for a lightweight aggregate kiln in two sections, which are tilted at different angles and which rotate at different speeds.[34]

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[21] Morris, W. E. (assigned to J. M. Huber Corp., Huber, Ga.), Method and Apparatus for Spray Drying: U.S. Patent 2,921,383, Jan. 19, 1960.

[22] Powell, M. J., and Cecil, T. A. (assigned to Minerals & Chemicals Corp. of America, Menlo Park (N.J.), Apparatus for Forming Sphericals Masses: U.S. Patent 2,944,986, July 12, 1960.

[23] Novak, J., and Others, Method of Preventing the Outbreak of Endogenous Mine Fires: U.S. Patent 2,924,279, Feb. 9, 1960.

[24] Burns, R. R., and Goldenburg, E. H. (assigned to Nalco Chemicals Co., Chicago, Ill.), Cation Modified Clay as a Thickener for Hydrocarbon Lubricating Oil: U.S. Patent 2,920,043, Jan. 5, 1960.

[25] King, E. H., Heine, R. W., and Schumacher, J. S. (assigned to Hill & Griffith Co., Cincinnati, Ohio), Carbonaceous Component for Foundry Molding Sand: U.S. Patent 2,920,970, Jan. 12, 1960.

[26] Dillon, E. T., and Turner, F. (assigned to Magnet Cove Barium Corp., Houston, Tex.), Beneficiated Clay Compositions and Method of Beneficiating Clay: U.S. Patent 2,948,678, Aug. 9, 1960.

[27] Haden, W. L., Jr. (assigned to Minerals & Chemicals Corp. of America, Menlo Park, N.J.), Tobacco Composition and Smoking Unit Containing Material for Eliminating Deleterious Matter: U.S. Patent 2,933,420, Apr. 19, 1960.

[28] Nack, H., and Sachsel, G. F. (assigned to G. & A. Laboratories, Inc., Savannah, Ga.), Pellet Formation: U.S. Patent 2,938,233, May 31, 1960.

[29] Holm, H. A. R., Method for Burning Clay Slate or Clay: U.S. Patent 2,948,630, Aug. 9, 1960.

[30] Gmeiner, A. R., and Hackbert, C. R. (assigned to Kimberly-Clark Corp., Neenah, Wis.), Porous Ceramic Products and Method: U.S. Patent 2,955,947, Oct. 11, 1960.

[31] Sainty, C. L. (assigned to Structural Concrete Components, Ltd., Hassocks, England), Manufacture of Pellets or Granular Material: U.S. Patent 2,938,230, May 31, 1960.

[32] Old, A. F., Gibson, R. F., and Duey, R. V. K. (assigned to Southern Lightweight Aggregate Corp., Richmond, Va.), Method and Apparatus for Separation of Lightweight Aggregate and Product: U.S. Patent 2,933,187, Apr. 19, 1960.

[33] Sainty, C. L. (assigned to Structural Concrete Components, Ltd.): Canadian Patent 598,772, May 24, 1960.

[34] Frokjaer-Jensen, A. (assigned to Leca (World) Ltd.): Australian Patent 224,023, Sept. 21, 1959.

Patents were issued for an improved slip-casting process for making ceramic ware,[35] and for a triangular one-piece support used in curing and firing ceramic ware.[36] A new transfer mechanism for ceramic-ware tunnel kilns was patented.[37]

A patent was obtained for a vitreous-silica glass-tank refractory made by removing nonsilica cations from kaolin, attapulgite, or other silicates.[38]

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[35] Tomkins, D. E. (assigned to Shenango China, Inc., New Castle, Pa.), Process for the Manufacture of Ceramic Objects: U.S. Patent 2,964,822, Dec. 20, 1960.

[36] Dopera, R., Supporting Device for Ceramic Ware: U.S. Patent 2,927,362, Mar. 8, 1960.

[37] Horni, E. C. (assigned to Swindler-Dressler Corp., Pittsburgh, Pa.), Transfer Mechanism for Tunnel Kiln: U.S. Patent 2,922,381, Jan. 26, 1960.

[38] Grim, R. E. (assigned to Minerals & Chemicals Corp. of America, Menlo Park, N.J.), Vitreous Refractory Composition and Method for Making Same: U.S. Patent 2,945,768, July 19, 1960.

Cobalt

By Joseph H. Bilbrey, Jr.,[1] and Dorothy T. McDougal[2]

COBALT production, imports, and consumption for the United States were less than in 1959. World production of cobalt also decreased, owing mainly to the closing of Calera Mining Company mine and refinery at Cobalt, Idaho. The political situation did not materially affect cobalt production in the Republic of the Congo. Canada and Morocco increased output, but events in Cuba prevented production of most of the expected 4.4 million pounds of cobalt at Freeport Nickel Company Moa Bay plant. The Defense Production Act inventory of cobalt was 25,355,000 pounds as of December 31, 1960, an increase of 2,618,000 pounds during the year.

TABLE 1.—Salient cobalt statistics

(Thousand pounds of contained cobalt)

	1951–55 (average)	1956	1957	1958	1959	1960
United States:						
Domestic mine production of ore or concentrate	1,626	3,595	4,144	4,844	2,994	(1)
Recoverable cobalt	1,149	2,544	3,303	4,023	2,331	(1)
Imports for consumption	15,641	15,577	17,379	15,149	[2] 21,245	12,170
Stocks, Dec. 31: Consumer	1,147	1,244	977	874	1,403	1,856
Consumption	9,718	9,562	9,157	7,542	9,899	8,930
Price: Metal ...... per pound	\$2.10–\$2.60	\$2.60–\$2.35	\$2.35–\$2.00	\$2.00	\$2.00–\$1.75	\$1.75–\$1.50
Free world: Production	24,800	31,800	31,800	29,200	[2] 34,600	33,400

[1] Figure withheld to avoid disclosing individual company confidential data.
[2] Revised figure.

DOMESTIC PRODUCTION

Domestic production of cobalt concentrate in 1960 was confined to the Bethlehem Corp. and the National Lead Co. Bethlehem Corp. produced 40 percent more cobalt in concentrate from its magnetite iron ores at Cornwall and Morgantown, Pa. The concentrate was processed into metal, oxides, and hydrate by Pyrites Co., Wilmington, Del.

Twenty-three tons of residue containing 1,851 pounds of cobalt was recovered at the Kellogg, Idaho, zinc plant of The Bunker Hill Co. No shipments were made.

The St. Louis Smelting and Refining Division of National Lead Co. produced 2 percent less cobalt metal from its mining and refining

[1] Commodity specialist, assisted technically by Isaac E. Weber, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

facilities near Fredericktown, Mo. Freeport Nickel Co. refined concentrate from Cuba to cobalt metal in its refinery at Port Nickel, La., and sold 307,840 pounds of cobalt to the U.S. Government under its Defense Production Act contract.

Based on cobalt content, domestic production of cobalt oxide increased 122 percent from 1959, output of hydrate declined 6 percent, and production of salts increased 24 percent.

TABLE 2.—Cobalt ore or concentrate produced and shipped in the United States

	1951–55 (average)	1956	1957	1958	1959	1960
Produced:						
Gross weight......short tons..	23,920	35,985	38,417	47,345	45,834	(1)
Cobalt content....thousand pounds..	1,626	3,595	4,144	4,844	2,994	(1)
Recoverable cobalt......do....	1,149	2,544	3,303	4,023	2,331	(1)
Shipped from mines:						
Gross weight......short tons..	23,996	36,956	39,744	46,294	40,896	(1)
Cobalt content....thousand pounds..	1,605	3,657	4,123	4,832	2,944	(1)
Recoverable cobalt......do....	1,152	2,655	3,281	4,017	2,316	(1)

[1] Figure withheld to avoid disclosing individual company confidential data.

TABLE 3.—Cobalt materials consumed by refiners or processors in the United States

(Thousand pounds of contained cobalt)

Form [1]	1951–55 (average)	1956	1957	1958	1959	1960
Alloy and concentrate	3,750	6,399	5,793	4,645	3,342	2,062
Metal	728	884	877	999	1,098	961
Hydrate	74	91	82	57	24	18
Carbonate	2	1	----	----	3	2
Purchased scrap	} 125	96	93	250	----	----
Other		61	93	56	55	28

[1] Total consumption is not shown because the metal, hydrate, and carbonate originated from alloy and concentrate.

TABLE 4.—Cobalt products produced and shipped by refiners and processors in the United States

(Thousand pounds)

Product	1959				1960			
	Production		Shipments		Production		Shipments	
	Gross weight	Cobalt content	Gross weight	Cobalt content	Gross weight	Cobalt content	Gross weight	Cobalt content
Metal	2,477	2,462	2,639	2,620	1,549	1,540	1,604	1,595
Oxide	233	163	228	159	517	362	506	354
Hydrate	200	114	210	120	189	107	165	93
Salts:								
Acetate	115	27	105	25	241	57	234	55
Carbonate	246	113	233	108	372	173	330	154
Sulfate	566	125	503	114	401	95	450	104
Other	176	46	209	53	242	60	247	61
Driers	13,361	768	13,005	745	12,333	711	12,507	727
Total	17,374	3,818	17,132	3,944	15,844	3,105	16,043	3,143

CONSUMPTION AND USES

Industrial demand for cobalt declined to 8.9 million pounds in 1960 and was 10 percent less than in 1959. Cobalt consumed for metallic uses dropped 12 percent and for nonmetallic uses (exclusive of salts and driers) decreased 6 percent. Consumption of cobalt for salts, driers, and other nonmetallic uses increased 4 percent.

Permanent magnet alloys, again the largest single use of cobalt, took 27 percent of the total, but 20 percent less was used than in 1959. The second largest use of cobalt was for high-temperature, high-strength alloys—23 percent of the total and 16 percent less than in 1959.

TABLE 5.—Cobalt consumed in the United States, by uses

(Thousand pounds of contained cobalt)

Use	1951-55 (average)	1956	1957	1958	1959	1960
Metallic:						
High-speed steel	227	259	237	88	214	155
Other tool steel	124	123	109	100	619	53
Other alloy steel						574
Permanent magnet alloys	2,199	2,787	2,927	2,340	2,979	2,387
Cutting- and wear-resisting materials	4,560	270	264	161	139	263
High-temperature high-strength alloys		3,019	2,755	2,193	2,423	2,024
Alloy hard-facing rods and materials	528	625	501	361	404	447
Cemented carbides	348	253	249	148	339	320
Nonferrous alloys	227	365	237	252	654	107
Other						495
Total	8,213	7,701	7,279	5,643	7,771	6,825
Nonmetallic (exclusive of salts and driers):						
Ground-coat frit	421	525	474	457	543	465
Pigments	124	232	205	251	200	190
Other	76	115	188	161	254	278
Total	621	872	867	869	997	933
Salts and driers: Lacquers, varnishes, paints, inks, pigments, enamels, glazes, feed, electroplating, etc. (estimate)	884	989	1,011	1,030	1,131	1,172
Grand total	9,718	9,562	9,157	7,542	9,899	8,930

TABLE 6.—Cobalt consumed in the United States, by forms

(Thousand pounds of contained cobalt)

Form	1951-55 (average)	1956	1957	1958	1959	1960
Metal	7,187	7,321	7,028	5,403	7,630	6,761
Oxide	624	857	755	754	877	757
Purchased scrap	1,021	395	363	355	261	240
Salts and driers	884	989	1,011	1,030	1,131	1,172
Total	[1] 9,718	9,562	9,157	7,542	9,899	8,930

[1] Includes a small quantity of ore and alloy.

PRICES

Effective March 1, 1960, the major supplier reduced the price of cobalt metal granules and regular fines 25 cents to $1.50 per pound, f.o.b. carrier, Port of New York, packed in 500-pound drums. Ceramic-grade oxide (72½–73½ percent cobalt, in 250-pound kegs) was reduced 18 cents to $1.15 a pound, east of the Mississippi River, f.o.b. shipping point, freight allowed. This price was subject to a 1-percent discount.

FOREIGN TRADE [3]

Imports.—The United States continued to depend almost entirely on imports for cobalt. A total of 12.2 million pounds of cobalt contained in concentrates, metal, oxide, and salts was imported in 1960, 43 percent less than in 1959. The decrease was due mainly to reduction of deliveries to the Government under a Defense Production Act contract that terminated during the year. The Republic of the Congo continued to be the main supplier of cobalt, providing 39 percent of all imports. Belgium supplied 35 percent. The Belgian metal and oxide came originally from the Congo, so that 74 percent of U.S. imports originated in the Republic of the Congo compared with 80 percent in recent years. Imports of cobalt, as metal, from West Germany were 9 percent of the total, 20 percent less than in 1959. Imports from Norway supplied 6 percent, from Canada 4 percent, and from the Federation of Rhodesia and Nyasaland 3 percent of the total.

Exports.—A total of 1,828,825 pounds of cobalt-bearing materials was exported, an increase of 159 percent over 1959. Scrap (5 percent or

TABLE 7.—U.S. imports for consumption of cobalt, by classes

(Thousand pounds and thousand dollars)

Year	White alloy [1]		Ore and concentrate [2]		Metal	
	Gross weight	Cobalt content	Gross weight	Cobalt content	Gross weight	Value
1951–55 (average)	5,312	2,396	245	22	[3] 12,866	[3] $30,154
1956	4,708	2,013	77	6	12,974	32,910
1957	1,883	817	140	15	[4] 16,173	[4] 32,431
1958					14,538	28,664
1959			[3 5] 772	[3 5] 35	20,087	35,926
1960			[3] 6,462	[3] 314	10,801	17,093

Year	Oxide		Salts and compounds		Total	
	Gross weight	Value	Gross weight	Value	Gross weight	Cobalt content (estimated)
1951–55 (average)	587	$944	201	$130	19,211	15,641
1956	828	1,413	398	247	18,985	15,577
1957	647	853	364	179	19,207	17,379
1958	837	1,116	234	145	15,609	15,149
1959	[5] 1,557	[5] 1,851	278	134	[5] 22,694	21,245
1960	1,459	1,520	230	104	18,952	12,170

[1] Reported by importer to Bureau of Mines, which adjusted the figures for "Ore and concentrates" for 1951–57, as reported by the Bureau of the Census, to exclude "white alloy" from the Republic of the Congo (Belgian Congo).
[2] Figures exclude receipts of "white alloy" from the Republic of the Congo (Belgian Congo).
[3] Adjusted by Bureau of Mines.
[4] Includes 4,903 pounds of scrap, valued at $1,698.
[5] Revised figure.

[3] Figures on U.S. imports and exports (unless otherwise indicated) compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 8.—U.S. imports for consumption of cobalt metal and oxide, by countries

(Thousand pounds)

Country	Metal		Oxide (gross weight)	
	1959	1960	1959	1960
North America: Canada	539	525	[1] 124	40
Europe:				
Belgium-Luxembourg	4,477	3,276	1,433	1,419
France	68	101		
Germany, West	1,377	1,106		
Norway	746	718		
United Kingdom	(2)	(2)		
Total	6,668	5,201	1,433	1,419
Asia: Japan	10			
Africa:				
Congo,[3] Republic of the, and Ruanda-Urandi	11,887	4,735		
Rhodesia and Nyasaland, Federation of	983	340		
Total	12,870	5,075		
Grand total	20,087	10,801	[1] 1,557	1,459

[1] Revised figure.
[2] Less than 1,000 pounds.
[3] Belgian Congo before July 1, 1960.

Source: Bureau of the Census.

more cobalt) was the main item. Only 30,607 pounds was in semifabricated forms. The remainder was ore, concentrate, metal, and alloys in crude form. Shipments to West Germany were 43 percent of the total, to the United Kingdom, 23 percent; to Japan, 12 percent; and to the Netherlands, 10 percent. All forms of cobalt metal remained on the positive list of commodities requiring validated export license for shipment to any destination other than Canada. On September 24, 1959, the Bureau of Foreign Commerce announced less restrictive controls on cobalt alloys and cobalt chemicals.

Tariff.—Cobalt metal and ore entered the United States duty-free. The duty on cobalt oxide continued to be 4 cents a pound, on sulfate 2½ cents a pound, on linoleate 5 cents, and on other salts and compounds 15 percent ad valorem.

On November 15, 1960, the U.S. Tariff Commission issued its Tariff Classification Studies, Explanatory and Background Materials, on Schedule 4—Chemicals and Related Products and Schedule 6—Metals and Metal Products. These reports to the President and to the Chairmen of the Committee on Ways and Means of the House of Representatives and the Committee on Finance of the Senate, Pursuant to Title I of the Customs Simplification Act of 1954, are a comprehensive study of U.S. laws prescribing the tariff status of imported articles, and a proposed revision and consolidation of those laws to eliminate anomalies and to simplify the determination and application of tariff classifications.

WORLD REVIEW

Estimated free world production of cobalt decreased 3 percent. Republic of the Congo produced 54 percent of the 1960 total, 2 percent less than in 1959. The Federation of Rhodesia and Nyasaland

TABLE 9.—Free world production of cobalt by countries [1] [2]

(Short tons of contained cobalt)

Country [1]	1951–55 (average)	1956	1957	1958	1959	1960
North America:						
Canada [3]	955	1,758	1,961	1,355	1,575	1,665
United States (recoverable cobalt)	573	1,272	1,652	2,012	1,165	(4)
Total	1,528	3,030	3,613	3,367	2,740	(4)
Africa:						
Congo, Republic of the (formerly Belgian), (recoverable cobalt)	8,378	10,019	8,945	7,166	9,294	9,083
Morocco: Southern zone (content of concentrate)	831	710	500	1,021	1,330	1,401
Rhodesia and Nyasaland, Federation of: Northern Rhodesia (content of white alloy, cathode metal, and other products)	844	1,205	1,583	1,792	2,270	2,036
Total	10,053	11,934	11,028	9,979	12,894	12,520
Oceania:						
Australia (recoverable cobalt in zinc concentrate)	12	13	14	17	16	[5] 16
New Caledonia (content of concentrate)				44	93	
Total	12	13	14	61	109	[5] 16
Free world total (estimate) [1] [2]	12,400	15,900	15,900	14,600	17,300	16,700

[1] Cobalt is also recovered, principally in West Germany, from pyrites produced in Finland and other European countries, and estimates are included in the world total. Production data for East Germany and U.S.S.R. are not available, and no estimates for these two countries are included in the world total.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Cobalt in all forms. Excludes the cobalt content of nickel oxide sinter shipped to the United Kingdom by International Nickel Company of Canada, Ltd., (estimate for which is included in the world total), but includes the cobalt content of Falconbridge Nickel Mines, Ltd., shipments of nickel-copper matte to Norway.
[4] Figure withheld to avoid disclosing individual company confidential data; U.S. figure included in world total.
[5] Estimate.

Compiled by Augusta W. Jann, Division of Foreign Activities.

ranked second with production of 12 percent. Canada produced 10 percent of the estimated free world output.

NORTH AMERICA

Canada.—Cobalt was obtained mainly as a byproduct of refining nickel-copper ores from the Sudbury district, Ontario, and Lynn Lake, Manitoba. Silver-cobalt ores of the Cobalt-Gowganda area of northern Ontario also contributed to production. The International Nickel Company of Canada, Ltd., (Inco), recovered electrolytic cobalt from its nickel refining operations at Port Colborne, Ontario. Impure cobalt oxide from the refinery was shipped to Inco's Clydach, Wales, plant for conversion to high-grade oxide, metal, and salts. Inco delivered 2.36 million pounds of cobalt, about the same as in 1959.[4] Falconbridge Nickel Mines, Ltd., delivered 827,000 pounds of cobalt, 13 percent more than in 1959. The cobalt was recovered from Sudbury nickel-cobalt matte exported to the Falconbridge refinery at Kristiansand S., Norway.[5]

Sherritt Gordon Mines, Ltd., produced 310,410 pounds of cobalt

[4] The International Nickel Company of Canada, Ltd., 1960 Annual Report, p. 9.
[5] Falconbridge Nickel Mines, Ltd., 1960 Annual Report, p. 6.

from Lynn Lake, Manitoba, nickel-copper ore, about the same as in 1959.[6]

Silver-cobalt ores were shipped by Agnico Mines, Ltd.; Deer Horn Mines, Ltd.; Langis Silver & Cobalt Mining Company, Ltd.; McIntyre Porcupine Mines, Ltd., Castle Division; Silver Miller Mines, Ltd.; and Siscoe Metals of Ontario, Ltd., from the Cobalt-Gowganda area for smelting at the Deloro Smelting & Refining Co., Ltd., plant at Deloro, E. Ontario.[7] Deloro announced that it would close its smelter at the beginning of 1961 after 50 years of operation. Thus, for treating ores, many of the silver-cobalt mines of the Cobalt-Gowganda area will need another facility, which can provide about 120 tons of cobalt a year. Sherritt Gordon Mines, Ltd., is expected to provide a special circuit to process these ores.[8]

Cuba.—Cuban Government restrictions and prohibitive taxation caused the Freeport Nickel Co. to suspend operations at its Moa Bay nickel-cobalt plant on April 1, 1960. In August 1960, the Cuban facilities were seized by the Cuban Government, and the Port Nickel, La., refinery was closed. Freeport's combined investment in Cuba and the United States was about $100 million. The facilities were to produce 4.4 million pounds of cobalt a year in addition to nickel. Before closing, the Freeport Nickel Co. refined concentrate from Cuba to cobalt metal at its refinery at Port Nickel and sold 307,840 pounds of cobalt to the U.S. Government under its Defense Production Act contract.[9]

On August 17, 1960, under Law No. 867, Cuba established a Cuban Mining Institute (Instituto Cubano de Mineria) as a dependency of the Industrialization Department of the National Institute of Agrarian Reform (INRA). The law centralized in the newly established Institute all the functions of research, planning, exploration, exploitation, processing, and commercialization of minerals, which the "free initiative and activity of private enterprise have not properly developed."[10]

EUROPE

Finland.—Copper-bearing pyrite from the Outokumpu Oy mine in eastern Finland, containing about 0.2 percent cobalt, was concentrated and roasted. The sinter was shipped to Duisburg, West Germany, for recovery of cobalt, copper, iron, and zinc.

Germany, West.—The Duisburger Kupferhütte refinery at Duisburg, the major producer, recovered cobalt mainly from pyrite sinter imported from Finland and other European countries. The refinery of Gebrüder Borchers A.G. at Goslar treated cobalt-bearing scrap, residues, and speiss.

AFRICA

Congo, Republic of the (formerly Belgian).—The Union Minière du Haut-Katanga produced 9,083 tons of cobalt, 54 percent of the estimated free world production and somewhat less than in 1959. The new Luilu copper electrolysis plant near Kolwezi began producing

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[6] Sherritt Gordon Mines, Ltd., 1960 Annual Report, p. 3.
[7] Canadian Department of Mines, Ontario.
[8] Sherritt Gordon Mines, Ltd., 1960 Annual Report, p. 6.
[9] Freeport Sulphur Co., Annual Report 1960, pp. 6–8.
[10] U.S. Embassy, Havana, Cuba: State Department Dispatch 580, Sept. 12, 1960, pp. 1–5.

on May 17, 1960. The cobalt section of the plant, scheduled to begin operating late in 1961, will have an annual production capacity of 1,900 short tons of cobalt.

An article, describing the production of electrolytic cobalt at the Union Minière du Haut-Katanga plant at Jadotville, was published.[11]

Morocco.—The Société Minière de Bou-Azzer et du Graara cobalt mine produced 14,013 tons of concentrate containing 1,401 tons of cobalt, a 5-percent increase over 1959.

Rhodesia and Nyasaland, Federation of.—In the fiscal year ending June 30, 1960, Rhokana Corporation, Ltd., milled 5,291,500 short tons of ore averaging 0.15 percent cobalt. This quantity was 28 percent more than was milled in fiscal 1959, when the average grade was 0.16 percent cobalt. Cobalt concentrate produced from the copper-cobalt ores of the Mindola and Nkana Mines was 99,122 tons containing 2.60 percent cobalt. Total production of cobalt was 1,307 tons, compared with 1,092 tons in fiscal 1959.[12]

During the fiscal year ending June 30, 1960, Chibuluma Mines, Ltd., produced 29,882 short dry tons of cobalt-copper concentrate, containing 3.22 percent copper and 3.64 percent cobalt. At the Ndola plant, 36,524 tons of cobalt-copper concentrate was treated, producing 9,778 tons of cobalt matte containing 9.46 percent cobalt and 11.61 percent copper. The matte was shipped to Belgium for refining; 800 tons of cobalt was returned, compared with 830 tons in fiscal 1959. Although some operational difficulties were experienced during the year at the cobalt plant, mill production exceeded mine output through the use of stockpiled cobalt concentrate. The ore reserve on June 30, 1960, including Chibuluma West, was 9.8 million tons averaging 4.89 percent copper and 0.18 percent cobalt. The ore reserve of Baluba Mines, Ltd., Northern Rhodesia, the largest undeveloped free world cobalt reserve, was 112 million short tons averaging 2.41 percent copper and 0.16 percent cobalt.[13]

TECHNOLOGY

As part of its pure-metals program, the Federal Bureau of Mines carried out research on extracting nickel and cobalt from lateritic ores by solvent extraction and other methods, on the alloying characteristics of high-purity cobalt, and on recovering alloy components from nickel- and cobalt-base high-temperature alloy scrap. Basic research was conducted on developing precise analytical methods for nickel- and cobalt-bearing materials.

The Bureau of Mines reported on the properties of titanium-vanadium-cobalt alloys.[14]

An article describing acid leaching of nickel and cobalt at Freeport Nickel's new plant in Cuba was published.[15]

The Defense Metals Information Center, Battelle Memorial Institute, Columbus, Ohio, published recent developments in cobalt-base

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[11] Bouchat, M. A., and Saquet, J. J., Electrolytic Cobalt in Katanga: Jour. Metals, October 1960, pp. 802–808.
[12] Rhokana Corporation, Ltd., Annual Report, June 30, 1960, p. 12.
[13] Rhodesian Selection Trust. Ltd.. Annual Report 1960, pp. 6, 41, 49, 52.
[14] Ramsdell, J. D., and Hull, E. D., Properties of Titanium-Vanadium Cobalt Alloys: Bureau of Mines Rept. of Investigations 5591, 1960, 13 pp.
[15] Carlson, E. T., and Simons, C. S., Acid Leaching Moa Bay's Nickel: Jour. Metals, vol. 12, March 1960, pp. 206–213.

superalloys[16] and a memorandum on the physical and mechanical properties of the cast cobalt-chromium-tungsten alloy WI–52 developed for gas-turbine components requiring high-strength properties in the 1,000° to 2,000° F. temperature range.[17]

A paper on applying magnetic materials in metallurgical technology was published.[18]

The Mellon Institute developed a new ultrahigh-strength steel suitable for missile motor cases by adding 1 percent cobalt to AISI 4100-series steel. The alloy was being made by U.S. Steel, Universal-Cyclops, Latrobe Steel, and Allegheny Ludlum. In addition to cobalt, the alloy contains 1 percent silicon, 1.10 percent chromium, 0.70 percent manganese, 0.39 percent carbon, 0.25 percent molybdenum, and 0.15 percent vanadium.[19]

A paper on cobalt-molybdenum desulfurisation catalyst, its composition, manufacture, and performance was published.[20]

Papers were presented at the 6th Conference on Magnetism and Magnetic Materials, New York, N.Y., in November 1960 on developing fine particle magnets, on a new light weight material for permanent magnets (28 percent cobalt, 57 percent iron), on the structure of Alnico V, on the metallurgy and magnetic properties of an iron-cobalt-vanadium alloy, and on the effect of cobalt oxide in porous nickel ferrites.

Articles were published on electrical and magnetic properties of thin cobalt films, nonmetallic dispersions in cobalt and its alloys, cobalt and cobalt alloys in powder metallurgy, welding and brazing of certain cobalt-containing alloys, application of a new cobalt-base alloy in metallurgical furnaces, development of wrought cobalt-tungsten-base alloys, use of permanent magnets in motors and generators, cobalt oxides as catalysts, the properties of cobalt that make it suitable for magnetic development, and high-temperature-bearing properties and cobalt-base alloys.[21]

A comprehensive monograph on cobalt was published.[22]

The Centre D'Information du Cobalt, Brussels, Belgium, also edited a comprehensive book on cobalt, which was prepared in collaboration with the staff of Battelle Memorial Institute, Columbus, Ohio.[23]

Patents were issued on recovering cobalt from ores,[24] separating

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[16] Wagner, H. J., Recent Developments in Superalloys: DMIC Memorandum 64, Sept. 8, 1960 (OTS PB 161214), 14 pp.

[17] Morral, F. R., and Wagner, H. J., Physical and Mechanical Properties of the Cobalt-Chromium-Tungsten Alloy WI–52: DMIC Memorandum 66, Sept. 22, 1960, (OTS PB 161216), 22 pp.

[18] Littmann, M. F., Application of Magnetic Materials: Jour. Metals, March 1960, pp. 220–224.

[19] American Metal Market, Scaife Says 4 Steel Firms Produce New MX–2 Alloy; Calls Cobalt Key: Vol. 47, June 15, 1960, p. 1.

[20] Andrews, E. B., Cobalt-Molybdenum Desulphurisation Catalyst: Chem. and Ind., No. 46, Nov. 12, 1960, pp. 1396–1400.

[21] Battelle Memorial Institute, Cobalt: Cobalt Inf. Center, quarterly publications, Nos. 6–9, March–December, 1960.

[22] Young, R. S. (ed.), Cobalt. Its Chemistry, Metallurgy, and Uses: Am. Chem. Soc. Monograph 149, Reinhold Pub. Corp., New York, N.Y., 1960, 424 pp.

[23] Cobalt Monograph, 1960, 515 pp. available from M. Weissenbruch S. A., 49, rue du Poinçon, Brussels.

[24] Donaldson, J. W., and Davis, H. F., Jr. (assigned to Quebec Metallurgical Industries, Ltd.) Method for Treating Nickel Sulphide Ore Concentrates: U.S. Patent 2,934,428, Apr. 26, 1960.

Queneau, P. E., Townshend, S. C., and Young, R. S. (assigned to The International Nickel Company, Inc.), Treatment of Nickel-Containing Sulfide Ores: U.S. Patent 2,944,883, July 12, 1960.

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of nickel from cobalt,[25] various alloys,[26] and cobalt catalysts,[27] a process of making cemented carbide products,[28] and producing cobaltous hydroxide.[29]

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[25] Bare, C. B., and Horst, R. J. (assigned to Bethlehem Steel Co.), Use of SO_2 in Ammonia Leaching Mayari Ore: U.S. Patent 2,928,732, Mar. 15, 1960.
Matson, R. F. (assigned to Freeport Sulphur Co.), Process for Separating Nickel and Zinc from Acidic Aqueous Solution Containing Nickel, Zinc, and Cobalt: U.S. Patent 2,933,370, Apr. 19, 1960.
Reynaud, F., and Roth, A. (assigned to Société d'Electro-Chimie d'Electro-Metallurgie et des Acieries Electriques d'Ugine), Process for Separating Nickel Contained in Solutions of Mixed Cobalt and Nickel Salts: U.S. Patent 2,960,400, Nov. 15, 1960.

[26] Shepard, A. P. (assigned to Metallizing Engineering Co., Inc.), Spray-Weld Alloys: U.S. Patent 2,936,229, May 10, 1960.
Franklin, A. W., and Barber, J. B. (assigned to The International Nickel Co., Inc.), Titanium-Hardened Nickel-Cobalt-Iron Alloys: U.S. Patent 2,941,882, June 21, 1960.
Klement, J. F. (assigned to Ampco Metal, Inc.), Aluminum Bronze Alloy Having Improved Wear Resistance by the Addition of Cobalt and Chromium: U.S. Patent 2,944,890, July 12, 1960.
Jahnke, L. P., and Pohlman, M. A. (assigned to General Electric Co.), Nickel Base Alloys: U.S. Patent 2,945,758, July 19, 1960.
Thielemann, R. H. (assigned to Sierra Metals Corp.), High Temperature Nickel Base Alloy: U.S. Patent 2,948,606, Aug. 9, 1960.
Brown, J. T. (assigned to Westinghouse Electric Corp.) High Temperature Nickel Base Alloy: U.S. Patent 2,951,757, Sept. 6, 1960.
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Elbaum, J. K. (assigned to Union Carbide Corp.), Cobalt-Base Alloy Suitable for Spray Hard-Facing Deposit: U.S. Patent 2,961,312, Nov. 22, 1960.

[27] Sullivan, J. K. (assigned to The Goodyear Tire & Rubber Co.), Preparation of Polyesters Using Cobaltous Chloride as Catalyst: U.S. Patent 2,937,160, May 17, 1960.
Scott, J. W., Jr. (assigned to California Research Corp.), Catalytic Conversion of Hydrocarbon Distillates: U.S. Patent 2,944,005, July 5, 1960.
Scott, J. W., Jr. (assigned to California Research Corp.), Hydrocracking of a Hydrocarbon Distillate Employing a Sulfide of Nickel or Cobalt, Disposed on an Active Siliceous Cracking Catalyst Support: U.S. Patent 2,944,006, July 5, 1960.
Viles, P. S. (assigned to Esso Research and Engineering Co.), Reduction of Ore: U.S. Patent 2,953,450, Sept. 20, 1960.

[28] Wellborn, W. W. (assigned to Firth Sterling, Inc.), Process of Making Cemented Carbide Products: U.S. Patent 2,942,971, June 28, 1960.

[29] Pincott, J. and West, De Witt H. (assigned to The International Nickel Company, Inc.), Production of Cobaltous Hydroxide: U.S. Patent 2,950,172, Aug. 23, 1960.

Columbium and Tantalum

By F. W. Wessel[1]

CONSUMPTION of columbium metal increased sharply in 1960, principally because of its use in the construction of what was intended to be the first nuclear-powered airplane. This represented the first consistent use of columbium and columbium-based alloys in quantity. Tantalum was also in greater demand.

Researchers were active in the fields of extractive and physical metallurgy. Outstanding achievements were the development by Naval Research Laboratories of an oxidation-resistant zinc coating for columbium and the development of corrosion-resistant columbium-vanadium alloys by Union Carbide Metals Co. and the Federal Bureau of Mines, working independently.

LEGISLATION AND GOVERNMENT PROGRAMS

The General Services Administration (GSA) on June 30 reported holdings of 1,362,318 pounds of nonspecification columbite and 1,857,394 pounds of nonspecification tantalite. All, or a substantial part, of this material was available for use by other Federal agencies; it had not been made available to private industry.

The Government held a substantial stockpile of columbium-tantalum-bearing tin slag, and consideration was given to its disposition on the open market.

In October, a meeting was called in London to discuss the possible formation of a Columbium Research Organization. The United States was invited to participate.

DOMESTIC PRODUCTION

There was no domestic mine production of tantalum-columbium ores in 1960. Porter Brothers Corp. closed its facilities for mining and concentrating euxenite at Bear Valley, Idaho, at the end of the 1959 season. These ores were processed by Mallinckrodt Chemical Works, St. Louis, Mo., and the combined columbium and tantalum oxide products were shipped to the national stockpile for the Porter Brothers account.

E. I. du Pont de Nemours & Co., Inc., continued to develop its pyrochlore deposit in Colorado. The reserve was reported to be from 15 to 20 million tons of ore.

Columbium production increased sharply over the 1959 figure. Wah Chang Corp., Albany, Oreg., was the principal producer, supplying the Pratt & Whitney Aircraft Division, United Aircraft Corp., with ingot, tube blanks, and tubing of columbium-1-percent-zirconium alloy, and with pure columbium metal. Other producers of columbium

[1] Commodity specialist, Division of Minerals.

included Union Carbide Metals Co., Niagara Falls, N.Y., E. I. du Pont de Nemours & Co., Inc., Newport, Del., and Fansteel Metallurgical Co., Muskogee, Okla.

TABLE 1.—Salient columbium-tantalum statistics

	1951–55 (average)	1956	1957	1958	1959	1960
United States:						
Columbium-tantalum concentrate shipped from mines:[1]						
Pounds	13,392	216,606	370,483	428,347	189,263	----------
Value	$25,483	(2)	(2)	(2)	(2)	----------
Imports for consumption:						
Columbium-mineral concentrate .... pounds	4,803,528	5,699,553	3,348,706	2,555,942	3,395,816	5,051,800
Tantalum-mineral concentrate .... pounds	843,256	1,312,865	828,265	1,035,588	652,839	709,936
Industrial consumption:[3]						
Contained metal .... tons	[4] 380	810	924	593	[5] 828	1,058
World: Production of columbium-tantalum concentrates .... pounds	6,440,000	8,940,000	6,840,000	4,880,000	6,050,000	6,350,000

[1] 1956-59 data are for columbite-tantalite concentrate plus columbium-tantalum oxide content of euxenite concentrate.
[2] Figure withheld to avoid disclosing individual company confidential data.
[3] Includes metal content of all raw materials consumed, including columbium-tantalum-bearing tin slags.
[4] Average for 1954–55.
[5] Revised figure.

Production of tantalum reached 150 short tons in 1960. Fansteel Metallurgical Corp. moved its entire tantalum operation from North Chicago, Ill., to Muskogee, Okla., and was the leader in the field. Kawecki Chemical Co., Boyertown, Pa., was also a major producer. Other producers included National Research Corp., Cambridge, Mass., and Wah Chang Corp., Albany, Oreg.

Fansteel Metallurgical Corp. instituted complete warehouse services for plate, sheet, foil, rod, and wire of several reactive metals, including tantalum. Du Pont completed construction of a fabricating facility in Baltimore, Md., to house a 2,500-ton extrusion press, a 2,000-ton forge press, a 35-inch rolling mill, several heat-treating furnaces, and auxiliary equipment.

Total ferroalloy production was 692 short tons, a 28-percent increase over 1959 output. Union Carbide Metals Co. was the leading producer, followed by Molybdenum Corporation of America, Shieldalloy Corp., Vanadium Corporation of America, Transition Metals & Chemicals Co., and Reading Chemicals.

In July, the Stauffer Chemical Co. announced the availability in commercial quantities of columbium and tantalum pentachlorides, 99.5-percent pure.

CONSUMPTION AND USES

Domestic consumption of columbium-tantalum-bearing concentrates and slags in terms of metal content was 769 tons of columbium and 289 tons of tantalum. Revised corresponding figures for 1959 were 595 and 233 tons, respectively. Consumption of tantalum and columbium metal was estimated at 400,000 pounds and 200,000 pounds, respectively.[2]

[2] Chemical Week, Major Gains in Minor Metals: Vol. 88, No. 5, Feb. 4, 1961, p. 47; Vol. 88, No. 12, Mar. 5, 1961, p. 9.

During 1960, manufacturers reported increased use of tantalum in capacitors. Fansteel Metallurgical Corp., P. R. Mallory & Co., Inc., Kemet Co. Division of Union Carbide Corp., and Kawecki Chemical Co. were active.

Newly developed applications included the use of tantalum as shielding for thermocouples and gaskets and as the material for constructing immersion heaters used in the chemical industry.

The principal demand for columbium metal and high-columbium alloys stemmed from developing a nuclear-powered aircraft. In connection with this program, the Wyman-Gordon Co., North Grafton, Mass., was making routine forgings of 1,100 to 1,300 pounds of metal.

The use of ferrocolumbium increased in semikilled steel for making pipe, pressure vessels, frames for trucks and railroad cars, and other items. Great Lakes Steel Corp., Detroit, Mich., and Armco Steel Corp., Middletown, Ohio, were principal producers of these steels.

PRICES AND SPECIFICATIONS

At the end of January, the price of 10 : 1-ratio columbite increased from the $1.05 to $1.10 range to $1.18 to $1.25 per pound of contained pentoxides, and the price of 8½ : 1 material from $0.95–$1.05 to $1.05–$1.10. Tantalite opened the year at $4.80 per pound of contained oxide, but owing to unsettled political conditions in the Republic of the Congo, the price increased to $7–$7.50 by yearend.

The prices of ferrotantalum-columbium and ferrocolumbium were unchanged at $3.05 and $3.45 per pound of contained metal, respectively.

In January, the price of tantalum powder for capacitor use was reduced to the $47.50–$50 range; lower grade powder declined to $30–$40 per pound. Columbium powder of 99.7-percent purity closed the year at $35 to $40 per pound. Tantalum and columbium ingot established new low prices in February, selling thereafter at $45 and $35 per pound, respectively. Tantalum sheet was quoted at $59 per pound.

TABLE 2.—Average grade of concentrate received by U.S. consumers and dealers in 1960, by country of origin

(Percent of contained pentoxides)

Country	Columbite		Tantalite	
	Cb_2O_5	Ta_2O_5	Ta_2O_5	Cb_2O_5
Australia			57	10
Brazil	44	16	49	22
British East Africa [1]	52	(2)		
Congo, Republic of [3]	49	24	37	36
Malagasy Republic	61	16	43	30
Malaya	59	16		
Mozambique	48	28	60	17
Nigeria	66	7		
Norway [1]	55	(2)	39	37
Portugal	33	27	34	35
Rhodesia and Nyasaland, Federation of			38	22
Spain			28	26

[1] Pyrochlore concentrate.
[2] Less than 0.5 percent.
[3] Does not include large shipment of low-grade columbite.

Tonnage lots of tantalum oxide were priced at $13.50 per pound and tonnage lots of columbium oxide at $6.25. Stauffer Chemical Co. offered ton lots of tantalum and columbium pentachlorides at $10 and $5 per pound, respectively. Carbides of each metal ranged from $20 to $22.50 in larger lots.

FOREIGN TRADE [3]

Imports.—In addition to imports of concentrate and ore shown in tables 3 and 4, 5,123 pounds of tantalum and columbium metal, valued at $133,237 was imported almost entirely from West Germany.

TABLE 3.—U.S. imports for consumption of columbium-mineral concentrates, by countries

(Pounds)

Country	1951-55 (average)	1956	1957	1958	1959	1960
North America: Canada					14, 000	
South America:						
Argentina	4, 365			2, 262	3, 591	
Bolivia	6, 153	3, 791				
Brazil	80, 651	160, 462	54, 500	101, 992	137, 648	126, 374
British Guiana	2, 031					
Total	93, 200	164, 253	54, 500	104, 254	141, 239	126, 374
Europe:						
Germany, West [1]	223, 453		1, 653	46, 628	11, 578	6, 283
Netherlands [1]					13, 000	35, 554
Norway	189, 202	521, 003	236, 147	310, 858	454, 535	164, 486
Portugal	77, 043	31, 024	72, 953	65, 461	38, 083	35, 383
Spain	1, 387					976
Sweden	3, 343					
United Kingdom [1]		11, 200	29, 621			22, 400
Total	494, 428	563, 227	340, 374	422, 947	517, 196	265, 082
Asia:						
Aden		1, 350				
Korea, Republic of	400					
Malaya, Federation of	163, 629	521, 741	127, 524	709, 077	151, 881	249, 946
Thailand					13, 546	
Total	164, 029	523, 091	127, 524	709, 077	165, 427	249, 946
Africa:						
British West Africa	2, 904					
Congo,[2] Republic of the, and Ruanda-Urundi	667, 394	758, 919	905, 989	507, 725	519, 712	227, 724
French Equatorial Africa	940					
Malagasy Republic [3]	9, 494	10, 621	3, 075	9, 920	11, 939	17, 412
Mozambique	38, 468	43, 124	81, 422	171, 164	85, 249	75, 851
Nigeria	3, 253, 869	3, 593, 114	1, 804, 631	543, 925	1, 936, 296	4, 071, 115
Rhodesia and Nyasaland, Federation of	9, 156	6, 652				1, 983
Uganda [4]	10, 672	18, 780		5, 771	2, 205	11, 670
Union of South Africa	34, 551	17, 772	31, 191	81, 159		4, 643
Total	4, 027, 448	4, 448, 982	2, 826, 308	1, 319, 664	2, 555, 401	4, 410, 398
Oceania: Australia	24, 423				2, 553	
Grand total: Pounds	4, 803, 528	5, 699, 553	3, 348, 706	2, 555, 942	3, 395, 816	5, 051, 800
Value	$8, 945, 120	$8, 386, 659	$3, 037, 706	$2, 345, 890	$2, 651, 783	$3, 686, 549

[1] Presumably country of transshipment rather than original source.
[2] Effective July 1, 1960; formerly Belgian Congo.
[3] Effective July 1, 1960; formerly Madagascar and Dependencies.
[4] Classified by the Bureau of the Census as British East Africa.

Source: Bureau of the Census.

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 4.—U.S. imports for consumption of tantalum-mineral concentrates, by countries

(Pounds)

Country	1951-55 (average)	1956	1957	1958	1959	1960
South America:						
Argentina	1,323	4,409	----------	11,635	1,611	----------
Brazil	114,665	140,039	199,205	159,015	205,898	182,118
French Guiana	11,776	14,532	3,075	----------	----------	----------
Total	127,764	158,980	202,280	170,650	207,509	182,118
Europe:						
Belgium-Luxembourg [1]	4,175	----------	6,391	10,681	21,871	2,426
Germany, West [1]	131,379	----------	----------	135,431	----------	----------
Netherlands	----------	----------	----------	----------	----------	8,012
Norway	2,346	----------	----------	----------	----------	----------
Portugal	56,529	7,054	5,966	32,513	27,227	34,062
Spain	2,403	----------	----------	----------	----------	3,157
Sweden	4,699	----------	----------	992	----------	----------
United Kingdom [1]	5,707	----------	----------	----------	----------	----------
Total	207,238	7,054	12,357	179,617	49,098	47,657
Asia:						
Malaya, Federation of Singapore, Colony of	} 2,612	----------	----------	{ 6,000	---------- ----------	14,714 ----------
Thailand	----------	----------	----------	----------	4,515	----------
Total	2,612	----------	----------	6,000	4,515	14,714
Africa:						
Congo, [2] Republic of the, and Ruanda-Urundi	382,832	953,092	491,124	370,120	166,317	332,424
Malagasy Republic [3]	3,373	20,165	6,835	7,716	9,375	30,738
Mozambique	13,615	4,409	24,046	149,777	68,343	87,801
Nigeria	72,337	31,174	16,815	34,537	50,902	7,698
Rhodesia and Nyasaland, Federation of	6,333	22,166	38,975	77,667	44,720	----------
Uganda [4]	2,543	----------	----------	2,034	2,690	----------
Union of South Africa	4,189	6,511	6,910	27,368	24,805	2,239
Total	485,222	1,037,517	584,705	669,219	367,152	460,900
Oceania: Australia	20,420	109,314	28,923	10,102	24,565	4,547
Grand total: Pounds	843,256	1,312,865	828,265	1,035,588	652,839	709,936
Value	$1,722,308	$1,180,118	$948,638	$1,838,338	$1,165,536	$1,136,868

[1] Presumably country of transshipment rather than original source.
[2] Effective July 1, 1960; formerly Belgian Congo.
[3] Effective July 1, 1960; formerly Madagascar and Dependencies.
[4] Classified by the Bureau of the Census as British East Africa.

Source: Bureau of the Census.

TABLE 5.—U.S. exports of columbium and tantalum, by classes, in 1960

Class	Pounds	Value
Ores and concentrates:		
Columbium	155,399	$149,843
Tantalum	32,406	62,907
Metals and alloys in crude form, and scrap	16,954	105,294
Metals and alloys in semifabricated forms	4,515	394,425
Tantalum metal powder [1]	1,174	49,395

[1] Adjusted by Bureau of Mines.

Source: Bureau of the Census.

Exports.—Exports are shown in table 5. The columbium ore was shipped principally to France; smaller quantities went to West Germany and Japan. Most of the tantalum ore went to West Germany, and smaller quantities to Austria, Japan, and France. Tantalum powder was received principally by Japan and Austria. The metals were shipped to the United Kingdom, and Canada, and other countries.

WORLD REVIEW

NORTH AMERICA

Canada.—St. Lawrence Columbium and Metals Corp. (formerly St. Lawrence River Mines, Ltd., and reportedly an affiliate of The Anaconda Company) has developed 17.6 million tons of ore at a grade of 0.36 percent columbium pentoxide (Cb_2O_5) at its property in the Oka district of Quebec. A 4-ton pilot mill, in operation since December 1959, made a 45-percent Cb_2O_5 concentrate at 80-percent recovery. Construction of a 500-ton mill began late in 1960. Samincorp was named agent for the sale of concentrates.

In the same district, Columbium Mining Products, Ltd., on the basis of preliminary drilling, established an indicated reserve of 300,000 tons of Cb_2O_5 and reportedly planned to build a 200-ton pilot plant at the property. A marketing contract was concluded with W. R. Grace & Co., New York, N.Y. and Metallgesellschaft A. G., Frankfurt, West Germany.

Quebec Columbium, Ltd., continued examination of its ore body, also at Oka. At North Bay, Ontario, however, Nova Beaucage Mines, Ltd., suspended operations, pending a stronger demand for columbium. A columbium-beryllium property in Labrador was examined.

SOUTH AMERICA

Brazil.—During the year, the Division for the Encouragement of Mineral Production, a governmental agency, processed 125,000 tons of tin-tantalum ore and 39 million cubic yards of alluvium containing tin, tantalum, and gold.

Reserves of columbium ore at Araxá, Minas Gerais, amounted to 360 million tons containing 4 percent Cb_2O_5, according to the National Commission for Nuclear Energy. In this area were properties controlled jointly by Wah Chang Corp. and Molybdenum Corporation of America, which were building a mill of 200 tons capacity.

EUROPE

Germany, West.—Gesellschaft für Elektrometallurgie m.b.H., leading producer of columbium ferroalloys in West Germany, estimated its 1960 requirement for columbium ore to be about 1,200 tons.

United Kingdom.—The last of the nation's stockpiled columbite was sold in September.

Some interest was shown in reopening a mine in Cornwall for its tin and columbium content.

The Dounreay, Scotland, atomic power plant, in which columbium was used as the canning material, went critical in January. Columbium used in this way will permit operation up to 1,500° F., compared with a maximum of 700° F. for zirconium.

ASIA

Korea, Republic of.—Tanlok Mining Co. began producing high-grade tantalite from its mine in Cholwon County.

TABLE 6.—Free world production of columbium and tantalum concentrate [1] by countries [2]

(Pounds)

Country	1951–55 (average)		1956		1957		1958		1959		1960	
	Columbium	Tantalum	Columbium	Tantalum	Columbium	Tantalum	Columbium	Tantalum	Columbium	Tantalum	Columbium	Tantalum
North America:												
Canada	[3] 42	[3] 390	---	---	---	---	---	---	[4] 14,000	---	---	---
United States (mine shipments)	13,392		216,606		370,483		428,347		189,263		---	---
South America:												
Argentina	783		3,968		688		[4] 2,262	[4] 11,635	[4] 3,591	[4] 1,611	---	
Bolivia (exports)	1,352	---	---		---		---		---		---	
Brazil (exports)	117,143	67,553	177,916	208,161	68,206	204,675	158,513	213,114	33,459	207,232	324,076	
British Guiana	[5] 6,100	---	---		---		---		---		---	
French Guiana	[6] 21,520		---	14,916	---	2,976	---		---		---	
Europe:												
Norway	[6] 369,572	---	573,196	---	425,488	---	630,516	---	639,334	---	600,000	---
Portugal (U.S. imports)	77,043	56,529	31,024	7,054	72,953	5,966	65,461	32,513	38,083	27,227	35,383	34,062
Spain (U.S. imports)	[6] 2,312	[5] 3,004	---		---	---	---		---		976	3,157
Sweden (U.S. imports)	[6] 5,571	[6] 7,831	---		---	---	---	992	---		---	
Asia: Malaya, Federation of	211,008	---	619,136	---	318,080	---	356,160	---	268,800	---	208,320	---
Africa:												
Congo, Republic of the (formerly Belgian), and Ruanda-Urundi [7]	600,004		932,546		524,695		553,355		535,718		[4] 227,724	[4] 332,424
Malagasy Republic (Madagascar)	19,621		19,400		19,180		28,880		26,455		[8] 25,000	
Mozambique	55,791		56,580		288,503		378,916		320,004		330,690	
Nigeria	4,655,616	13,440	5,832,960	33,600	4,307,520	40,320	1,803,200	49,930	3,559,875	31,114	[4] 4,071,115	[4] 7,698
Rhodesia and Nyasaland, Federation of	[5] 9,130	11,26	5,080	29,320	760	76,960	---	96,260	---	116,820	---	108,080
Sierra Leone	[9] 8,960		---		---		---		---		---	
South-West Africa	12,708		9,607	3,740	9,325	14,676	4,152	6,574	2,610	1,539	10,390	
Swaziland (Yttrotantalite)	---		---		---	32,920	---		---		---	
Uganda [10]	26,463		3,494		4,054		6,384		5,264		5,040	
Union of South Africa	---	24,400	---	2,900	---	1,981	---	37,920	---	11,500	---	14,000
Oceania: Australia	36,853		159,655		50,038		13,507		18,950		[1] 10,000	
Free world total (estimate) [2]	6,440,000		8,940,000		6,840,000		4,880,000		6,050,000		6,350,000	

[1] Frequently the composition (Cb_2O_5–Ta_2O_5) of this concentrate lies in an intermediate position, neither Cv_2O_5 nor Ta_2O_5 being strongly predominant. In such cases the production figure has been centered.

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail. The world total does not include U.S.S.R., for which no production data are available.

[3] One year only, as 1955 was first year of commercial production.

[4] United States imports.

[5] Average for 1952–55.

[6] Average for 1953–55.

[7] In addition, tin-columbium-tantalum concentrate was produced as follows: 1951–55, 4,082,478 pounds; 1956, 6,501,365 pounds; 1957, 4,360,699 pounds; 1958, 3,196,670 pounds; 1959, 2,773,387 pounds; 1960 estimated 1,500,000 pounds; columbium-tantalum content averaging about 10 percent.

[8] Estimate.

[9] Average for 1954–55.

[10] In addition, tin-columbium-tantalum concentrate was produced as follows: 1951–55 (average), 3,060 pounds; no further production recorded.

Compiled by Augusta W. Jann, Division of Foreign Activities.

AFRICA

Angola.—Lobito, port of origin for an occasional shipment of columbite or tantalite in the past, was severely strained during 1960 to handle the transshipment of mineral products from the Republic of the Congo. In November and December 42,560 pounds of tantalite cleared Lobito for New York; this was presumably Congolese material, since no producing mines were known in Angola.

British East Africa.—Pilot-plant operations at Panda Hill for the Mbeya Exploration Co. Ltd., continued during the year; the pyrochlore concentrate was shipped to the Netherlands.

Congo, Republic of the (formerly Belgian).—A newly discovered pyrochlore deposit was said to contain 30 million tons of ore at a grade of 1.34 percent Cb_2O_5; the deposit, at Lueshe in northeastern Kivu, also contains apatite.

The operation of the Compagnie Géologique et Minière des Ingénieurs et Industriels Belges (Geomines) near Manono closed on September 14 because of the unsettled political situation, leaving Société des Mines d'Etain du Ruanda-Urundi (Minetain) as the only major producer operating. Shipments to the United States in 1960 were distributed as follows:

Quarter:	*Columbite (pounds)*	*Tantalite (pounds)*
First	98, 199	88, 346
Second	39, 893	84, 933
Third	60, 824	30, 204
Fourth	40, 478	128, 941

Much of the material received since July 1, however, may have been in transit.

Nigeria.—The various producers of columbite and cassiterite in Nigeria reported good operations and profits for 1960. Although demand for both products was strong, a measure of additional protection for Nigerian columbium producers was written into the International Tin Council agreement.

Sierra Leone.—An area of nepheline syenites in the Gola Forests was discovered to contain a uraniferous pyrochlore. The deposit was examined for its extent by the colony's Geological Survey.

Union of South Africa.—Small showings of columbite-tantalite ores in Namaqualand, Transvaal, and South-West Africa were being examined to determine their significance.

OCEANIA

Australia.—A plant to treat a tantalite-spodumene ore was under construction near Ravensthorpe, Western Australia.

TECHNOLOGY

A detailed description of the geology of the tin–tantalum-columbium deposits of North Lugulu, Kivu, Republic of the Congo, was published. The deposit was stated to be the world's largest source of tantalum.[4]

A paper on the availability of columbium discussed the abundance of columbium in the earth's crust, and gave information on the known

[4] deKun, Nicolas [The Cassiterite and Columbo-Tantalite Deposits of North Lugulu, Kivu, Belgian Congo]: Mem. Soc. Geol. Belg., vol. 82, 1960, pp. 81–196.

world ore reserves of 7 million tons and on the potential annual commercial availability of 10,000 pounds of mill products in the United States.[5]

Two important technical conferences were held during the year: Columbium and tantalum were discussed at the University of Sheffield, Sheffield, England,[6] and columbium metallurgy was the subject of a meeting at Bolton Landing, N.Y.[7]

New processes for the reduction of columbium and tantalum were described. One was the reduction of columbium pentachloride with hydrogen in a fluidized bed reactor; [8] in another, tantalum was prepared as an intermetallic compound with aluminum and recovered by separation.[9]

Much work was done during the year on developing and evaluating various columbium alloys. In addition to those listed in table 7, a columbium-20-percent-uranium alloy for fuel rods was devised by Battelle Memorial Institute, Columbus, Ohio. Constitution diagrams were published for the systems columbium-rhenium,[10] columbium-carbon,[11] and tantalum-rhenium.[12]

TABLE 7.—Columbium-based alloys developed for strength and corrosion resistance at high temperatures

Company	Designation	Composition, percent							
		Cb	Ta	W	Mo	V	Ti	Zr	Al
General Electric Co.	F48	79		15	5			1	
E. I. du Pont de Nemours & Co., Inc.	D31	80			10		10		
Armour Research Foundation		75				20	5		
Federal Bureau of Mines		[1]				[1]			
Union Carbide Metals Co.		50				50			
Do.	Cb22	[1]				[1]			[1]
Do.	Cb65	92					7.5	0.75	
Do.		[1]	[1]	[1]					

[1] Composition not available.

The electron-beam furnace was applied to the purification of columbium and tantalum by its maker, Stauffer-Temescal Corp., and by Wah Chang Corp., Deutsche Gold-und Silber Scheideanstalt (Degussa), and Alloyd Corp.

Developments in fabrication techniques permitted the forming of tantalum and columbium tubing from ductile ingot.

A zinc coating on columbium protects it against oxidation at temperatures up to 2,200° F. Naval Research Laboratories developed the technique in response to the need for structural columbium in jet

[5] Sims, C. T., Availability of Niobium: Knolls Atomic Power Laboratory, Schenectady, N.Y.: KAPL–M–CTS–1, Mar. 8, 1960, 8 pp.

[6] Metal Industry, Niobium, Tantalum, Molybdenum, and Tungsten: Vol. 97, No. 18, Oct. 28, 1960, pp. 359–361.

[7] Shabel, B. S., Columbium Metallurgy. . . . A Report on the Lake George Meeting: Jour. Metals, vol. 12, September 1960, pp. 703–705.

[8] Chemical and Engineering News, Fluidized Bed May Make Niobium Cheaper: Vol. 38, No. 27, July 4, 1960, p. 51.

[9] Baughman, R. L., and Taylor, D. F., Tantalum Metal by Selective Solution: Jour. Metals, vol. 12, February 1960, p. 160.

[10] Levesque, P., Bekebrede, W. R., and Brown, H. A., The Constitution of Rhenium-Columbium Alloys: Metal Prog., vol. 78, No. 4, October 1960, pp. 260–262.

[11] Elliott, R. P., Columbium-Carbon System: Metal Prog., vol. 78, No. 4, October 1960, pp. 246–248.

[12] Brophy, J. H., Schwartzkopf, P., and Wulff, J., The Tantalum-Rhenium System: Trans. Met. Soc. AIME, vol. 218, No. 5, October 1960, pp. 910–914.

engines and space vehicles. Research by Union Carbide Metals Co. revealed that coatings of chromium, Nichrome, and other materials protected columbium up to 1,500° F.

The addition of columbium to some of the less costly semikilled steels resulted in increased tensile strength at no sacrifice in ductility and weldability.[13] These steels attracted increasing interest for use in pipe, tanks, truck and railroad car frames, and, possibly, wire and cable.

[13] Fletcher, E. E., and Elsea, A. R., Add Columbium to Killed Steel to Retard Grain Growth: Iron Age, vol. 185, No. 8, Feb. 25, 1960, pp. 72–73.

Copper

By H. M. Callaway,[1] Gertrude N. Greenspoon,[2] and Wilma F. Washington [2]

Contents

RECORD PRODUCTION, record exports, a lower consumption rate, and rising stocks characterized the U.S. copper industry in 1960.

Strikes that had begun in mid-1959 continued into early 1960. The need for primary source materials at smelters and refineries after settlement of the strikes stimulated production from domestic mines and caused near-record imports of blister copper. Mine production in the United States was the largest since 1957. Copper recovery from domestic ores set a new record; production at smelters from imported materials more than doubled; and recovery of copper from scrap increased one-third.

Consumption of copper declined considerably in the United States in 1960. However, demand for copper in the rest of the world was unusually great. Stocks at U.S. refineries at the beginning of the year were the lowest since the turn of the century because of the continuing strikes and the relatively high rate of consumption in 1959. Return to work at primary refineries resulted in near-capacity output. The brisk export of domestic copper in the more active Western European markets failed to prevent stock additions in April through December.

Despite labor disputes and political unrest, world copper production was at a record high. Planned production cutbacks by some producers to limit stock buildups and prevent price declines were more than offset by expanded output from other producers and entry of new facilities into the productive stage.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

TABLE 1.—Salient copper statistics

	1951–55 (average)	1956	1957	1958	1959	1960
United States:						
Ore produced [1] thousand short tons	100,542	131,776	129,716	114,824	103,716	134,994
Average yield of copper percent	0.85	0.78	0.77	0.79	0.74	0.73
Primary (new) copper produced—						
From domestic ores, as reported by—						
Mines short tons	922,836	1,104,156	1,086,859	979,329	824,846	1,080,169
Value thousands	$533,366	$938,532	$654,289	$515,127	$506,455	$693,468
Smelters short tons	928,644	1,117,580	1,081,055	992,918	799,329	1,142,848
Percent of world total	28	28	27	25	19	23
Refineries short tons	929,240	1,080,207	1,050,496	1,001,645	796,452	1,121,286
From foreign ores, matte, etc., refinery reports short tons	317,196	362,426	403,680	350,875	301,795	397,641
Total new refined, domestic and foreign short tons	1,246,436	1,442,633	1,454,176	1,352,520	1,098,247	1,518,927
Secondary copper recovered from old scrap only short tons	444,760	468,489	444,492	411,367	471,007	429,365
Imports, general:						
Unmanufactured [2] do	594,610	595,747	594,032	496,301	[3] 570,891	524,357
Refined do	255,488	191,745	162,309	128,464	214,058	142,709
Exports:						
Metallic copper [4] do	224,487	[5] 280,575	[5] 430,446	[5,6] 428,015	[5,6] 196,012	[5,6] 512,332
Refined do	166,558	223,103	346,025	384,868	158,938	433,762
Stocks Dec. 31: Producers:						
Refined short tons	34,000	78,000	109,000	48,000	18,000	98,000
Blister and materials in solution short tons	196,000	261,000	274,000	257,000	253,000	261,000
Total do	230,000	339,000	383,000	305,000	271,000	359,000
Withdrawals (apparent) from total supply on domestic account:						
Primary copper short tons	1,333,000	1,367,000	1,239,000	1,157,000	1,183,000	1,148,000
Primary and old copper (old scrap only) short tons	1,779,000	1,835,000	1,683,000	1,568,000	1,654,000	1,577,000
Price: Average cents per pound	[7] 28.8	[7] 42.5	[7] 30.1	[7] 26.3	[7] 30.7	[7] 32.1
World:						
Production:						
Mine short tons	3,100,000	3,790,000	3,890,000	[3] 3,770,000	[3] 4,040,000	4,590,000
Smelter do	3,280,000	[3] 3,990,000	4,040,000	3,950,000	[3] 4,190,000	4,950,000
Price: London, average cents per pound	[8] 37.52	41.03	27.36	24.79	29.80	30.81

[1] Includes old tailings smelted or re-treated. Not comparable with mine production figure shown in that latter includes recoverable copper content of ores not classified as "copper."
[2] Data are "general" imports; that is, they include copper imported for immediate consumption plus material entering country under bond. Comprises copper in ingots, plates, and bars, ores and concentrates, regulus, blister, and scrap.
[3] Revised figure.
[4] Total exports of copper, exclusive of ore, concentrates, composition metal, and unrefined copper. Exclusive also of "Other manufacturers of copper," for which quantity figures are not recorded before 1953. (See table 37.)
[5] Due to changes in classification 1956–60 data are not strictly comparable to earlier years.
[6] Beginning Jan. 1, 1958, copper rods not separately classified; included in "Other copper manufactures."
[7] Exclusive of copper produced abroad and delivered in the United States.
[8] Average for 1954–55.

LEGISLATION AND GOVERNMENT PROGRAMS

Through the Office of Minerals Exploration (OME), the Government participated with private industry to the extent of 50 percent of the financial risk in exploratory ventures judged capable of increasing the Nation's resources for selected mineral commodities. In 1960 two new contracts to explore for copper ores were made and another was amended. William R. Noack obtained a loan for exploration of the Loretta mine, Inyo County, Calif. Estimated total cost of the project was $29,600. Copper Camp Co. concluded the other loan agreement for a $34,840-exploratory project at the Copper Camp mine,

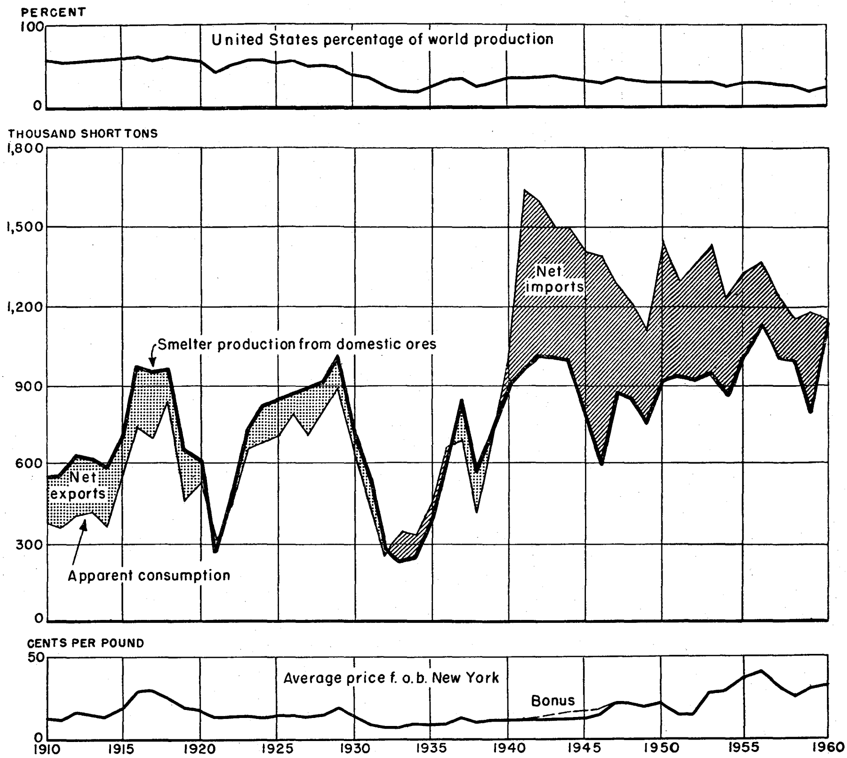

FIGURE 1.—Production, consumption, and price of copper in the United States. 1910–60.

Valley County, Idaho. The amended contract for $39,940 was executed with Golden Copper Queen Mining Corp. for the Copper Queen prospect, Lemhi County, Idaho.

The 1.7-cent-a-pound excise tax on copper imports, effective July 1, 1958, was unchanged.

DOMESTIC PRODUCTION

PRIMARY COPPER

Despite labor strikes and resulting curtailed production in the early months of the year, 1960 mine output was the largest since 1957, and record production was reported from domestic copper smelters and refineries.

Strikes, most of which began in August 1959, continued into the early months of 1960. Magma Copper Co., Magma mine and smelter resumed operations on January 19 and February 11, respectively. The Utah Copper Division of Kennecott Copper Corp. commenced production early in February. Phelps Dodge Corp.'s mines at Morenci and Bisbee, Ariz., its smelter at Douglas, Ariz., and Phelps Dodge Refining Corp.'s refinery at El Paso, Tex., started up February 10. The strike at The Anaconda Company's Montana properties

TABLE 2.—Salient copper statistics

(All figures in short tons, except price and tenor of ore)

Year	United States												World production (smelter)
	Mine production	Average yield of copper ores (percent)	Refinery production from—			Imports (refined) [1]	Exports (refined) [1]	Apparent consumption of new copper [2]	Quoted price at New York [3] (cents per pound)	Production from scrap as metal and in alloys			
			Domestic ores	Foreign ores	Total					Old scrap	New scrap	Total	
1924	803,083	1.59	837,107	292,931	1,130,038	72,955	504,812	677,371	13.16	266,200	122,100	388,300	1,493,600
1925	839,059	1.54	841,448	260,839	1,102,287	49,887	484,033	700,506	14.16	291,010	129,200	429,210	1,546,500
1926	862,638	1.46	865,649	295,594	1,161,243	85,283	428,062	785,068	13.93	337,300	142,500	479,800	1,608,300
1927	824,980	1.41	859,476	303,406	1,162,882	51,640	461,233	711,480	13.05	339,400	150,800	490,200	1,673,300
1928	904,898	1.41	895,899	347,905	1,243,804	42,365	474,737	804,269	14.68	365,500	170,900	536,400	1,880,500
1929	997,555	1.41	991,366	378,690	1,370,056	67,007	411,227	889,293	18.23	404,350	222,200	626,550	2,098,800
1930	705,074	1.43	695,612	382,918	1,078,530	43,105	297,057	632,509	13.11	342,200	125,000	467,200	1,760,000
1931	528,875	1.50	537,303	213,418	750,721	87,225	202,698	451,032	8.24	261,300	85,700	347,000	1,536,000
1932	238,111	1.83	222,539	117,895	340,434	83,897	110,977	259,602	5.67	180,980	67,200	248,180	1,027,000
1933	190,643	2.11	240,669	130,120	370,789	5,432	124,582	339,350	7.15	260,300	77,800	338,100	1,143,000
1934	237,401	1.92	233,029	212,331	445,360	27,417	262,366	322,638	8.53	310,900	66,500	377,400	1,448,000
1935	386,491	1.89	338,321	250,484	588,805	18,071	260,735	441,371	8.76	361,700	87,200	448,900	1,681,000
1936	614,516	1.54	645,462	177,027	822,489	4,782	220,390	656,179	9.58	382,700	101,900	484,600	1,895,000
1937	841,998	1.29	822,253	244,561	1,066,814	7,487	295,064	694,906	13.27	408,900	123,200	532,100	2,585,000
1938	557,763	1.34	552,574	239,842	792,416	1,802	370,545	406,994	10.10	267,300	92,500	359,800	2,254,000
1939	728,320	1.25	704,873	304,642	1,009,515	16,264	372,777	714,873	11.07	286,900	212,800	499,700	2,396,000
1940	878,086	1.20	927,239	386,317	1,313,556	68,337	356,431	1,008,785	11.40	333,890	198,156	532,046	2,734,000
1941	958,149	1.15	975,408	419,901	1,395,309	346,994	103,602	1,641,550	11.87	412,699	313,697	726,396	2,905,000
1942	1,080,061	1.09	1,064,792	349,769	1,414,561	401,436	131,406	1,608,000	11.87	427,122	500,633	927,755	3,076,000
1943	1,090,818	1.04	1,082,079	297,184	1,379,263	402,762	175,859	1,502,000	11.87	427,521	658,526	1,086,047	3,038,000
1944	972,549	.99	973,852	247,335	1,221,187	492,395	68,373	1,504,000	11.87	456,710	494,232	950,942	2,850,000
1945	772,894	.93	775,738	332,861	1,108,599	531,367	48,563	1,415,000	11.87	497,095	509,421	1,006,516	2,436,000
1946	608,737	.91	578,429	300,233	878,662	154,371	52,629	1,391,000	13.92	406,453	397,093	803,546	2,067,000
1947	847,563	.90	909,213	250,757	1,159,970	149,478	147,642	1,286,000	21.15	503,376	458,365	961,741	2,490,000
1948	834,813	.92	860,022	247,424	1,107,446	249,124	142,598	1,214,000	22.20	505,464	467,324	972,788	2,580,000
1949	752,750	.91	695,015	232,912	927,927	275,811	137,827	1,072,000	19.36	383,548	329,595	713,143	2,600,000
1950	909,343	.89	920,748	319,086	1,239,834	317,363	144,561	1,447,000	21.46	485,211	492,028	977,239	2,915,000
1951	928,330	.90	951,559	255,429	1,206,988	238,972	133,305	1,304,000	24.37	458,124	474,158	932,282	3,085,000
1952	925,359	.85	923,192	254,504	1,177,696	346,960	174,135	1,360,000	24.37	414,635	488,562	903,197	3,105,000
1953	926,448	.85	932,232	360,885	1,293,117	274,111	109,580	1,435,000	28.92	429,388	529,076	958,464	3,275,000
1954	835,472	.83	841,717	370,202	1,211,919	215,086	215,951	1,235,000	29.82	407,066	432,841	839,907	3,275,000
1955	998,570	.83	997,499	344,960	1,342,459	202,312	199,819	1,336,000	37.39	514,585	474,419	989,004	3,630,000
1956	1,104,156	.78	1,080,207	362,426	1,442,633	191,745	223,103	1,367,000	41.88	468,489	462,175	930,664	[4] 3,990,000
1957	1,086,859	.77	1,050,496	403,680	1,454,176	162,309	346,025	1,239,000	29.99	444,492	397,395	841,887	4,040,000
1958	979,329	.79	1,001,645	350,875	1,352,520	128,464	384,868	1,157,000	26.13	411,367	386,021	797,388	3,950,000
1959	824,846	.74	796,452	301,795	1,098,247	214,058	158,938	1,183,000	30.82	471,007	459,563	930,570	[4] 4,190,000
1960	1,080,169	.73	1,121,286	397,641	1,518,927	142,709	433,762	1,148,000	32.16	429,365	442,023	871,388	4,950,000

[1] Imports and exports may include some refined copper produced from scrap. Categories not wholly comparable from year to year.
[2] Adjusted for changes in stocks.
[3] American Metal Market price for electrolytic copper in New York; f. o. b. refinery through August 1927, New York refinery equivalent thereafter.
[4] Revised figure.

TABLE 3.—Copper produced from domestic ores, by sources

(Short tons)

Year	Mine	Smelter	Refinery	Year	Mine	Smelter	Refinery
1956	1,104,156	1,117,580	1,080,207	1959	824,846	799,329	796,452
1957	1,086,859	1,081,055	1,050,496	1960	1,080,169	1,142,848	1,121,286
1958	979,329	992,918	1,001,645				

TABLE 4.—Copper ore and recoverable copper produced, by mining methods

(Percent)

Year	Open pit		Underground		Year	Open pit		Underground	
	Ore	Copper	Ore	Copper		Ore	Copper	Ore	Copper
1943	69	54	31	46	1952	85	77	15	23
1944	68	57	32	43	1953	83	75	17	25
1945	68	61	32	39	1954	83	79	17	21
1946	66	58	34	42	1955	83	77	17	23
1947	73	68	27	32	1956	78	73	22	27
1948	76	68	24	32	1957	77	72	23	28
1949	78	70	22	30	1958	76	71	24	29
1950	81	74	19	26	1959	79	74	21	26
1951	84	74	16	26	1960	80	75	20	25

TABLE 5.—Mine production of recoverable copper in the United States in 1960, by months [1]

Month	Short tons	Month	Short tons
January	47,572	August	90,898
February	75,211	September	97,478
March	96,339	October	100,399
April	97,559	November	98,074
May	98,370	December	96,750
June	95,210		
July	86,309	Total	1,080,169

[1] Monthly figures adjusted to final annual mine-production total.

ended February 15. In February the strike also ended at White Pine Copper Co. operations in Michigan, and on March 28 the Phelps Dodge refinery at Laurel Hill, N.Y., resumed production.

Mine Production.—Production of copper by U.S. mines increased 31 percent to 1,080,169 tons. The reduced rate of monthly output in the last half of 1959 continued into early 1960. Following resumption of full working schedules by mid-March, output rose rapidly, reaching a high of 100,000 tons in October. The annual total was the largest since 1957.

Arizona continued to lead all States in mine production, by a wide margin. Although Arizona's contribution to total U.S. production declined slightly, output from the State was considerably higher than in 1959 and was 4 percent greater than the record output of 1957. Phelps Dodge Corp. was the leading Arizona producer. The company's mines at Morenci, Bisbee, and Ajo produced 28.3 million tons of ore that yielded 231,000 tons of copper. Weighted average stripping ratio of waste to ore in Arizona open-pit mines of Phelps Dodge Corp. was 1.72 to 1 in 1960.

TABLE 6.—Mine production of recoverable copper in the United States, with production of maximum year, and cumulative production from earliest record to end of 1960, by States

(Short tons)

State	Maximum production [1]		Production by years						Total production from earliest record to end of 1960
	Year	Quantity	1951–55 (average)	1956	1957	1958	1959	1960	
Alabama	1907	42	---	---	---	---	---	---	(2)
Alaska	1916	59,927	1	(3)	(3)	5	36	41	685,992
Arizona	1960	538,605	407,429	505,908	515,854	485,839	430,297	538,605	17,195,391
California	1909	28,644	616	859	945	749	663	1,087	637,388
Colorado	1938	14,171	3,721	4,228	5,115	4,193	2,940	3,247	299,031
Georgia	1917	465	---	---	---	---	---	---	(2)
Idaho	1958	9,846	3,791	6,656	7,912	9,846	8,713	4,208	170,886
Maine	1918	383	---	---	---	---	---	---	(2)
Maryland	1917	146	---	---	---	---	---	---	(2)
Massachusetts	1906	5	---	---	---	---	---	---	(2)
Michigan	1916	136,846	28,887	61,526	58,400	58,005	55,300	56,385	5,350,615
Missouri	1949	3,670	2,204	1,890	1,604	1,429	1,065	1,087	[4] 48,554
Montana	1916	176,464	67,572	96,426	91,512	90,683	65,911	91,972	7,579,960
Nevada	1942	83,663	65,001	80,824	77,750	66,137	57,375	77,485	2,652,714
New Hampshire	1908	[5] 94	---	---	---	---	---	---	(2)
New Mexico	1942	80,100	69,825	74,345	67,472	55,540	39,688	67,288	2,260,234
North Carolina	1930	6,695	---	(6)	(6)	(6)	(6)	(6)	(2)
Oregon	1916	1,791	6	7	23	10	---	6	12,474
Pennsylvania	1942	6,410	3,838	[7] 4,102	[7] 7,516	[7] 8,073	[7] 6,604	[7] 7,907	(2)
South Carolina	(2)	(2)	---	---	---	---	---	---	(2)
South Dakota	1918	32	---	---	---	---	---	1	107
Tennessee	1960	12,723	8,303	10,449	9,790	9,109	11,490	12,723	(2)
Texas	1928	224	4	---	---	---	---	---	1,384
Utah	1943	323,989	253,652	250,604	237,857	189,184	144,715	218,049	8,178,525
Vermont	1954	4,352	4,030	3,403	3,405	475	---	---	(2)
Virginia	1944	291	---	---	---	---	---	---	(2)
Washington	1940	9,612	3,956	2,926	1,700	52	49	78	121,748
Wisconsin	1914	5	---	---	---	---	---	---	(2)
Wyoming	1900	2,102	---	3	4	(3)	---	---	16,335
Total	1956	1,104,156	922,836	1,104,156	1,086,859	979,329	824,846	1,080,169	[8] 46,011,270

[1] For Missouri and States east of the Mississippi River, maximum since 1905.
[2] Data not available.
[3] Less than 1 ton.
[4] Small quantity for Wisconsin included with Missouri.
[5] The 1908 volume of Mineral Resources credits this figure to Massachusetts and New Hampshire; the 1909 volume credits it to New Hampshire alone.
[6] Included with Pennsylvania to avoid disclosing operations of individual companies.
[7] Includes North Carolina to avoid disclosing operations of individual companies.
[8] Largely smelter production for States east of the Mississippi River except Michigan; includes 799,932 tons for States indicated by footnote 2.

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TABLE 7.—Twenty-five leading copper-producing mines in the United States in 1960, in order of output

Rank	Mine	District or region	State	Operator	Source of copper
1	Utah Copper	West Mountain (Bingham)	Utah	Kennecott Copper Corp	Copper ore.
2	Morenci	Copper Mountain (Morenci)	Arizona	Phelps Dodge Corp	Copper, gold-silver ores.
3	Butte Mines (includes Kelley, Berkeley).	Summit Valley (Butte)	Montana	The Anaconda Company	Copper, silver-zinc ores.
4	San Manuel	Old Hat	Arizona	San Manuel Copper Corp	Copper ore.
5	New Cornelia	Ajo	do	Phelps Dodge Corp	Copper, gold-silver ores.
6	Chino	Central	New Mexico	Kennecott Copper Corp	Copper ore.
7	Copper Queen-Lavender Pit	Warren (Bisbee)	Arizona	Phelps Dodge Corp	Do.
8	Ray Pit	Mineral Creek (Ray)	do	Kennecott Copper Corp	Do.
9	Liberty Pit	Robinson (Ely)	Nevada	do	Do.
10	Inspiration	Globe-Miami	Arizona	Inspiration Consolidated Copper Co.	Do.
11	White Pine	Lake Superior	Michigan	White Pine Copper Co	Do.
12	Yerington	Yerington	Nevada	The Anaconda Company	Do.
13	Esperanza	Pima	Arizona	Duval Sulphur & Potash Co	Do.
14	Silver Bell	Silver Bell	do	American Smelting and Refining Co.	Do.
15	Magma	Pioneer (Superior)	do	Magma Copper Co	Copper, gold-silver ores.
16	Copper Cities	Globe-Miami	do	Tennessee Corp	Copper ore.
17	Calumet & Hecla, Inc	Lake Superior	Michigan	Calumet & Hecla, Inc	Copper ore and tailings.
18	Pima	Pima	Arizona	Pima Mining Co	Copper ore.
19	Burra-Boyd	Polk County	Tennessee	Tennessee Copper Co	Copper-zinc ore.
20	Bagdad	Eureka (Bagdad)	Arizona	Bagdad Copper Corp	Copper ore.
21	Miami	Globe-Miami	do	Tennessee Corp	Copper precipitates.
22	Ore Knob	Ashe County	North Carolina	Appalachian Sulfides, Inc	Copper ore.
23	Old Dick	Eureka (Bagdad)	Arizona	Cyprus Mines Corp	Copper-zinc ore.
24	Castle Dome Dump	Globe-Miami	do	Tennessee Corp	Copper precipitates.
25	Cornwall	Lebanon County	Pennsylvania	Bethlehem Cornwall Corp	Magnetite-pyrite-chalcopyrite ore.

TABLE 8.—Copper ore sold or treated in the United States in 1960, with copper, gold, and silver content, in terms of recoverable metals [1]

State	Ore sold or treated, short tons	Recoverable metal content				Value of gold and silver per ton of ore
		Copper		Gold, fine ounces	Silver, fine ounces	
		Pounds	Percent			
Alaska	60	82,681	68.90		970	$14.63
Arizona	66,032,439	993,370,700	.75	115,602	3,689,622	.11
California	17,292	901,300	2.61	3,273	35,454	8.48
Colorado	9,649	525,000	2.72	3,597	312,186	42.33
Idaho	77,612	3,164,100	2.04	741	11,112	.46
Michigan [2]	7,793,108	112,770,000	.72			
Montana	11,974,566	174,729,600	.73	19,090	2,356,757	.23
Nevada	11,779,975	154,940,300	.66	39,805	265,881	.14
New Mexico	7,526,259	83,628,300	.56	3,189	71,827	.02
North Carolina	289,942	10,330,000	1.78	1,660	22,736	.27
Oregon	342	12,000	1.75	32	46	3.40
South Dakota	13	2,000	7.69	1	19	4.00
Tennessee [3]	1,429,220	25,446,000	.89	123	64,560	.04
Utah	28,061,672	410,421,800	.73	352,039	2,637,193	.52
Washington	1,933	64,000	1.66	97	770	2.12
Total	134,994,082	1,970,387,781	.73	539,249	9,469,133	.20

[1] Excludes copper recovered from precipitates as follows: Arizona, 66,691,000 pounds; California, 160,000 pounds; Montana, 8,553,500 pounds; New Mexico, 49,307,300 pounds; Utah, 20,028,400 pounds.
[2] Includes tailings.
[3] Copper zinc ore.

TABLE 9.—Copper ore concentrated in the United States in 1960, with content in terms of recoverable copper

State	Ore concentrated, short tons	Recoverable copper content	
		Pounds	Percent
Arizona	[1] 65,514,603	[2] 953,448,600	0.73
California	16,355	833,600	2.55
Idaho	74,176	2,814,400	1.90
Michigan [3]	7,793,108	112,770,000	.72
Montana	11,974,187	174,680,400	.73
Nevada	[4] 11,694,268	[4] 152,700,100	.65
New Mexico	[5] 7,444,121	[6] 83,093,100	.56
North Carolina	289,942	10,330,000	1.78
Oregon	204	6,000	1.47
Tennessee [7]	1,429,220	25,446,000	.89
Utah	28,060,300	410,226,200	.73
Washington	1,896	60,100	1.58
Total	134,292,380	1,926,408,500	.72

[1] Includes ore that was treated by leaching followed by concentration. In addition 14,000 tons was treated by vat leaching.
[2] In addition 139,200 pounds of copper was recovered by vat leaching.
[3] Includes tailings.
[4] Includes ore treated by straight leaching, and copper precipitates recovered therefrom; Bureau of Mines not at liberty to publish.
[5] In addition 18,200 tons was treated by vat leaching.
[6] In addition 165,000 pounds of copper was recovered by vat leaching.
[7] Copper-zinc ore.

The San Manuel mine produced 12.3 million tons of ore averaging 0.71 percent sulfide copper in 1960. Ore was extracted from block-caving operations at the average rate of 34,249 tons per day. The Magma mine at Superior, Ariz., operated by the parent company, Magma Copper Co., produced 386,600 tons of ore assaying 5.10 percent copper. Heavy ground and irregular ore shoots continued to be problems at Magma.

TABLE 10.—Copper ore shipped to smelters in the United States in 1960, with content in terms of recoverable copper

State	Ore shipped to smelters: Short tons	Recoverable copper content: Pounds	Recoverable copper content: Percent	State	Ore shipped to smelters: Short tons	Recoverable copper content: Pounds	Recoverable copper content: Percent
Alaska	60	82,681	68.90	New Mexico	63,938	370,200	.29
Arizona	503,836	39,782,900	3.95	Oregon	138	6,000	2.17
California	937	67,700	3.61	South Dakota	13	2,000	7.69
Colorado	9,649	525,000	2.72	Utah	1,372	195,600	7.13
Idaho	3,436	349,700	5.09	Washington	37	3,900	5.27
Montana	379	49,200	6.49				
Nevada	85,707	2,240,200	1.31	Total	669,502	43,675,081	3.26

TABLE 11.—Copper ores[1] produced in the United States, and average yield in copper, gold, and silver

Year	Smelting ores: Short tons	Smelting ores: Yield in copper, percent	Concentrating ores: Short tons[2]	Concentrating ores: Yield in copper, percent	Total: Short tons[2 3]	Total: Yield in copper, percent	Total: Yield per ton in gold, ounce	Total: Yield per ton in silver, ounce	Total: Value per ton in gold and silver
1951–55 (average)	869,588	3.64	96,120,820	0.82	100,542,115	0.85	0.0056	0.090	$0.28
1956	906,319	4.11	127,251,488	.75	131,775,959	.78	.0044	.087	.23
1957	827,226	4.32	124,640,436	.76	129,715,586	.77	.0043	.086	.23
1958	631,714	4.78	114,027,754	.77	114,824,468	.79	.0040	.080	.21
1959	467,598	3.98	103,239,445	.72	103,715,843	.74	.0035	.066	.18
1960	669,502	3.26	134,306,380	.72	134,994,082	.73	.0040	.070	.20

[1] Includes old tailings, smelted or re-treated, etc., for 1951–52.
[2] Includes some ore classed as copper-zinc ore.
[3] Includes copper ore leached.

Inspiration Consolidated Copper Company's open-pit mine produced 5.3 million tons of ore having a combined oxide and sulfide copper content of 0.878 percent. The ratio of waste to ore removal was 0.77:1 for the year. Development of the Christmas mine continued; the McDonald 18-foot circular ore-hoisting shaft was sunk to 1,576 feet, 204 feet short of the final depth. An unanticipated water problem on the 1,600 level of the Christmas No. 3 shaft slowed lateral development. Production was expected by mid-1962. The reserve was reported to be 20 million tons averaging 1.83 percent copper.

The $35 million expansion of productive capacity at the Ray Division mine of Kennecott Copper Corp. was completed in mid-1960. Mill capacity was increased to 22,500 tons of ore a day, and expansion of the open-pit limits permitted production of an additional 20,000 tons of copper a year. In 1960 the Ray pit produced 6.5 million tons of ore, which yielded 58,799 tons of copper.

American Smelting and Refining Company continued construction and stripping activities at the Mission property near Tucson, Ariz. Total overburden removed amounted to 31,329,000 tons, well over half the total preproduction waste removal. Construction of the 15,000-ton concentrator was begun in late 1960.

Duval Sulphur & Potash Co. completed the first full year's operation at its Esperanza open-pit mine and 12,000-ton-per-day mill in Pima County. In July, Transarizona Resources, Inc., began operations at its plant south of Casa Grande, Ariz.

Bagdad Copper Corp. produced 11,931 tons of copper from its open pit mine near Prescott, Ariz. Construction of the new leaching plant to process the oxide portion of the ore proceeded on schedule during 1960.

Utah continued to rank second among the copper-producing States, contributing 20 percent of the Nation's total output. Copper production in Utah increased 51 percent to 218,049 tons in 1960. The Utah Division of Kennecott Copper Corp. (Bingham open-pit mine) was the State's leading producer. Approximately 28.1 million tons of ore was mined from the Bingham pit, and 215,125 tons of copper was recovered. A 5-million-ton excavation project was started in mid-1960 to lower the bottom of the Bingham pit 150 feet to connect with the recently completed 17,600-foot locomotive tunnel for gravity-aided transportation of the ore to the mill.

Montana, having a production of 92,000 tons, was the third-ranking copper-producing State, contributing 9 percent of the Nation's output. The Anaconda Company mines at Butte were the leading producers. Production of ore from the Berkeley pit averaged 32,610 tons per operating day. The average stripping ratio during 1960 was 2.4 tons of waste to 1 ton of ore. New electric trucks, designed to haul 70 tons on a 15 percent grade at speeds of 12 to 15 miles per hour, underwent evaluation tests in the pit in late 1960. The Kelley block-caving operation produced a daily average of 11,505 tons of copper ore. Nine new ore blocks were brought to a productive stage during the year. High-grade deep-lying ore was mined from the lower levels of the Mountain Con mine, and the Steward vein mine was prepared for deep-mine production. Shaft sinking continued at the Kelley No. 1 central hoisting shaft and at several other deep-mine shafts that will connect with haulageways to the Kelley No. 1 shaft on the 4,400-foot level.

Other States with significant mine output of copper in 1960 in order of production were Nevada, New Mexico, Michigan, and Tennessee. In Nevada, The Anaconda Copper Company's Yerington open pit more than doubled its 1959 production of copper. Construction of a new mill to process sulfide ore proceeded on schedule. The Liberty pit operated by Kennecott Copper Corp. near Ely, Nev., produced 7.4 million tons of ore that yielded 47,439 tons of copper. Automatic equipment was introduced for various applications, including operation of the car dumper with closed-circuit television.

The Chino open-pit mine of Kennecott Copper Corp. was the principal producer in New Mexico. Work began at Chino to install a skip hoist to elevate ore from the lower pit levels more economically than by rail. Lateral pit limits were expanded significantly. During the year, the Chino mine produced 7.3 million tons of ore that yielded 62,725 tons of copper.

In Michigan, the White Pine mine was again the leading copper producer. Output was 4.1 million tons of ore that averaged approximately 23 pounds of copper per ton. Shaft sinking continued on the new, higher-grade, Southwest ore body. Calumet Division mines of Calumet & Hecla, Inc., were the second significant copper producers in the State. Mining in the conglomerate area through Osceola No. 13 shaft continued with new centralized pumping facilities on the Osceola Lode. Plans called for early completion of similar centralized pumping installations on the Kearsarge Lode.

Classification of total domestic production by mining method showed that approximately 75 percent of the recoverable copper and 80 percent of the copper ore came from open pits. Most domestic copper ore was treated by flotation at or near the mine of origin, and the resulting concentrate was shipped for local smelting. A small quantity of ore was smelted directly, either because of its high grade or because of its fluxing qualities.

The first 5 mines in table 7 produced 52 percent of the total U.S. copper production, the first 10 produced 76 percent, and the entire 25 furnished 97 percent.

Smelter Production.—The recovery of copper from ores of domestic origin by smelters in the United States rose 43 percent in 1960 to establish a record high. Copper produced from foreign materials was more than double that of 1959, and output from secondary sources gained 36 percent. Total output of the smelters increased 46 percent.

Smelter-production data are based upon reports from domestic primary smelters handling copper-bearing materials. Blister copper is accounted for in terms of copper content. Production of furnace-refined copper in Michigan is included in smelter production, as well as in refinery output. Metallic and cement copper recovered from leaching solution is included in smelter production.

TABLE 12.—Copper produced by primary smelters in the United States

(Short tons)

Year	Domestic	Foreign	Secondary	Total
1951–55 (average)	928,644	103,616	59,321	1,091,581
1956	1,117,580	113,772	81,374	1,312,726
1957	1,081,055	97,090	75,931	1,254,076
1958	992,918	76,134	61,848	1,130,900
1959	799,329	42,466	54,895	896,690
1960	1,142,848	90,781	74,472	1,308,101

Refinery Production.—Refined copper from primary-source materials was produced at 15 plants, some of which also treated scrap materials. Of these 15 plants, termed "primary refineries," 9 used the electrolytic-refining method exclusively. Three plants used only fire-refining methods (Lake copper refineries), and two plants employed both electrolytic and fire-refining techniques. One plant, a western smelter, fire-refined a portion of its blister-copper output and shipped the remainder to an electrolytic plant for refining. Inspiration Consolidated Copper Co. at Inspiration, Ariz., produced electrolytic copper directly from leaching solutions; most of the product was shipped to other refineries for melting and casting, consequently, for statistical purposes this copper is included in the refinery product of the plant producing the cast commercial shapes.

TABLE 13.—Copper produced (smelter output from domestic ores) in the United States

Year	Short tons	Value (thousands)	Year	Short tons	Value (thousands)	Year	Short tons	Value (thousands)
1845	112	$45	1884	72,473	$18,843	1923	717,500	$210,945
1846	169	57	1885	82,938	17,915	1924	817,125	214,087
1847	336	124	1886	78,881	17,512	1925	837,435	237,832
1848	560	218	1887	90,739	25,044	1926	869,811	243,547
1849	784	349	1888	113,181	38,029	1927	842,020	220,609
1850	728	320	1889	113,388	30,615	1928	912,950	262,930
1851	1,008	334	1890	129,882	40,523	1929	1,001,432	352,504
1852	1,232	542	1891	142,061	36,368	1930	697,195	181,271
1853	2,240	985	1892	172,499	40,020	1931	521,356	94,887
1854	2,520	1,108	1893	164,677	35,570	1932	272,005	34,273
1855	3,360	1,814	1894	177,094	33,648	1933	225,000	28,800
1856	4,480	2,419	1895	190,307	40,726	1934	244,227	39,076
1857	5,376	2,688	1896	230,031	49,687	1935	381,294	63,295
1858	6,160	2,833	1897	247,039	59,289	1936	611,410	112,499
1859	7,056	3,104	1898	263,256	65,288	1937	834,661	201,988
1860	8,064	3,709	1899	284,333	97,242	1938	562,328	110,216
1861	8,400	3,696	1900	303,059	100,615	1939	712,675	148,236
1862	10,580	4,655	1901	301,036	100,546	1940	909,084	205,453
1863	9,520	6,473	1902	329,754	80,460	1941	966,072	227,993
1864	8,960	8,422	1903	349,022	95,632	1942	1,087,991	[1] 256,766
1865	9,520	7,473	1904	406,269	104,005	1943	1,092,939	[1] 257,934
1866	9,968	6,828	1905	444,392	138,650	1944	1,003,379	[1] 236,797
1867	11,200	5,682	1906	458,903	177,136	1945	782,726	[1] 184,723
1868	12,992	5,976	1907	434,498	173,799	1946	599,656	[1] 172,701
1869	14,000	6,790	1908	471,285	124,419	1947	862,872	[1] 360,680
1870	14,112	5,977	1909	546,476	142,084	1948	842,477	365,635
1871	14,560	7,023	1910	540,080	137,180	1949	757,931	298,625
1872	14,000	9,956	1911	548,616	137,154	1950	911,352	379,122
1873	17,360	9,721	1912	621,634	205,139	1951	930,774	450,495
1874	19,600	8,624	1913	612,242	189,795	1952	927,365	448,845
1875	20,160	9,152	1914	575,069	152,968	1953	943,391	541,506
1876	21,280	8,937	1915	694,005	242,902	1954	834,381	492,285
1877	23,520	8,937	1916	963,925	474,288	1955	1,007,311	751,454
1878	24,080	7,994	1917	943,060	514,911	1956	1,117,580	949,943
1879	25,760	9,582	1918	954,267	471,408	1957	1,081,055	650,795
1880	30,240	12,943	1919	643,210	239,274	1958	992,918	522,275
1881	35,840	13,046	1920	604,531	222,467	1959	799,329	490,788
1882	45,323	17,313	1921	252,793	65,221	1960	1,142,848	733,708
1883	57,763	19,062	1922	475,143	128,289			

[1] Exclusive of bonus payments of the Office of Metals Reserve under Premium Price Plan, which covered the period February 1, 1942, to June 30, 1947, inclusive.

Total capacity of the electrolytic plants was rated at 1,974,000 tons of refined copper per year, and 83 percent of this capacity was in use in 1960. Six large electrolytic plants on the Atlantic seaboard near industrial markets refined imports of blister copper in addition to treating domestic smelter output. Four electrolytic refineries (Great Falls, Mont., Inspiration, Ariz., Garfield, Utah, and El Paso, Tex.) were operated in the Western interior chiefly to refine blister copper derived from nearby mining districts. A single West Coast electrolytic plant treated imported copper. In addition to electrolytic copper, the El Paso plant of Phelps Dodge Refining Corp. and the Carteret plant of the American Metal Climax, Inc., produced fire-refined copper.

The three Lake plants at Hubbell, Hancock, and White Pine, Mich., produced fire-refined copper from blister derived from Upper Peninsula ores. Capacity of the Lake refineries was rated at 127,000 tons in 1960.

Copper Sulfate.—With the resumption of full working schedules at copper plants in early 1960, copper sulfate production rose markedly. Production increased 44 percent and shipments gained 29 percent over 1959. Of the total shipments of 54,300 tons (42,100 in 1959), pro-

TABLE 14.—Primary and secondary copper produced by primary refineries in the United States

(Short tons)

	1951-55 (average)	1956	1957	1958	1959	1960
Primary:						
From domestic ores, etc.:[1]						
Electrolytic	828,445	948,732	945,394	892,758	699,890	1,009,983
Lake	25,712	57,053	58,814	59,111	54,543	56,232
Casting	75,083	74,422	46,288	49,776	42,019	55,071
Total	929,240	1,080,207	1,050,496	1,001,645	796,452	1,121,286
From foreign ores, etc.:[1]						
Electrolytic	307,630	351,768	372,791	340,470	256,002	389,178
Casting and best select	9,566	10,658	30,889	10,405	45,793	8,463
Total refinery production of primary copper	1,246,436	1,442,633	1,454,176	1,352,520	1,098,247	1,518,927
Secondary:						
Electrolytic[2]	152,225	220,340	203,073	199,508	200,183	241,169
Casting	14,471	13,477	8,521	7,828	11,405	10,585
Total secondary	166,696	233,817	211,594	207,336	211,588	251,754
Grand total	1,413,132	1,676,450	1,665,770	1,559,856	1,309,835	1,770,681

[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 copper reported from foreign scrap.

TABLE 15.—Copper cast in forms at primary refineries in the United States

Form	1959		1960	
	Thousand short tons	Percent	Thousand short tons	Percent
Billets	152	12	159	9
Cakes	112	9	134	8
Cathodes	118	9	158	9
Ingots and ingot bars	135	10	124	7
Wirebars	776	59	1,180	66
Other forms	17	1	16	1
Total	1,310	100	1,771	100

ducers' reports indicated that 16,700 tons (19,400) was for agricultural uses, 20,000 (19,200) for industrial uses, and 17,600 (3,500) for other purposes, chiefly for export. Resumption in use of copper sulfate as a fungicidal spray on banana plants was chiefly responsible for the increase in exports.

Stocks on hand December 31, 1960, were more than double those at the beginning of the year. Imports of copper sulfate totaled 1,100 tons, more than double the 1959 quantity.

Laboratory tests with copper sulfate were reported[3] to have produced economically interesting results in the treatment of natural asphalts and bituminous materials to adjust their fluidity and plasticity at temperature extremes. A superior road-surfacing compound resistant to frost-wedging may be indicated.

[3] Oil, Paint and Drug Reporter, vol. 178, No. 12, Sept. 12, 1960, p. 42.

TABLE 16.—Production, shipments, and stocks of copper sulfate

(Short tons)

Year	Production		Shipments (gross weight)	Stocks Dec. 31 [1] (gross weight)
	Gross weight	Copper content		
1951-55 (average)	83,564	20,891	82,904	5,847
1956	66,808	16,702	67,008	4,068
1957	70,680	17,670	70,256	3,828
1958	48,596	12,149	46,580	5,168
1959	40,292	10,073	42,100	2,500
1960	58,000	14,500	54,272	5,480

[1] Some small quantities are purchased and used by producing companies, so that the figures given do not balance exactly.

SECONDARY COPPER AND BRASS

Copper-bearing scrap processed in the United States totaled 1,208,000 tons and yielded 871,000 tons of copper. The volume of scrap processed and the copper recovered therefrom both declined slightly compared with 1959. During the first 3 months of 1960, consumption of purchased new and old copper-base scrap remained at about 99,000 tons per month. A slackened scrap-processing period began in May and monthly output reached a low of 72,000 tons in mid-summer. Thereafter scrap consumption increased until near the end of the year, establishing the year's high of 101,000 tons in October.

New and old scrap contributed nearly equally to the raw-material mix. Secondary smelters consumed 335,000 tons of copper scrap, gross weight, of which 260,000 tons was old scrap of widely varying types. Primary copper producers consumed slightly over 400,000 tons, gross weight, composed mainly of new and old clean copper scrap and residues, and alloys quite low in copper content. Of the 355,000 tons of scrap consumed in brass mills, all but 29,000 tons was new scrap, mostly yellow brass. The old scrap used in the brass-mills mix was cartridge brass and clean, high-grade copper metal scrap. Foundries and other plants consumed 117,000 tons of scrap.

Most of the secondary copper recovered as refined metal was produced at refineries whose principal product was primary refined copper. Of the 300,000 tons of unalloyed secondary copper only 40,000 was produced at secondary smelters.

TABLE 17.—Secondary copper produced in the United States

(Short tons)

	1951-55 (average)	1956	1957	1958	1959	1960
Copper recovered as unalloyed copper	212,478	273,060	248,015	255,121	261,588	300,259
Copper recovered in alloys [1]	712,093	657,604	593,872	542,267	668,982	571,129
Total secondary copper	924,571	930,664	841,887	797,388	930,570	871,388
Source:						
New scrap	479,811	462,175	397,395	386,021	459,563	442,023
Old scrap	444,760	468,489	444,492	411,367	471,007	429,365
Percentage equivalent of domestic mine output	100	84	77	81	113	81

[1] Includes copper in chemicals, as follows: 1951-55 (average), 18,759; 1956, 14,739; 1957, 14,240; 1958, 9,491; 1959, 10,061; 1960, 12,714.

Approximately two-thirds of the total copper recovered from scrap was in the form of brass and bronze and was mainly the product of secondary smelters and brass mills.

Stocks of copper scrap at scrap processing plants dropped 15 percent during the year, presumably due to competition from foreign buyers for the copper-hungry industries of Japan and Western Europe.

TABLE 18.—Copper recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

Kind of scrap	1959	1960	Form of recovery	1959	1960
New scrap:			As unalloyed copper:		
Copper-base	453,144	436,326	At primary plants	211,588	251,754
Aluminum-base	6,199	5,550	At other plants	50,000	48,505
Nickel-base	175	114			
Zinc-base	45	33	Total	261,588	300,259
Total	459,563	442,023	In brass and bronze	637,387	539,765
			In alloy iron and steel	3,289	2,779
Old scrap:			In aluminum alloys	17,899	15,605
Copper-base	467,161	426,222	In other alloys	346	266
Aluminum-base	3,156	2,505	In chemical compounds	10,061	12,714
Nickel-base	583	546			
Tin-base	17	25	Total	668,982	571,129
Zinc-base	90	67			
			Grand total	930,570	871,388
Total	471,007	429,365			
Grand total	930,570	871,388			

TABLE 19.—Copper recovered as refined copper, in alloys and in other forms, from copper-base scrap processed in the United States

(Short tons)

	From new scrap		From old scrap		Total	
	1959	1960	1959	1960	1959	1960
Recovered by—						
Secondary smelters	58,630	50,250	223,705	200,854	282,335	251,104
Primary copper producers	96,600	123,392	116,472	132,102	213,072	255,494
Brass mills	277,562	243,253	48,480	24,234	326,042	267,487
Foundries and manufacturers	19,019	18,192	72,233	62,489	91,252	80,681
Chemical plants	1,333	1,239	6,271	6,543	7,604	7,782
Total	453,144	436,326	467,161	426,222	920,305	862,548

TABLE 20.—Production of secondary copper and copper-alloy products in the United States

(Short tons)

Item produced from scrap	Gross weight	
	1959	1960
Unalloyed copper products:		
Refined copper by primary producers	211,588	251,754
Refined copper by secondary smelters	38,645	39,960
Copper powder	9,796	6,866
Copper castings	1,559	1,679
Total	261,588	300,259

TABLE 20.—Production of secondary copper and copper-alloy products in the United States—Continued

(Short tons)

Item produced from scrap	Nominal composition (percent)					Gross weight	
	Cu	Sn	Pb	Zn	Ni	1959	1960
Brass and bronze ingots:							
Tin bronze	88	10	------	2	------	15,036	15,513
Leaded tin bronze	88	6	1.5	4.5	------	16,939	16,605
Leaded red bronze	85	5	5	5	------	93,590	83,938
Leaded semired brass	81	3	7	9	------	73,163	64,198
High-leaded tin bronze	80	10	10	------	------	16,872	14,897
Do	84	6	8	2	------	15,638	14,040
Do	75	5	20	------	------	4,438	3,591
Leaded yellow brass	66	1	3	30	------	14,754	11,760
Nickel silver	58	2	7	18	14	3,055	2,926
Do	65	4	3	5	22		
Low brass	80	------	------	20	------	2,503	2,622
Conductor bronze	94	2	2	2	------	539	461
Manganese bronze	60 Cu 40 Zn, ±Mn, Al, etc					12,665	12,590
Aluminum bronze	90 Cu 10 Al, ±Mn, Zn, Fe, etc					6,187	6,452
Silicon bronze	92 Cu +Si, ±Zn, Fe, Al, Mn					4,290	4,008
Copper-base hardeners and special alloys						13,525	12,411
Total						293,194	266,012
Brass-mill products						423,789	348,074
Brass and bronze castings						86,439	77,941
Brass powder						1,397	1,597
Copper in chemical products						10,061	12,714
Grand total						1,076,468	1,006,597

TABLE 21.—Composition of secondary copper-alloy production

(Short tons, gross weight)

Year	Copper	Tin	Lead	Zinc	Nickel	Aluminum	Total
Brass and bronze production:[1]							
1959	231,196	13,931	18,701	28,864	438	64	293,194
1960	210,659	12,347	16,445	26,035	463	63	266,012
Secondary metal content of brass-mill products:							
1959	326,040	132	3,595	92,598	1,412	12	423,789
1960	265,774	118	2,976	77,811	1,387	8	348,074
Secondary metal content of brass and bronze castings:							
1959	66,399	3,755	10,501	5,619	39	126	86,439
1960	60,322	3,466	8,895	5,144	24	90	77,941

[1] About 95 percent from scrap and 5 percent from other than scrap.

TABLE 22.—Stocks and consumption of copper scrap in the United States in 1960

(Short tons, gross weight)

Class of consumer and type of scrap	Stocks Jan. 1	Receipts		Consumption				Stocks Dec. 31
		Purchased scrap	Machine shop scrap	Purchased scrap			Machine shop scrap	
				New	Old	Total		
Secondary smelters:								
No. 1 wire and heavy copper	3,597	36,900	--------	3,871	33,963	37,834	--------	2,663
No. 2 wire, mixed heavy, and light copper	3,534	54,595	--------	5,802	48,947	54,749	--------	3,380
Composition or red brass	5,364	84,246	--------	30,453	55,009	85,462	--------	4,148
Railroad-car boxes	115	404	--------	--------	366	366	--------	153
Yellow brass	6,200	52,727	--------	7,221	47,345	54,566	--------	4,361
Cartridge cases and brass	124	832	--------	--------	652	652	--------	304
Auto radiators (unsweated)	4,952	37,658	--------	--------	39,986	39,986	--------	2,624
Bronze	2,241	28,668	--------	6,575	21,874	28,449	--------	2,460

TABLE 22.—Stocks and consumption of copper scrap in the United States in 1960—Continued

(Short tons, gross weight)

Class of consumer and type of scrap	Stocks Jan. 1	Receipts: Purchased scrap	Receipts: Machine shop scrap	Consumption: Purchased scrap: New	Consumption: Purchased scrap: Old	Consumption: Purchased scrap: Total	Consumption: Machine shop scrap	Stocks Dec. 31
Secondary smelters—Con.								
Nickel silver	684	3,496		452	2,823	3,275		905
Low brass	326	2,345		1,462	833	2,295		376
Aluminum bronze	280	332		58	343	401		211
Low-grade scrap and residues	5,121	26,156		19,601	7,843	27,444		3,833
Total	32,538	328,359		75,495	259,984	335,479		25,418
Primary producers:								
No. 1 wire and heavy copper	1,771	61,711		29,936	31,067	61,003		2,479
No. 2 wire, mixed heavy, and light copper	4,003	125,685		67,155	57,091	124,246		5,442
Refinery brass	7,501	27,973		11,713	18,830	30,543		4,931
Low-grade scrap and residues	61,026	177,610		73,568	111,421	184,989		53,647
Total	74,301	392,979		182,372	218,409	400,781		66,499
Brass mills: [1]								
No. 1 wire and heavy copper	5,113	67,944		56,496	11,448	67,944		5,828
No. 2 wire, mixed heavy, and light copper	7,932	34,560		31,075	3,485	34,560		3,555
Yellow brass	16,322	173,552		173,552		173,552		15,771
Cartridge cases and brass	3,545	45,279		31,591	13,688	45,279		2,834
Bronze	673	2,232		2,232		2,232		427
Nickel silver	2,988	7,205		7,205		7,205		2,584
Low brass	3,235	20,159		20,159		20,159		2,613
Aluminum bronze	98	68		68		68		149
Mixed alloy scrap	11,474	4,488		4,488		4,488		8,543
Total [1]	51,380	355,487		326,866	28,621	355,487		42,304
Foundries, chemical plants, and other manufacturers:								
No. 1 wire and heavy copper	2,745	18,931	603	5,372	13,824	19,196	445	2,638
No. 2 wire, mixed heavy, and light copper	1,757	12,155	567	4,720	7,548	12,268	586	1,625
Composition or red brass	1,674	8,308	13,255	5,012	3,784	8,796	12,435	2,006
Railroad-car boxes	2,526	47,714	2,210		48,361	48,361	2,122	1,967
Yellow brass	1,750	12,264	7,071	5,780	6,291	12,071	7,548	1,466
Auto radiators (unsweated)	312	4,037			4,125	4,125		224
Bronze	1,401	2,379	2,072	1,075	1,534	2,609	2,171	1,072
Nickel silver	30	86	96		90	90	85	37
Low brass	237	570	1,370	30	478	508	1,466	203
Aluminum bronze	263	628	372	137	500	637	393	233
Low-grade scrap and residues	1,803	6,835	1,490	1,774	6,252	8,026	1,449	653
Total	14,498	113,907	29,106	[2] 23,900	[2] 92,787	[2] 116,687	28,700	12,124
Grand total: [3]								
No. 1 wire and heavy copper	13,226	185,486	603	95,675	90,302	185,977	445	13,608
No. 2 wire, mixed heavy, and light copper	17,226	226,995	567	108,752	117,071	225,823	586	14,002
Composition or red brass	7,038	92,554	13,255	35,465	58,793	94,258	12,435	6,154
Railroad-car boxes	2,641	48,118	2,210		48,727	48,727	2,122	2,120
Yellow brass	24,272	238,543	7,071	186,553	53,636	240,189	7,548	21,598
Cartridge cases and brass	3,669	46,111		31,591	14,340	45,931		3,138
Auto radiators (unsweated)	5,264	41,695			44,111	44,111		2,848
Bronze	4,315	33,279	2,072	9,882	23,408	33,290	2,171	3,959
Nickel silver	3,702	10,787	96	7,657	2,913	10,570	85	3,526
Low brass	3,798	23,074	1,370	21,651	1,311	22,962	1,466	3,192
Aluminum bronze	641	1,028	372	263	843	1,106	393	593
Low-grade scrap and residues [4]	75,451	238,574	1,490	106,656	144,346	251,002	1,449	63,064
Mixed alloy scrap	11,474	4,488		4,488		4,488		8,543
Total [3]	172,717	1,190,732	29,106	608,633	599,801	1,208,434	28,700	146,345

[1] Brass-mill stocks include home scrap; purchased scrap consumption assumed equal to receipts, so figures in brass-mills and grand total sections do not balance.
[2] Of the totals shown, chemical plants reported the following: Unalloyed copper scrap, 1,018 tons of new and 4,645 old; copper-base alloy scrap, 852 tons of new and 6,174 old.
[3] Includes machine shop scrap receipts and consumption for foundries, chemical plants, and other manufacturers.
[4] Includes refinery brass.

TABLE 23.—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
1959:						
Copper scrap	327,206	430,711		130,293	379,706	1,267,916
Refined copper [1]		584,100	836,177	34,643	8,111	1,463,031
Brass ingot		7,062	166	[2] 283,102		290,330
Slab zinc		116,048		3,536	9,694	129,278
Miscellaneous		43		275	6,669	6,987
1960:						
Copper scrap	400,781	355,487		116,687	335,479	1,208,434
Refined copper [1]		486,460	828,823	26,407	8,206	1,349,896
Brass ingot		6,054	126	[2] 259,857		266,037
Slab zinc		86,639		3,227	9,157	99,023
Miscellaneous		60		465	4,106	4,631

[1] Detailed information on consumption of refined copper will be found in table 27.
[2] Shipments to foundries by smelters plus decrease in stocks at foundries.

TABLE 24.—Dealers' monthly average buying price for copper scrap and consumers' alloy-ingot prices at New York in 1960

(Cents per pound)

Grade	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
No. 1 Heavy copper scrap	23.20	22.70	20.61	20.47	20.75	20.91	21.42	21.75	21.70	20.17	19.75	20.55	21.16
No. 1 Composition scrap	18.95	18.61	16.90	16.97	17.25	17.41	17.92	18.25	18.20	17.12	17.00	17.57	17.68
No. 1 Composition ingot	30.75	30.75	30.62	29.25	29.25	29.25	29.25	29.25	29.25	28.60	28.25	28.25	29.39

Source: Metal Statistics, 1961.

TABLE 25.—Foundry consumption of brass ingot, by type, in the United States

(Short tons)

Type of ingot	1951–55 (average)	1956	1957	1958	1959	1960
Tin bronze	16,535	15,012	15,408	10,272	11,257	9,689
Leaded tin bronze	32,608	30,272	23,118	20,591	24,868	23,818
Leaded red brass	155,561	150,532	138,289	138,183	162,798	142,817
High-leaded tin bronze	23,525	28,428	24,691	17,478	19,413	18,076
Leaded yellow brass	20,294	17,887	15,906	15,790	17,344	15,887
Manganese bronze	14,840	12,748	11,436	8,155	9,609	9,540
Hardeners	2,460	2,594	2,348	1,565	2,185	2,268
Nickel silver	2,958	4,333	2,967	2,428	2,921	2,732
Low brass	7,291	7,939	8,631	6,690	7,699	7,365
Total	276,072	269,745	242,794	221,152	258,094	232,192

CONSUMPTION

Apparent withdrawals of primary copper decreased 3 percent in 1960.

Consumption of refined copper in the United States declined 8 percent in 1960. This conclusion is based on a tabulation of quantities that, according to consumer reports, entered fabricating processes dur-

TABLE 26.—Primary refined-copper supply and withdrawals on domestic account

(Short tons)

Supply and withdrawals	1951–55 (average)	1956	1957	1958	1959	1960
Production from domestic and foreign ores, etc	1,246,436	1,442,633	1,454,176	1,352,520	1,098,247	1,518,927
Imports [1]	255,488	191,745	162,309	128,464	214,058	142,709
Stock Jan. 1 [1]	32,000	34,000	78,000	109,000	48,000	18,000
Total available supply	1,533,924	1,668,378	1,694,485	1,589,984	1,360,305	1,679,636
Copper exports [1]	166,558	223,103	346,025	384,868	158,938	433,762
Stock Dec. 31 [1]	34,000	78,000	109,000	48,000	18,000	98,000
Total	200,558	301,103	455,025	432,868	176,938	531,762
Apparent withdrawals on domestic account [2]	1,333,000	1,367,000	1,239,000	1,157,000	1,183,000	1,148,000

[1] May include some copper refined from scrap.
[2] Includes copper delivered by industry to the national strategic stockpile.

TABLE 27.—Refined copper consumed, by classes of consumers

(Short tons)

Year and class of consumer	Cathodes	Wire bars	Ingots and ingot bars	Cakes and slabs	Billets	Other	Total
1959:							
Wire mills	6,432	817,030	11,790			925	836,177
Brass mills	86,648	64,277	116,190	146,852	170,074	59	584,100
Chemical plants			310			484	794
Secondary smelters	5,320		2,079	246		466	8,111
Foundries	4,877	218	11,465	17	216	795	17,588
Miscellaneous [1]	1,298	4	4,064	6	295	10,594	16,261
Total	104,575	881,529	145,898	147,121	170,585	13,323	1,463,031
1960:							
Wire mills	3,928	810,570	13,450			875	828,823
Brass mills	74,993	48,776	80,247	137,667	144,725	52	486,460
Chemical plants			465			571	1,036
Secondary smelters	5,939		1,913	177		177	8,206
Foundries	4,644	92	10,224	26	275	900	16,161
Miscellaneous [1]	1,220	5	2,328	6	558	5,093	9,210
Total	90,724	859,443	108,627	137,876	145,558	7,668	1,349,896

[1] Includes iron and steel plants, primary smelters producing alloys other than copper, consumers of copper powder and copper shot, and miscellaneous manufacturers.

ing the year. Unlike table 26, which from a practical standpoint accounts only for primary copper, table 27 includes all copper in refined form. Thus, the difference between total consumption shown in table 27 and apparent withdrawals of primary copper shown in table 26 roughly measures the consumption of copper that was refined from scrap.

Consumption during the early months of the year was at a rate lower than the monthly average during 1959. An upturn in March was not long sustained, and by midsummer consumption had declined to only about three-fourths the rate established during the earlier months. August and September consumption rates were markedly above the midsummer low and about the same as those of April, May, and June. However, the remaining quarter of the year saw a gradual decline that terminated with a December rate somewhat lower than the rate at the beginning of the year.

The pattern of uses for refined copper remained essentially unchanged. Wire mills consumed 61 percent and brass mills 36 percent of the total.

STOCKS

Owing to the relatively high rate of consumption and the continuing strikes at smelters and refineries, stocks of refined copper at primary plants on January 1, 1960, (18,000 tons) were the lowest reported since the turn of the century. Settlement of the strikes and resulting return to near capacity output at primary refineries caused inventories to rise from April through December. Mild buyers' interest contributed to abnormally high yearend inventories.

According to United States Copper Association statistics, fabricators' stocks of refined metal rose 10 percent during 1960. Yearend stocks (including in-process copper and primary fabricated shapes) were 456,100 tons, the largest on record. Working stocks were (see table 29) 370,100 tons, 9 percent more than on January 1. After unfilled sales orders for metal were discounted, copper classed as "available for sale" was 35,000 tons, the highest since 1939.

TABLE 28.—Stocks of copper at primary smelting and refining plants in the United States Dec. 31

(Short tons)

Year	Refined copper [1]	Blister and materials in process of refining [2]	Year	Refined copper [1]	Blister and materials in process of refining [2]
1951–55 (average)	34,000	196,000	1958	48,000	257,000
1956	78,000	261,000	1959	18,000	253,000
1957	109,000	274,000	1960	98,000	261,000

[1] May include some copper refined from scrap.
[2] Includes copper in transit from smelters in the United States to refineries therein.

TABLE 29.—Stocks of copper in fabricators' hands Dec. 31

(Short tons)

Years	Stocks of refined copper [1] (1)	Unfilled purchases of refined copper from producers (2)	Working stocks (3)	Unfilled sales to customers (4)	Excess stocks over orders booked [2] (5)
1956	437,187	117,601	336,217	183,834	34,737
1957	430,171	75,627	347,465	138,631	19,702
1958	446,358	90,401	326,438	177,869	32,452
1959	414,757	130,324	340,349	202,775	1,957
1960	456,094	75,222	370,055	126,260	35,001

[1] Includes in-process metal and primary fabricated shapes. Also includes small quantities of refined copper held at refineries for fabricators' account.
[2] Columns (1) plus (2) minus (3) and minus (4) equal column (5).

Source: United States Copper Association.

PRICES

Reports from copper-selling agencies indicated that 1,074,246 tons of domestic refined copper was delivered to purchasers at an average price of 32.1 cents per pound. The average price of foreign copper delivered in the United States was 32.5 cents a pound.

The primary producers' price for electrolytic copper, delivered, established at 33 cents per pound on November 12, 1959, was unchanged until October 12. On that date, cumulative effects of increased output, slackened demand, and resulting large consumer inventories caused a 3-cent-a-pound drop to 30 cents.

Due presumably to the extension of the labor strikes into the early months of 1960, custom smelters did not quote prices until about mid-March, when a 33-cent-per-pound price was established; it was reduced to 31 cents on October 3 and to 30 cents on October 12.

London Price.—During January the price of copper on the London Metal Exchange (LME) averaged £259 5s. 3d. per long ton (32.41 cents a pound). In February, the year's high of £263 17s. (33.02 cents) was recorded. During the spring and summer months the LME price was equivalent to 30-31 cents a pound. Corresponding to the decrease in the U.S. price, the London price fell to the equivalent of 27.89 cents in October and remained at that level throughout the rest of the year.

TABLE 30.—Average weighted prices of copper deliveries,[1] consumer plants

(Cents per pound)

Year	Domestic copper	Foreign copper	Year	Domestic copper	Foreign copper
1956	43.5	43.2	1959	30.7	31.6
1957	30.1	29.6	1960	32.1	32.5
1958	26.3	25.0			

[1] Covers copper produced in the United States and delivered here and abroad and copper produced abroad and delivered in the United States; excludes copper both produced and delivered abroad, whether or not handled by U.S. selling agencies.

TABLE 31.—Average monthly quoted prices of electrolytic copper for domestic and export shipments, f.o.b. refineries, in the United States and for spot copper at London

(Cents per pound)

Month	1959				1960			
	Domestic, f.o.b. refinery [1]	Domestic, f.o.b. refinery [2]	Export, f.o.b. refinery [2]	London, spot [3, 4]	Domestic, f.o.b. refinery [1]	Domestic, f.o.b. refinery [2]	Export, f.o.b. refinery [2]	London, spot [3, 4]
January	28.82	28.636	27.927	28.83	32.82	33.654	31.555	32.41
February	29.80	29.617	28.726	29.62	32.82	32.976	31.994	33.02
March	30.97	31.031	30.271	31.20	32.82	32.613	30.745	31.72
April	31.32	31.300	29.397	30.18	32.82	32.600	31.684	32.88
May	31.32	31.155	28.814	29.68	32.82	32.600	30.302	31.10
June	31.32	31.102	28.114	28.88	32.82	32.600	30.290	31.37
July	30.44	30.077	26.732	27.72	32.82	32.600	31.010	31.92
August	29.82	29.893	28.270	29.20	32.82	32.600	29.925	30.76
September	30.40	31.018	28.015	28.83	32.82	32.600	28.611	29.47
October	30.57	32.576	29.150	30.31	30.87	30.598	27.111	27.89
November	32.20	34.060	30.481	31.35	29.82	29.600	27.470	28.43
December	32.82	33.724	30.801	31.91	29.82	29.600	28.036	28.95
Average	30.82	31.182	28.892	29.80	32.16	32.053	29.894	30.81

[1] American Metal Market.
[2] E&MJ Metal and Mineral Markets.
[3] Metal Bulletin (London).
[4] Based on average monthly rates of exchange by Federal Reserve Board

FOREIGN TRADE [4]

Imports.—Imports of unmanufactured copper declined 8 percent to the lowest level since 1958. The most significant drop was in refined copper. A less-than-vigorous demand in the United States prompted the refined copper of international trade to flow to the more active European markets. Scrap copper also found more willing buyers in Europe. However, the need for primary-source materials to supply domestic refineries after settlement of the strikes in early 1960 sustained near-record imports of blister copper. Imports of copper in concentrates remained virtually unchanged, and a decline in copper-matte imports was offset by an increase in ore entries.

Although the quantity of Chilean copper shipped to the United States diminished considerably, Chile remained the chief source of imported copper, supplying approximately 40 percent of the total. A large proportion of the Chilean copper was in smelter products that required treatment at United States refineries. Canada was the second largest supplier of copper to the United States, accounting for 22 percent of the total. The Canadian receipts were mostly refined metal. Peru rose to third place, becoming a major supplier of blister copper from the newly opened Toquepala unit of Southern Peru Copper Corp. Peru contributed 17 percent of the U.S. imported supply in 1960. Imports from Mexico and the producing countries of South and Central Africa declined. Copper, in concentrates, from the Philippines rose markedly.

TABLE 32.—U.S. imports [1] of copper (unmanufactured), by classes and countries

(Short tons, copper content)

Year and country	Ore	Concentrates	Matte	Blister	Refined	Scrap	Total
1951-55 (average) [2]	5,141	103,849	5,533	217,580	255,488	7,019	594,610
1956	17,459	97,404	7,311	276,085	191,745	5,743	595,747
1957	18,838	99,755	6,196	301,136	162,309	5,798	594,032
1958	8,217	79,200	5,178	268,182	128,464	7,060	496,301
1959:							
North America:							
Canada	[3] 330	5,306	926	149	103,237	2,370	[3] 112,318
Cuba	------	9,942	------	------	------	865	10,807
Mexico	9	445	1,120	21,215	6,575	129	29,493
Other North America	------	------	2	------	------	410	412
Total	[3] 339	15,693	2,048	21,364	109,812	3,774	[3] 153,030
South America:							
Chile	176	[3] 15,793	------	[3] 211,251	14,172	------	[3] 241,392
Peru	[3] 1,918	5,620	930	3,052	17,205	------	[3] 28,725
Other South America	347	1,611	7	17	------	272	2,254
Total	[3] 2,441	[3] 23,024	937	[3] 214,320	31,377	272	[3] 272,371
Europe:							
Belgium-Luxembourg	------	------	------	------	8,504	------	8,504
Germany, West	------	------	------	------	24,305	37	24,342
Malta, Gozo, and Cyprus	------	3,524	------	------	------	------	3,524
Sweden	------	------	------	------	3,428	------	3,428

See footnotes at end of table.

[4] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 32.—U.S. imports [1] of copper (unmanufactured), by classes and countries—Continued

(Short tons, copper content)

Year and country	Ore	Con-centrates	Matte	Blister	Refined	Scrap	Total
1959—Continued							
Europe—Continued							
United Kingdom					13,366	70	13,436
Other Europe					774	1,129	1,903
Total		3,524			50,377	1,236	55,137
Asia:							
Philippines	1	12,881	5			872	13,759
Other Asia				1,094		41	1,135
Total	1	12,881	5	1,094		913	14,894
Africa:							
Rhodesia and Nyasaland, Federation of			35	16,191	16,396		32,622
Union of South Africa	4,049	7,638	5,924	[3] 11,658	1,712		[3] 30,981
Other Africa					4,384		4,384
Total	4,049	7,638	5,959	[3] 27,849	22,492		[3] 67,987
Oceania: Australia	[3] 500	2,551			4,421		[3] 7,472
Grand total	[3] 7,330	[3] 65,311	8,949	[3] 269,048	214,058	6,195	[3] 570,891
1960:							
North America:							
Canada	273	14,108	569	333	100,641	1,730	117,654
Cuba		6,554				14	6,568
Mexico	71	36	1,787	18,647	2,038	77	22,656
Other North America	[4]		5			185	190
Total	344	20,698	2,361	18,980	102,679	2,006	147,068
South America:							
Bolivia	76	1,270					1,346
Chile		14,192		190,489	3,486		208,167
Peru	1,534	6,474	1,444	73,938	8,234		91,624
Other South America		7		4			11
Total	1,610	21,943	1,444	264,431	11,720		301,148
Europe:							
Belgium-Luxembourg					2,673		2,673
Germany, West					8,727	12	8,739
Spain					4,203		4,203
Sweden					2,789		2,789
United Kingdom					729	52	781
Other Europe					1,591	636	2,227
Total					20,712	700	21,412
Asia:							
Philippines	43	17,510	9				17,562
Other Asia				547		2	549
Total	43	17,510	9	547		2	18,111
Africa:							
Rhodesia and Nyasaland, Federation of			10		5,785		5,795
Union of South Africa	7,203	5,385	1,225	14,415			28,228
Other Africa	9				812		821
Total	7,212	5,385	1,235	14,415	6,597		34,844
Oceania: Australia	773				1,001		1,774
Grand total	9,982	65,536	5,049	298,373	142,709	2,708	524,357

[1] Data are "general" imports; that is, they include copper imported for immediate consumption plus material entering the country under bond.
[2] Some copper in "Ore" and "Other" from the Philippines is not separately classified and is included with "Concentrates."
[3] Revised figure.
[4] Less than 1 ton.

Source: Bureau of the Census.

Exports.—Exports of refined copper more than doubled in 1960. Unusually strong demand in Europe and high levels of refinery output in the United States were the determining factors. The quantity—434,000 tons—was the largest recorded since 1928. West Germany, United Kingdom, Italy, and France were the major recipients, but significant shipments went to many other countries, chiefly Japan, Brazil, and Argentina.

Exports of scrap copper expanded sixfold. Although substantial shipments were made to a score of countries, West Germany alone re-

TABLE 33.—U.S. imports [1] of copper (unmanufactured), by countries

(Short tons, copper content)

Country	1951–55 (average)	1956	1957	1958	1959	1960
North America:						
Canada	88,172	120,489	120,224	74,813	[2] 112,318	117,654
Cuba	19,969	16,345	17,435	14,464	10,807	6,568
Mexico	53,113	52,835	47,746	50,023	29,493	22,656
Other North America	576	671	543	453	412	190
Total	161,830	190,340	185,948	139,753	[2] 153,030	147,068
South America:						
Bolivia	3,746	4,500	4,463	3,395	1,790	1,346
Chile	281,088	236,623	236,016	200,145	[2] 241,392	208,167
Peru	20,293	42,841	41,636	30,426	[2] 28,725	91,624
Other South America	174	772	986	963	464	11
Total	305,301	284,736	283,101	234,929	[2] 272,371	301,148
Europe:						
Belgium-Luxembourg	1,472	800	447	56	8,504	2,673
France	1,854	991	660	1,188	1,125	526
Germany [3]	3,233	2,744	2,552	4,173	24,342	8,739
Malta, Gozo, and Cyprus	3,813	6,945	8,937	6,911	3,524	----------
Netherlands	511	11	22	392	727	506
Norway	2,048	5,969	----------	20	50	248
Sweden	648	254	2,689	1,063	3,428	2,789
United Kingdom	2,782	3,356	2,415	7,185	13,436	781
Yugoslavia	6,974	138	----------	----------	----------	----------
Other Europe	37	----------	----------	----------	1	5,150
Total	23,372	21,208	17,722	20,988	55,137	21,412
Asia:						
Philippines	14,736	10,911	13,067	14,583	13,759	17,562
Turkey	3,777	5,586	3,496	1,094	1,094	547
Other Asia	532	811	22	40	41	2
Total	19,045	17,308	16,585	15,717	14,894	18,111
Africa:						
Congo, Republic of the, and Ruanda-Urundi [4]	7,100	12,764	10,221	15,515	4,335	196
Rhodesia and Nyasaland, Federation of [5]	59,166	27,562	45,430	35,169	32,622	5,795
Union of South Africa	10,038	21,291	19,945	29,169	[2] 30,981	28,228
Other Africa	3	1,085	----------	----------	49	625
Total	76,307	62,702	75,596	79,853	[2] 67,987	34,844
Oceania:						
Australia	8,674	19,453	15,075	5,061	[2] 7,472	1,774
Other Oceania	81	----------	5	----------	----------	----------
Total	8,755	19,453	15,080	5,061	[2] 7,472	1,774
Grand total	594,610	595,747	594,032	496,301	[2] 570,891	524,357

[1] Data are "general" imports; that is, they include copper imported for immediate consumption plus material entering the country under bond.
[2] Revised figure.
[3] Beginning Jan. 1, 1952, classified as West Germany.
[4] Prior to July 1, 1960, classified as Belgian Congo.
[5] Prior to July 1, 1954, classified as Southern and Northern Rhodesia.

Source: Bureau of the Census.

ceived about one-third of the total. Spain and Japan were also major recipients of U.S. copper scrap.

Brass and bronze scrap exports exceeded the previous record, set in 1954, by 31 percent and were the largest since their data were recorded separately in 1929. Three-fourths of the total went to Japan.

Tariff.—Because the price of copper remained above the 24-cent boundary, the 1.7-cent-a-pound excise tax effective July 1, 1958, was applied to imported copper throughout 1960. A price below 24 cents would have resulted in an upward adjustment to 2 cents a pound, according to law.

TABLE 34.—U.S. imports for consumption of old brass and clippings from brass or Dutch metal [1]

Year	Short tons		Value (thousands)	Year	Short tons		Value (thousands)
	Gross weight	Copper content			Gross weight	Copper content	
1951-55 (average)	8,711	6,405	$3,267	1958	6,763	4,201	$1,852
1956	6,519	4,310	[2] 3,003	1959	2,054	1,257	698
1957	7,911	4,643	[2] 2,393	1960	566	309	184

[1] For remanufacture.
[2] Data known to be not comparable with other years.

Source: Bureau of the Census.

TABLE 35.—U.S. imports for consumption of copper (copper content), by classes

Year	Ore		Concentrates		Matte	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1951-55 (average)[1]	5,251	$2,960	97,454	$54,602	4,876	$3,054
1956	6,089	4,049	74,651	54,515	5,198	4,395
1957	20,951	12,217	62,361	34,258	5,361	3,213
1958	5,926	2,357	84,871	37,968	4,925	2,173
1959	[2] 60	[2] 20	9,299	5,505	7,113	4,260
1960	3,503	2,016	20,935	12,391	185	80

Year	Blister		Refined		Scrap		Total value (thousands)
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	
1951-55 (average)	218,684	$136,479	256,286	$163,360	7,415	[3] $4,201	[3] $364,656
1956	276,085	[3] 225,932	191,812	157,944	5,410	[3] 3,463	[3] 450,298
1957	301,136	179,440	162,309	97,024	5,843	[3] 3,049	[3] 329,201
1958	138,633	66,321	124,629	61,139	5,849	2,676	172,634
1959	203	126	237,304	146,478	2,984	1,635	[2] 158,024
1960	486	311	171,021	109,760	1,836	1,106	125,664

[1] Some copper in "Ore" and "Other" from the Philippines is not separately classified and is included with "Concentrates."
[2] Revised figure.
[3] Data known to be not comparable with other years.

Source: Bureau of the Census.

TABLE 36.—U.S. exports of copper by classes and countries

(Short tons)

Year and destination	Ore, concentrates, matte (copper content)	Refined	Rods[1]	Scrap	Pipes and tubes	Plates and sheets	Wire and cable, bare[2]	Wire and cable, insulated	Other copper manufactures[2]
1951-55 (average)	3,329	166,558	665	31,619	1,773	467	7,197	16,208	(3)
1956	13,717	223,103	366	25,681	1,550	337	11,104	18,434	185
1957	15,656	346,025	1,659	48,989	1,354	265	11,119	21,035	238
1958	11,475	384,868	(1)	21,861	1,608	166	5,030	14,482	2,302
1959	2,982	158,938	(1)	10,721	799	313	3,378	21,863	4,352
1960:									
North America:									
Canada	7	1,333		3,878	132	46	634	4,915	358
Cuba		4			3	3	7	99	1,301
Mexico	91	106			34	8	9	453	1
Other North America		4			113	10	134	1,516	5
Total	98	1,447		3,878	282	67	784	6,983	1,665
South America:									
Argentina		12,469		66	5		13	221	4
Brazil		14,892		103	9	(4)	9	187	34
Colombia		29			58	2	22	194	923
Venezuela		9			86	22	181	455	2,478
Other South America		99			33	3	68	560	1
Total		27,498		169	191	27	293	1,617	3,440
Europe:									
Belgium-Luxembourg		3,318		2,414	1		48	51	
France		56,866		663	2	15	3	40	12
Germany, West	1,763	105,998		20,373	2	19	13	67	
Italy	5,805	61,459		3,131	6	11	33	144	(4)
Netherlands		13,658		2,058	2	2	39	81	
Norway		3,460			2	1	48	4	
Spain		28		7,682	12		1	51	
Sweden		5,314		1,246	(4)	15	20	35	
Switzerland		6,945		277	1	7	(4)	9	10
United Kingdom	1,223	90,664		1,891	(4)	39	3	47	5
Yugoslavia		5,450		5,361				12	
Other Europe		5,276		166	8		41	507	1
Total	8,791	358,436		45,262	36	109	249	1,048	28
Asia:									
India		5,258		1,590	24	42	2	42	35
Japan	2,222	35,569		9,216	1	5	11	157	
Taiwan		1,611		99	1		64	130	
Other Asia		163		468	123	28	1,083	2,985	7
Total	2,222	42,601		11,373	149	75	1,160	3,314	42
Africa		6		16	43	2	780	320	5
Oceania		3,774			25	220	12	86	1
Grand total	11,111	433,762	(1)	60,698	726	500	3,278	13,368	5,181

[1] Beginning Jan. 1, 1958, not separately classified, included in "Other copper manufactures."
[2] Owing to changes in classifications, 1952-60 data not strictly comparable with earlier years.
[3] Weight not recorded before 1953; 1953, 294 tons; 1954, 250 tons; 1955, 234 tons.
[4] Less than 1 ton.

Source: Bureau of the Census.

TABLE 37.—U.S. exports of copper, by classes

Year	Ore, concentrates, and matte (copper content)		Refined copper and semimanufactures [1]		Other copper manufactures [1]		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1951–55 (average)	3,329	$2,349,546	224,487	$154,992,625	(2)	$632,401	227,816	$157,974,572
1956	13,717	11,648,348	280,575	253,614,925	185	290,552	294,477	265,553,825
1957	15,656	9,963,640	430,446	288,936,283	238	321,237	446,340	299,221,160
1958	11,475	5,864,534	[3] 428,015	[3] 229,534,839	[3] 2,302	[3] 1,567,100	441,792	236,966,473
1959	2,982	1,808,289	[3] 196,012	[3] 128,577,107	[3] 4,352	[3] 3,280,116	203,346	133,665,512
1960	11,111	6,832,050	[3] 512,332	[3] 327,939,855	[3] 5,181	[3] 4,006,049	528,624	338,777,954

[1] Owing to changes in classifications, 1952–60 data not strictly comparable with earlier years.
[2] Weight not recorded before 1953; 1953, 294 tons ($352,124); 1954, 250 tons ($307,848); 1955, 234 tons ($308,792).
[3] Beginning Jan. 1, 1958, copper rods not separately classified; included in "Other copper manufactures."

Source: Bureau of the Census.

TABLE 38.—U.S. exports of copper-base alloys (including brass and bronze), by classes

Class	1959		1960	
	Short tons	Value	Short tons	Value
Ingots	383	$898,218	699	$1,645,920
Scrap and other forms	29,406	12,497,070	122,957	52,220,441
Bars, rods, and shapes	515	803,736	571	926,963
Plates, sheets, and strips	573	1,172,252	650	1,662,638
Pipes and tubes	1,273	1,848,775	1,035	1,487,445
Pipe fittings	1,691	3,850,983	1,400	3,391,334
Plumbers' brass goods	2,453	6,693,763	2,202	5,871,981
Welding rods and wire	724	1,413,958	794	1,587,843
Castings and forgings	136	260,137	276	688,288
Powder	391	402,044	325	385,145
Semifabricated forms, not elsewhere classified	62	160,973	13	40,079
Total	37,607	30,001,909	130,922	69,908,077

Source: Bureau of the Census.

TABLE 39.—U.S. exports of unfabricated copper-base-alloy [1] ingots, bars, rods, shapes, plates, sheets, and strips

Year	Short tons	Value	Year	Short tons	Value
1951–55 [2] (average)	3,891	$3,614,028	1958 [2]	1,396	$2,228,688
1956 [2]	2,233	3,844,261	1959 [2]	1,471	2,874,206
1957 [2]	1,747	2,943,557	1960 [2]	1,920	4,235,521

[1] Includes brass and bronze.
[2] Owing to changes in classifications, data 1953–60 not strictly comparable with earlier years.

Source: Bureau of the Census.

TABLE 40.—U.S. exports of copper sulfate (blue vitrol)

Year	Short tons	Value	Year	Short tons	Value
1951–55 (average)	37,271	$7,529,850	1958	7,248	$1,175,944
1956	30,177	8,036,233	1959	2,672	674,522
1957	33,644	6,534,037	1960	14,841	3,376,649

Source: Bureau of the Census.

TABLE 41.—U.S. imports and exports of brass and copper scrap

(Short tons)

	1951-55 (average)	1956	1957	1958	1959	1960
Imports for consumption:						
Brass scrap (gross weight)	8,711	6,519	7,911	6,763	2,054	566
Copper scrap (copper content)	7,415	5,410	5,843	5,849	2,984	1,836
Exports:						
Brass scrap [1]	36,806	50,485	69,996	28,502	29,406	122,957
Copper scrap	31,619	25,681	48,989	21,861	10,721	60,698

[1] Beginning Jan. 1, 1952, classified as copper-base-alloy scrap (new and old).

Source: Bureau of the Census.

TABLE 42.—U.S. imports for consumption and exports of copper scrap, in 1960, by countries

(Short tons)

Country	Imports		Exports	
	Unalloyed copper scrap (copper content)	Copper-alloy scrap (gross weight)	Unalloyed copper scrap	Copper-alloy scrap
North America:				
Canada	1,288	405	3,878	184
Mexico	50	7		1,236
Other North America	302	151		(1)
Total	1,640	563	3,878	1,420
South America			169	127
Europe:				
Belgium-Luxembourg			2,414	412
France	20		663	370
Germany, West	12		20,373	11,673
Italy	3		3,130	8,586
Netherlands	9		2,058	3,197
Spain			7,682	126
Sweden			1,246	118
United Kingdom	52		1,891	2,732
Yugoslavia		3	5,361	468
Other Europe	98		443	780
Total	194	3	45,261	28,462
Asia:				
Hong Kong			364	81
India			1,590	1,985
Japan			9,216	90,772
Other Asia	2		204	83
Total	2		11,374	92,921
Africa			16	27
Grand total	1,836	566	60,698	122,957

[1] Less than 1 ton.

Source: Bureau of the Census.

WORLD REVIEW

Preliminary reports suggested a considerable increase in world copper consumption in 1960. Trends were mixed. Western Europe attained a consumption rate of 2 million tons per year, about half the world total. Nearly all Asian countries showed marked increases, but Western Hemisphere countries used less copper than in 1959.

There was some evidence that world consumption did not increase as much as preliminary reports, based on sales, indicated. It was suggested that buyers' anxiety caused by political unrest and labor disputes in copper-producing countries contributed to abnormally high market activity in Europe. Hence, a portion of the copper reported consumed possibly represented a buildup in consumer inventories.

Despite labor disputes and political unrest, world production of primary copper rose to 4.6 million tons, a new record high. Planned production cutbacks by some producers to limit stock buildups and prevent price declines were more than offset by expanded output from other producers and initial production at new facilities.

TABLE 43.—World mine production of copper (content of ore) by countries [1 2]

(Short tons)

Country	1951–55 (average)	1956	1957	1958	1959	1950
North America:						
Canada	281,997	354,860	359,109	345,114	395,269	438,383
Cuba	19,519	18,200	18,000	14,343	9,942	[3] 13,058
Mexico	65,134	60,478	66,800	71,609	63,134	66,502
United States	922,836	1,104,156	1,086,859	979,329	824,846	1,080,169
Total	1,289,486	1,537,694	1,530,768	1,410,395	1,293,191	1,598,112
South America:						
Bolivia (exports)	4,667	4,896	4,320	3,168	2,461	2,503
Brazil [4]	[5] 728	880	1,400	1,300	1,500	1,500
Chile	429,818	539,844	535,306	514,925	602,108	586,862
Ecuador	6	13	17	53	148	110
Peru	39,672	50,966	63,023	59,105	55,872	201,572
Total	474,891	596,599	604,066	578,551	662,089	792,547
Europe:						
Albania [4]	440	660	1,200	1,900	2,200	2,200
Austria	2,888	2,579	2,574	2,695	2,726	2,188
Bulgaria [4]	4,100	5,800	7,700	8,600	11,000	15,400
Finland	22,465	23,150	28,700	31,800	32,400	31,000
France [6]	517	450	410	794	674	733
Germany:						
East [4]	17,000	17,900	18,400	19,100	27,100	27,500
West	2,126	1,076	1,202	1,156	1,584	1,959
Ireland	----	----	----	[4] 5,300	5,281	6,685
Italy [7]	1,296	2,384	3,900	4,073	4,066	[4] 4,000
Norway	15,044	16,488	16,787	17,501	15,828	16,000
Poland	4,475	8,000	8,300	[4] 8,800	[4] 9,900	[4] 11,600
Portugal	646	1,066	619	819	791	[4] 550
Spain [8]	8,462	7,525	11,077	7,466	12,137	8,786
Sweden	16,038	18,436	19,924	20,453	19,079	18,396
U.S.S.R. [4 9 10]	335,000	430,000	450,000	470,000	480,000	510,000
Yugoslavia	34,268	35,088	36,883	38,840	38,141	36,681
Total [4 9]	465,000	571,000	608,000	639,000	663,000	694,000
Asia:						
Burma [4]	97	165	143	143	165	160
China [4]	8,400	13,000	16,500	33,000	55,000	77,000
Cyprus (exports) [8]	26,977	39,497	43,676	36,614	39,978	39,096
India	7,519	8,800	9,000	9,150	8,900	9,750
Japan	64,919	86,497	90,066	89,837	93,970	98,391
Korea, Republic of	883	970	710	590	449	649
Philippines	15,538	29,722	44,513	51,842	54,587	48,513
Taiwan	763	1,875	2,095	1,702	1,793	2,315
Turkey	[10] 23,866	30,544	28,871	27,744	30,551	30,110
Total [4 9]	149,000	211,100	235,600	250,600	285,400	306,000
Africa:						
Algeria	130	209	476	435	57	127
Angola	1,513	1,617	1,879	1,688	1,932	2,108
Congo, Republic of the (formerly Belgian) [10]	235,408	275,538	267,028	261,867	310,955	333,175

See footnotes at end of table.

TABLE 43.—World mine production of copper (content of ore) by countries [1] [2]—Continued

(Short tons)

Country	1951-55 (average)	1956	1957	1958	1959	1960
Africa—Continued						
Morocco: Southern zone	778	852	694	1,216	1,601	1,680
Rhodesia and Nyasaland, Federation of:						
Northern Rhodeisa	392,012	445,466	480,313	441,073	598,835	635,326
Southern Rhodesia	380	1,931	3,226	8,430	12,016	15,128
South-West Africa	16,333	28,980	29,910	30,975	34,436	22,555
Tanganyika [11]	421	1,276	1,178	1,770	1,220	1,383
Uganda	----------	3,230	11,723	11,201	11,761	[10] 16,257
Union of South Africa	42,321	51,252	50,959	54,615	54,066	[10] 50,847
Total	689,296	810,351	847,386	813,270	1,026,879	1,078,586
Oceania: Australia	35,738	59,406	64,034	82,269	106,063	121,761
World total (estimate)	3,100,000	3,790,000	3,890,000	3,770,000	4,040,000	4,590,000

[1] Czechoslovakia, Hungary, and Iran also produce copper, but production data are not available. Israel and Nicaragua are also producing a small amount of copper. No estimates for these countries are included in the total.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Exports.
[4] Estimate.
[5] One year only, as 1955 was first year of production reported.
[6] Includes copper content of auriferous ores.
[7] Revised to include copper content of cupriferous pyrites.
[8] According to Yearbook of American Bureau of Metal Statistics. These data do not include content of iron pyrites, the copper content of which may or may not be recovered.
[9] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.
[10] Smelter production.
[11] Copper content of exports and local sales.

Compiled by Augusta W. Jann, Division of Foreign Activities.

NORTH AMERICA

Canada.—Canadian refineries produced 416,000 tons of copper, an increase of 14 percent. Consumption declined 10 percent to 117,600 tons. Exports increased markedly. Of the 278,000 tons refined copper exported, 215,000 was shipped in nearly equal quantities to the United States and United Kingdom. In addition, Canada exported 47,600 tons of copper in ore, matte, and blister, mainly to Norway, United States, and Japan.

All operating mines of The International Nickel Company of Canada, Ltd., Canada's largest copper producer, operated at capacity throughout 1960. Approximately 16.8 million tons of ore was mined, mostly from the underground operations of the Sudbury district, Ontario. The proved ore reserve at the end of the year was 290 million tons, containing about 3 percent combined nickel and copper. In addition to nickel and other metal products, the company delivered 146,000 tons of refined copper to markets in Canada, United States, and Europe.

Hudson Bay Mining and Smelting Co., Ltd., mined and milled 1,681,963 tons of ore, mostly from its Flin Flon mine, Manitoba. In addition, 8,968 tons of ore was smelted directly. Metal production included 40,000 tons of blister copper that was refined by Canadian Copper Refiners, Ltd. At yearend, ore reserves totaled 15.8 million tons, averaging 2.63 percent copper, 5.2 percent zinc, and minor quantities of lead, gold, silver, cadmium, and selenium.

TABLE 44.—World smelter production of copper, by countries [1]

(Short tons)

Country	1951–55 (average)	1956	1957	1958	1959	1960
North America:						
Canada	244,223	328,458	323,540	329,239	365,366	416,401
Mexico	55,519	52,089	62,061	67,109	61,105	64,681
United States [2]	1,032,260	1,231,352	1,178,145	1,069,052	841,795	1,233,629
Total	1,332,002	1,611,899	1,563,746	1,465,400	1,268,266	1,714,711
South America:						
Chile	402,259	506,256	496,736	484,678	570,593	556,636
Peru	27,858	35,005	46,137	42,403	38,024	181,649
Total	430,117	541,261	542,873	527,081	608,617	738,285
Europe:						
Albania	[3] 880	635	1,020	[4] 1,100	[4] 1,100	[4] 1,100
Austria	8,875	11,088	8,806	10,525	11,601	12,964
Bulgaria [4]	2,400	5,000	5,600	6,748	7,200	11,000
Finland	21,964	24,767	28,469	33,873	35,941	34,140
Germany:						
East [4]	25,400	27,500	27,500	27,500	33,000	35,000
West [5]	242,081	279,463	279,313	295,609	310,729	340,695
Italy	344	428	147	117	405	[4] 440
Norway	12,653	17,013	17,447	19,365	21,218	23,664
Poland	[5] 14,092	22,396	21,966	19,146	19,127	23,961
Spain	6,003	6,940	6,600	5,556	7,686	9,041
Sweden	17,636	18,673	21,472	22,268	27,921	23,927
U.S.S.R.[4 6]	335,000	430,000	450,000	470,000	480,000	510,000
Yugoslavia	34,078	32,390	37,186	37,117	38,858	39,384
Total [4 6 7]	721,000	876,000	906,000	949,000	995,000	1,065,000
Asia:						
China [4]	8,400	13,000	16,500	[8] 33,000	[8] 55,000	[8] 77,000
India	7,285	8,543	8,790	8,782	8,459	9,822
Japan	67,607	101,946	120,013	113,979	170,682	206,522
Korea, Republic of	230	1,000	874	886	824	1,113
Taiwan	863	1,659	1,883	1,833	1,986	1,962
Turkey	23,866	27,297	26,897	24,835	27,599	28,903
Total [4 6]	108,300	153,400	175,000	183,300	264,600	325,300
Africa:						
Angola	1,376	1,537	1,855	1,608	1,782	1,735
Congo, Republic of the (formerly Belgian)	235,408	275,538	267,028	261,867	310,955	333,175
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia	382,112	429,503	466,157	420,936	593,747	624,604
Uganda	----------	168	8,361	12,130	13,376	16,257
Union of South Africa	41,040	48,681	48,229	53,406	53,843	50.847
Total	659,936	755,427	791,630	749,947	973,703	1,026,618
Oceania: Australia	32,456	54,914	56,440	72,360	76,713	79,130
World total (estimate)	3,280,000	3,990,000	4,040,000	3,950,000	4,190,000	4,950,000

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] Smelter output from domestic and foreign ores, exclusive of scrap. Production from domestic ores only, exclusive of scrap, was as follows: 1951–55 (average), 928,644 short tons; 1956, 1,117,580; 1957, 1,081,055; 1958, 992,918; 1959, 799,329; and 1960, 1,142,848.
[3] Average for 1954–55.
[4] Estimate.
[5] Includes scrap.
[6] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.
[7] Belgium reports a large output of refined copper which is believed to be produced principally from crude copper from Republic of the Congo (formerly Belgian); it is not shown here, as that would duplicate output reported under latter country.
[8] Data represent estimated mine production.

Compiled by Augusta W. Jann, Division of Foreign Activities.

Canada's second ranking copper producer was Gaspé Copper Mines, Ltd., subsidiary of Noranda Mines, Ltd. Output from the company underground and open pit mines of the Gaspé Peninsula, Quebec, was

2,542,000 tons of ore, averaging 1.47 percent copper. The Gaspé smelter treated 121,700 tons of Gaspé mine concentrate and 71,440 tons of customs concentrate to produce 48,900 tons of copper in anodes.

Waite Amulet Mines, Ltd., also a Noranda subsidiary, produced 297,100 tons of ore that yielded 13,153 tons of copper. Reserves were being depleted, and a shutdown was anticipated in 1962.

At the Horne mine of Noranda Mines, Ltd., preparation was completed for sinking a new internal shaft from the 6,000- to the 8,000-foot level to develop deeper ore. Approximately 1,332,000 tons of ore, having a 1.96 percent copper content, was extracted. Gold-bearing pyrite was also a principal product. Sulfide ore reserves at yearend were 8.7 million tons, averaging 2.32 percent copper and 0.18 ounce of gold per ton. The Noranda smelter treated 1,540,000 tons of company and custom materials that yielded 158,450 tons of copper in anodes.

TABLE 45.—Canada: Copper production (mine output), by Provinces

(Short tons)

Province	1951–55 (average)	1956	1957	1958	1959	1960 (preliminary)
British Columbia	22,816	21,682	15,411	6,010	8,121	15,950
Manitoba	13,256	17,973	18,551	12,601	12,945	12,307
New Brunswick	7	6	5,738	328	------	------
Newfoundland	3,041	3,108	4,535	14,751	14,989	13,875
Northwest Territories	------	------	165	434	494	625
Nova Scotia	638	404	------	------	------	------
Ontario	134,383	156,271	171,703	142,035	188,272	204,121
Quebec	75,517	122,300	112,409	131,445	134,912	159,512
Saskatchewan	32,339	33,116	30,597	37,510	35,536	31,993
Total	281,997	354,860	359,109	345,114	395,269	438,383

Source: Dominion Bureau of Statistics, Department of Trade and Commerce, Government of Canada, Preliminary Report on Mineral Production, 1960.

Development of the ore block between the 4,000- and 6,000-foot levels continued at the Falconbridge mine, Sudbury district, Ontario. During 1960, mines of Falconbridge Nickel Mines, Ltd., produced 2.4 million tons of ore. Deliveries of copper by the company increased 10 percent to 18,000 tons. Blister output was shipped to Norway for refining. Developed and indicated ore in company mines of the Sudbury basin at yearend was 46.1 million tons, containing 1.46 percent nickel and 0.81 percent copper.

Increased mill capacity and increased production marked the operations of Campbell Chibougamau Mines, Ltd., in northern Quebec. Approximately 742,000 tons of ore was extracted that averaged 2.37 percent copper and 0.065 ounce of gold per ton. The ore yielded 15,500 tons of copper in concentrates.

Geco Mines, Ltd., produced 1.3 million tons of ore from its copper-zinc ore body in the Manitouwadge district, Ontario. The mill produced 77,424 tons of 28.11 percent copper concentrate that was shipped to the Noranda smelter. Ore reserves of the Geco ore body were 17 million tons, containing 1.97 percent copper, 4.18 percent zinc, and 2.2 ounces of silver per ton.

In addition to zinc, gold, and silver, the mine of Quemont Mining Corp., Ltd., at Noranda, Quebec, produced 10,210 tons of copper. Yearend ore reserves were reported to be 5.3 million tons, averaging

1.29 percent copper, 2.75 percent zinc, 50 percent pyrite, 1.05 ounces of silver, and 0.174 ounce of gold per ton.

The Normetal Mining Corp., Ltd., extracted 347,000 tons of ore, averaging 3.28 percent copper, 4.19 percent zinc, and small quantities of gold and silver, from its mine near Dupuy, Quebec. Most of the copper concentrate was smelted at Noranda, although about 3,200 tons was smelted in Japan.

The production of East Sullivan Mines, Ltd., Quebec, diminished markedly. Approximately 564,000 tons of ore was mined, which yielded 3,700 tons of copper in concentrates. Average ore grade was 0.73 percent copper, 1.04 percent zinc, and minor quantities of gold and silver.

Willroy Mines, Ltd., produced 429,000 tons of ore from its mine in the Manitouwadge district, Ontario. The ore averaged 1.24 percent copper, 7.39 percent zinc, and minor quantities of lead, silver, and gold.

Sherritt Gordon Mines, Ltd., mined 1,151,400 tons of ore from its Lynn Lake nickel-copper ore body in Manitoba. Approximately 5,500 tons of copper in concentrates was shipped to the Noranda and Flin Flon smelters. The resulting blister copper was refined and sold by Noranda Mines, Ltd. Ore reserves were calculated at 14.3 million tons, averaging 0.92 percent nickel and 0.53 percent copper.

Exports of copper ingots, bars, and billets, in short tons were:

Destination:	*1959*	*1960*
United Kingdom	83,487	110,540
United States	101,501	104,602
Germany, West	9,510	12,940
France	10,038	12,880
India	7,619	10,908
Netherlands	2,939	5,318
Japan	110	4,861
Belgium	3,738	4,481
Sweden	224	2,522
Italy	1,400	2,516
Finland	-------	2,127
Australia	280	1,847
Other countries	1,591	2,524
Total	222,437	278,066

Mexico.—Operations of the Cananea Consolidated Copper Co., S.A., Sonora, continued without interruption during 1960. About 65 percent of the 5 million tons of ore mined came from Cananea's open pit. Production totaled 31,000 tons of copper, all of which was shipped to Cobre de Mexico, S.A., for refining.

SOUTH AMERICA

Chile.—Copper production at the Chuquicamata mine of the Chile Exploration Co., a subsidiary of The Anaconda Company, totaled 254,800 tons, a considerable drop from the 1959 production. A general strike that closed the mine and surface plants on October 1 for a 6-week period accounted for most of the production loss. Increased grinding-mill capacity and water facilities were planned to sustain copper output as sulfide ore treated increased at the expense of ore, owing to the diminishing oxide ore reserve.

Copper output from the El Salvador mine of Andes Copper Mining Co., also an Anaconda subsidiary, exceeded the planned rate of production by late 1960. Despite a labor strike that closed the mine during most of May, production rose 44 percent to 86,800 tons of copper. El Salvador concentrate was smelted at Porterillos.

La Africana mine of Santiago Mining Co., subsidiary of Anaconda, operated throughout the year and produced 21,000 tons of concentrate, which averaged 28.1 percent copper.

The copper content of ore mined from El Teniente mine, Braden Copper Co., subsidiary of Kennecott Copper Corp., increased to 39.9 pounds per ton in 1960. Approximately 11.5 million tons of ore was produced by block caving, and 187,200 tons of copper was recovered. The European market absorbed virtually the entire Braden output.

TABLE 46.—Chile: Exports of copper by principal types

(Short tons)

Destination	1959				1960			
	Refined		Standard (blister)	Total	Refined		Standard (blister)	Total
	Electrolytic	Fire-refined			Electrolytic	Fire-refined		
Belgium	2,326	---	---	2,326	1,260	1,456	---	2,716
France	6,671	---	---	6,671	16,590	276	---	16,866
Germany, West	32,667	9,055	42,159	83,881	25,163	16,833	49,577	91,573
Italy	16,905	12,076	1,291	30,272	12,807	11,620	2,690	27,117
Netherlands	58,554	1,755	56	60,365	49,677	2,632	---	52,309
Spain	---	---	3,426	3,426	---	---	---	---
Sweden	11,823	---	---	11,823	20,987	56	642	21,685
Switzerland	---	1,597	---	1,597	---	---	---	---
United Kingdom	23,057	50,128	33,690	106,875	24,704	48,262	45,882	118,848
United States	13,993	2,804	201,417	218,214	600	1,251	201,999	203,850
Other countries	144	944	---	1,088	---	---	---	---
Total	166,140	78,359	282,039	526,538	151,788	82,386	300,790	534,964

Cerro Corp. conducted negotiations with the Government of Chile and with lending institutions preparatory to bringing the Rio Blanco copper deposit into production. The property is 31 miles northeast of Santiago. Indicated ore reserves total 120 million tons, averaging 1.58 percent copper. Block-caving at a daily rate of 11,000 tons was planned.

The Paipote smelter, operated by the Government's Empresa Nacional de Fundiciones, produced 28,400 tons of blister copper. Output of small mines served by Paipote totaled 30,200 tons of ores, concentrates, and cement copper.

In addition to the exports shown in table 46, a total of 29,000 tons of copper in ores and concentrates was shipped to the United States, West Germany, Japan, Poland, and Sweden.

Peru.—Southern Peru Copper Corp., jointly owned by American Smelting and Refining Company, Cerro Corp., Phelps Dodge Corp., and Newmont Mining Corp., commenced scheduled production at Toquepala January 1, 1960. Mine production of ore and waste averaged 166,897 tons per day. The mill operated at a rate of about 26,000 tons per day. The grade of ore milled, substantially higher than the average grade of the ore body, was reported to have been 1.73

percent in 1960. Approximately 40 percent of the 145,000 tons of blister copper produced from Toquepala ore was sold in Europe through the Southern Peru Copper Sales Corp. The balance was sold to the four U.S. stockholding companies.

Late in 1960 the capacity of the copper refinery of Cerro de Pasco Corp. at La Oroya was increased from 31,500 to 37,500 tons per year. The company established new production records for refined copper, lead, zinc, silver, cadmium, and selenium. A significant increase in the output of ore from the McCune pit reduced the proportion of copper ore from Cerro's underground mines to only 20 percent. In September, the company appropriated US$2,230,000 to expand the Paragsha concentrator at Cerro de Pasco from 35,000 to 50,000 tons of copper ore per month. During 1960 Cerro de Pasco Corp. (Cerro-Peru) produced 36,800 tons of copper from company mines and purchased ores.

EUROPE

United Kingdom.—Consumption of copper in the United Kingdom rose sharply to total 809,000 tons, about 100,000 tons more than the 1959 quantity. Consumption of copper reclaimed from scrap increased only slightly, but refined virgin-copper use increased nearly 40 percent. Approximately 594,000 tons of refined copper and 119,000 tons of copper in scrap were consumed in semimanufactures; and 23,000 tons of refined copper and 73,000 tons of copper in scrap were used in castings, production of copper sulfate, and miscellaneous uses.

Industry stocks in the United Kingdom at the end of 1960 were reported at 108,300 tons of refined copper and 20,000 tons of blister, considerably higher than the 1959 closing stocks.

Copper sulfate production declined slightly to 32,300 tons.

Data reported by the British Bureau of Nonferrous Metal Statistics on imports of copper into the United Kingdom are listed in table 47.

Exports and reexports of refined copper were 62,300 tons (111,400 in 1959), of which 11,700 (10,100) went to Czechoslovakia, 9,900 (800) to East Germany, 6,500 (11,600) to West Germany, 6,500 (26,700) to the U.S.S.R., 5,400 (3,300) to the Netherlands, 4,100 (8,700) to China,

TABLE 47.—United Kingdom: Imports of copper, by countries

(Short tons)

Country	1959			1960		
	Blister	Electrolytic	Fire-refined	Blister	Electrolytic	Fire-refined
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia	74,744	182,143		76,371	200,865	
Chile	32,422	23,228	46,984	47,759	29,884	50,371
Canada		81,576			115,246	
United States		31,057	1,959		66,009	6,213
Australia		618			4,490	
Union of South Africa		280	5,683			3,349
Peru		588		693	2,552	
Congo, Republic of the		4,541			3,134	
Germany, West		6			2,658	
Norway		3,455			2,464	
Belgium		452			1,688	
Other Countries	5	9		1,137	403	139
Total	107,171	327,953	54,626	125,960	429,393	60,072

3,300 (3,500) to Hungary, 2,900 (4,000) to India, 2,000 (11,500) to Poland, 1,900 (2,000) to Argentina, 1,800 (17,600) to the United States, and the remainder in lots of less than 1,500 tons to other countries. No blister copper was reexported in 1959 or 1960.

ASIA

Cyprus.—Engineering plans to develop the Skouriotissa and Apliki mines by open-pit methods were completed during 1960. Production of copper concentrates from Cyprus mines totaled 104,800 tons. In addition, 195,200 tons of cupreous pyrites and 2,200 tons of copper precipitate were produced. The ore reserve at the Mavrovouni mine was estimated at 2,058,600 tons, averaging 3.6 percent copper. Combined reserves at the Skouriotissa and Apliki mines were 4,648,000 tons, averaging about 1.9 percent copper.

Philippines.—Atlas Consolidated Mining & Development Corp. produced 3,351,600 tons of ore and removed 11,355,000 tons of waste from the Toledo open-pit mine. The mill produced 65,721 tons of copper concentrate, averaging 27.14 percent copper. The estimated ore reserve at yearend was 106.8 million tons, averaging 0.694 percent copper.

Production of Lepanto Consolidated Mining Co. increased to 15,278 tons of copper in 1960. Gold and silver were byproducts. The mine output was 470,420 tons of 3.41-percent copper ore containing 0.139 ounce of gold per ton. The ore reserve was estimated at 4.7 million tons, averaging 3.41-percent copper and 0.13 ounce of gold per ton.

AFRICA

Congo, Republic of the.—Despite political and social upheaval, production of copper increased markedly in 1960. Union Miniere du Haut-Katanga, the only producer, had a record output of 331,400 tons of copper from its mines and processing plants in Upper Katanga. On July 10 the operations were closed to enable personnel to evacuate their families to politically more stable Northern Rhodesia. However, the rapidly improving local situation permitted gradual return to normal production activities by July 18. Ore output continued to come chiefly from mines in the West Zone (Kamoto, Musonoi, Ruwe, and Kolwezi mines) and from the Prince Leopold mine at Kipushi in the South Zone. The Prince Leopold mine yielded slightly more than 1.1 million tons of copper-zinc ore. Top-slicing mining with metal ground supports was adopted throughout the mine. The Kambove mine of the Central Zone produced 1.3 million tons of copper ore from the Kambove West ore zone, but the product was stockpiled pending completion of a new concentrator. The Ruashi open-pit mine near Elisabethville was reopened to replace the Lukuni mine, depleted in 1960. Total ore extraction from Katanga mines was 8.2 million tons.

The Kolwezi concentrator treated 4.3 million tons of siliceous oxide and sulfide ores chiefly from the Kamoto and Musonoi open pits. The yield was 718,300 tons of concentrate, averaging 24.76 percent copper and 1.29 percent cobalt.

The Kipushi concentrator treated 1.2 million tons of ore, mainly Prince Leopold mine sulfide ores. Mill output was 247,500 tons of 25.81-percent copper concentrate, 212,800 tons of 56.57-percent zinc concentrate, and 11,000 tons of concentrate containing 33.83 percent lead and 8.32 percent copper. In addition, 8,900 tons of 27.03-percent copper concentrate was produced from Lukuni and Ruashi mine oxidized ores.

The concentrator serving the Ruwe open pit produced 55,000 tons of 20.68-percent copper concentrate and 168,400 tons of material containing 7.67 percent copper to be reprocessed at Kolwezi.

Copper production was as follows:

	Short tons
Lubumbashi (blast furnaces and converters)	133,964
Jadotville-Shituru (leaching, electrolysis, and refining)	159,492
Luilu (leaching and electrolysis)	34,436
Jadotville-Panda electric smelter (recoverable copper in white cobalt alloy)	3,093
Recoverable copper contained in zinc concentrates	452
	331,437

The Luilu (leach-electrolysis) plant was put into operation in April 1960 with an initial capacity of 55,000 tons of refined copper per year. Automated installations worked satisfactorily. Building continued on the second stage corresponding to an additional 55,000 tons per year capacity.

Rhodesia and Nyasaland, Federation of.—Mines of the Northern Rhodesian copper belt produced 626,000 tons of copper, an increase of 5.5 percent over 1959. The principal corporate groups were Anglo American Corporation of South Africa, Ltd. (administers Nchanga,

TABLE 48.—Federation of Rhodesia and Nyasaland: Exports of copper in January–September 1960

(Short tons)

Destination	Ore and concentrates	Blister	Electrolytic			Copper slimes
			Bar and ingot	Cathodes	Wirebars	
Argentina			2,546	34	8,360	
Belgium		1,344	224		392	
Brazil					4,669	
Czechoslovakia					2,520	
Denmark					1,205	
France		140	5,133	2,016	15,100	
Germany, West		39,533		8,224	25,260	
India		13,622	1,768		13,861	
Italy		5,573		224	24,649	
Japan	21,179			7,524	4,441	
Netherlands					1,792	
Norway					2,548	
Poland	240	896			672	
Spain		582				
Sweden	40	672			16,660	
Switzerland		532	896	1,400	6,545	
Union of South Africa	4,129	328	1,061		8,268	
U.S.S.R.		10,640			6,442	
United Kingdom	910	55,980	7,302	9,605	117,908	
United States			31		14,273	1,641
Yugoslavia				1,452		
Other countries		560			280	
Total	26,498	130,402	18,961	30,479	275,845	1,641

Rhokana, and Bancroft mines and affiliated smelters and refinery), and Rhodesian Selection Trust, Ltd. (administers Mufulira, Roan Antelope, Chibuluma, Chambishi, and Baluba properties with affiliated smelters and refinery).

Rhokana Corporation, Ltd., mined and milled 5.3 million tons of ore from its Nkana and Mindola ore bodies during the fiscal year ended June 30, 1960. Concreting of the Mindola shaft to the 3,660 level was completed, and sinking of the V.5 ventilation shaft was started. The mill, operating at an average rate of 14,500 tons per day, produced 314,476 tons of 32.5-percent copper concentrate containing 0.76 percent cobalt, in addition to 99,122 tons of 2.60-percent cobalt concentrate containing 16.56-percent copper. Production of primary blister copper and anodes at the Rhokana smelter totaled 301,530 tons. In addition to Rhokana concentrate, the smelter treated products of Nchanga and Bancroft. In mid-1960 the estimated ore reserves in the Rhokana ore bodies was 120 million tons, averaging 3.07 percent copper.

Nchanga Consolidated Copper Mines, Ltd., produced 199,410 tons of copper in the fiscal year ended March 31, 1960. Approximately 3.2 million tons of ore was extracted from the Nchanga West block-cave mine. Progress was made in driving dewatering crosscuts through ground requiring heavy support on the 970 level. Average daily quantity of water pumped from the Nchanga West was 15.1 million gallons. The Chingola and Nchanga open pits produced 1.2 million tons of ore, and 5 million cubic yards of waste were removed to develop deeper ore benches. The estimated Nchanga ore reserve at end of the fiscal year was 180 million tons of ore containing 4.65 percent copper. In addition to Nchanga copper concentrate smelted by Rhokana, Nchanga produced 73,677 tons of cathode copper from leach solutions at its Chingola electrolytic refinery.

At Bancroft Mines, Ltd., mining of the Kirila Bomwe South ore body continued, and production for the year ended June 30, 1960, was 57,256 tons of copper. Work continued on extending drifts north and south of Number One shaft and on sinking twin incline shafts to exploit downward-extending ore zones. Approximately 1.6 million tons of ore was mined and milled by Bancroft in the fiscal year. The reserve was reported to be 105 million tons, averaging 3.73 percent copper.

Rhodesia Copper Refineries, Ltd., also administered by Anglo American Corp., produced 247,808 tons of electrolytic copper from the Rhokana smelter output of blister and anodes.

Operating mines of the Rhodesian Selection Trust Group (Mufulira, Roan Antelope, and Chibuluma) produced 243,654 tons of copper in the fiscal year ended June 30, 1960. The Group production represented about 7 percent of the free-world primary output.

Roan Antelope Copper Mines, Ltd., produced 6.7 million tons of ore averaging 1.85 percent copper. Refinery output from Roan Antelope concentrate totaled 103,422 tons. The ore reserve in mid-1960 was reported to be 95 million tons, averaging 3.04 percent copper.

Mufulira Copper Mines, Ltd., produced a record 115,531 tons of copper in the fiscal year ended June 30, 1960. Crude-ore output, mostly from block-cave slopes, increased 20 percent to 4.9 million tons. Average grade of ore milled was 2.65 percent copper. Underground development for the Mufulira West extension continued. Shaft sinking and lateral drives totaled 75,603 feet. Surface preparations kept apace. New crushing, grinding, and flotation units were being installed during the year. The reserve was estimated at 179 million tons, averaging 3.35 percent copper.

Copper production of Chibuluma Mines, Ltd., was 24,700 tons during the year ended June 30, 1960. Cobalt metal, refined in Belgium from Chibuluma ores, amounted to approximately 1.6 million pounds. The Chibuluma ore reserve was estimated at 10 million tons, averaging 4.89 percent copper and 0.18 percent cobalt.

The Ndola Copper Refineries, Ltd., (Rhodesian Selection Trust subsidiary) operated its refinery without interruption during the year, though not at capacity. A total of 68,579 tons of copper was produced, 95 percent of which was for the account of Roan Antelope Copper Mines, Ltd.

Near the end of 1960 a new copper smelter and refinery began producing at Alaska in the Lamogundi district of Southern Rhodesia. Owned by the Messina Rhodesia Smelting and Refining Co., Ltd., the plant was erected to process copper concentrates from Messina's Mangula and Alaska mines.

South-West Africa.—Tsumeb Corporation, Ltd., produced 614,000 tons of ore averaging 24 percent combined copper, lead, and zinc with significant values in cadmium, silver, and germanium during the year ended June 30, 1960. Sales of Tsumeb metals, in concentrates or refined, included 27,400 tons copper, 51,800 tons lead, and 24,900 tons zinc. The assured ore reserve above the 3,150-foot level at yearend was 8 million tons, averaging 5.18 percent copper, 14.85 percent lead, and 4.47 percent zinc. Construction of the new copper smelter, scheduled for completion in 1962, continued on schedule.

Uganda.—Kilembe Mines, Ltd., produced 910,156 tons of ore, of which 4,781 tons was direct smelting ore. The concentrator treated 893,467 tons, and 11,908 tons was stockpiled. Blister output totaled 16,257 tons.

Union of South Africa.—O'okiep Copper Co., Ltd., produced 39,500 tons of copper from its several mines near Springbok, Cape Province, during the fiscal year ended June 30, 1960. Average grade of ore treated was 2.37 percent copper. Shaft sinking at the new Carolusberg property proceeded on schedule. Cost of copper sold during the year, including freight refining and marketing charges, rose about 1½ cents to 16¼ cents per pound. The O'okiep ore reserve was estimated at 26.3 million tons, averaging 2.17 percent copper.

OCEANIA

Australia.—Mount Isa Mines, Ltd., Queensland, subsidiary of Amercan Smelting and Refining Company, completed design work on a new 24-foot diameter shaft at Mount Isa and continued scheduled construction of additional copper refinery capacity at Townsville. Mount Isa production of ore during the year ended June 30, 1960, increased 18 percent to 3 million tons—a new record. Approximately one-half was copper ore. Copper output was 45,332 tons of blister copper and 97,000 tons of copper concentrate containing 24,000 tons of copper for treatment overseas. In addition, Mount Isa ore yielded 56,600 tons of high-silver lead bullion and 37,700 tons of zinc concentrate containing 19,600 tons of zinc.

Mt. Morgan, Ltd., copper and gold producer, during its 1960 fiscal year increased copper output to 9,085 tons from 971,000 tons of ore. Total ore production was 5,172,000 tons.

Production of copper by Mount Lyell Mining & Railway Co., Ltd., Tasmania, totaled 13,033 tons in fiscal 1960. The mines (surface and underground) produced 2,225,000 tons of ore, which assayed 0.734 percent copper. Concentrates were reduced to blister copper at the company's Queenstown smelter and refined in the electrolytic plant at Mount Lyell. Company ore reserves were estimated at 27.4 million tons, averaging 0.80 percent copper, with supporting economical quantities of silver and gold.

TECHNOLOGY

The Bureau of Mines published the results of several mining methods and costs studies relating to open-pit copper mining in southwestern United States.[5]

The relation of geology to block-cave mining at the San Manuel copper mine in Arizona was analyzed in a Bureau of Mines publication;[6] and a bulletin[7] published by the Geological Survey described the geologic features of the copper mining area in Pima County, Ariz.

An informative paper titled Calculating Ore Reserves Using a Digital Computer was presented at the Symposium of Surface Mining Practices, University of Arizona, October 1960. Digital computer programs were developed using basic data derived from a mined-out portion of the Silver Bell open-pit copper mine near Tucson, Ariz. The computer compared the various methods of ore estimation, and selected the factors responsible for nonconformity among the methods. Among other conclusions, the author inferred that triangular, polygonal, and statistical methods all should be used, and the resulting three sets of data compared to test the accuracy of reserve estimates.

Two Bureau of Mines reports published during 1960 decribed in detail aspects of acid leaching of oxidized copper ores.[8]

The segregation process was applied commercially to a mixed silicate-sulfide ore during 1960. The ore is combined with a carbon reductant, either coke or coal, and common salt and the mixture is heated in a gas-fired kiln at 700° C. Copper, gold, and silver are reduced to the metallic state and deposited on the carbon. The metal particles

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[5] Hardwick, W. R., and Stover, M. M., Open-Pit Copper Mining Methods and Practices, Copper Cities Division, Miami Copper Co., Gila County, Ariz.: Bureau of Mines Inf. Circ. 7985, 1960, 51 pp.
Hardwick, W. R., Open-Pit Copper Mining Methods at New Carnelia Branch, Phelps Dodge Corp., Pima County, Ariz.: Bureau of Mines Inf. Circ. 7938, 1960, 83 pp.

[6] Wilson, E. D., Geologic Factors Related to Block Caving at San Manuel Copper Mine, Pinal County, Ariz. 2. Progress Report, April 1956–March 1958: Bureau of Mines Rept. of Investigations 5561, 1960, 43 pp.

[7] Cooper, J. R., Some Geologic Features of the Pima Mining District, Pima County, Ariz.: Geol. Survey Bull. 1112–C, 1960, pp. 63–103.

[8] McKinney, W. A., and Rampacek, Carl, Acid Leaching of Oxidized Copper Ores by Downward Percolation: Bureau of Mines Rept. of Investigations 5629, 1960, 16 pp.
McKinney, W. A., and Rampacek, Carl, Acid Curing and Countercurrent Decantation Washing of an Oxidized Copper Ore From Pinal County, Ariz.: Bureau of Mines Rept. of Investigations 5685, 1960, 10 pp.

are subsequently concentrated by flotation. Extensive work was done on the segregation process at the Bureau of Mines, Tucson, Ariz., Metallurgy Research Laboratory in 1958 and 1959.

The Strategic-Udy process for recovering iron, copper, and zinc from copper-smelter slag was demonstrated on a pilot scale at Niagara Falls, Ontario, Canada. Webb & Knapp Strategic Corp. was developing the process for a 1,000-ton-per-day steel plant to be built at Anaconda, Mont. Production was scheduled for mid-1963. The process is based on low cost electric smelting of the Anaconda slag, the metal content of which will be reduced by coal in a kiln before electric smelting. Approximately 5,500 pounds of slag, 4,700 pounds of limestone, 440 pounds of pyrite, and 600 pounds of coal will be needed to yield 2,000 pounds of steel, 150 pounds of zinc oxide, 150 pounds of sulfur, and 25 pounds of copper contained in matte. Power consumption, contracted for approximately 2 mills per kilowatt hour, will be 3,000 kilowatt hours per ton of steel.[9]

In a paper discussing trends in the copper smelting industry delivered at the annual meeting of the AIME, Charles R. Kuzell traced the development of simplified approaches to copper smelting. The author pointed out that older methods have been replaced by a simple two-step process: (1) Unroasted sulfide concentrate mixed with recycled molten converter slag yields molten matte in the reverberatory furnace, and (2) the molten matte yields blister copper in the converter. The process of smelting cannot properly be called a reduction, rather, it can more accurately be described as a selective oxidation method.

Numerous papers were published relating to the measurement of physical properties of copper and copper alloys. Among them was a description of a method using a pycnometer to determine the density of liquid metals.[10] Measurements were made of the relations of volume to mass in the liquid and solid phases of the copper lead system that provide an explanation of the high pressure-tightness of cast copper lead alloys.

J. Porter and J. C. Levy [11] reported on an investigation to determine the precise shape and significance of the fatigue curve of copper.

Technologic advancements in copper alloying were reported.[12] A leaded nickel copper composed of 97.8 percent copper, 1 percent lead, 1 percent nickel, and 0.2 percent phosphorus was reported to have a superior combination of high-tensile and high-yield strength and high electrical conductivity. Addition of mercury to certain copper alloys was reported to inhibit algal growth and corrosion in tubing susceptible to "biofouling." Other copper alloys developed during the year included a precipitation-hardened copper containing about 0.15 percent zirconium reportedly having properties intermediate between those of pure copper and beryllium copper. Beryllium copper alloys found extended use during 1960 in plastic molds and injection nozzles. High heat conductivity, characteristic of the beryllium coppers, was the use-determining factor.

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[9] Steel, vol. 147, No. 23, Dec. 5, 1960, p. 63.
[10] Malmberg, Tore, Determination of the Specific Volume of Liquid Copper-Lead Alloys, Jour. of Inst. of Metals (London): Vol. 89, part 4, December 1960, pp. 137–139.
[11] Journal of Institute of Metals (London), The Fatigue Curves of Copper: Vol. 89, pt. 3, November 1960, pp. 23–27.
[12] Metal Progress, Progress in Copper Alloys: Vol. 78, No. 4, October 1960, pp. 143–158.

The Copper Products Development Association, a copper producers organization whose membership represented 90 percent of copper production of the world (excluding the Soviet bloc), planned extensive research on copper, its alloys, and compounds. Copper-containing catalysts as fuel additives were one of the association's projects. Others related to smog control and improved and extended electrical uses of copper.

Diatomite

By John W. Hartwell[1] and Victoria M. Roman[2]

PRODUCTION of diatomite in the United States continued to increase in 1960. Early in the year, the Federal Government authorized shipment of diatomaceous earth and its products to Hong Kong and Macao without restrictions. Originally, licenses were required for exporting minerals and mineral products to Hong Kong and Macao, to control reexport to China. The restriction on diatomite shipments was removed after it was decided that diatomite was not of strategic importance and that there was no demand for this commodity in China.

DOMESTIC PRODUCTION

California was the leading producing State, followed, in order, by Nevada, Oregon, and Washington. The domestic industry consisted of 10 firms with 13 plants engaged in both mining and processing. Three firms with six operations supplied a very large part of the production. The average value of the 1957–59 production, the latest data available for publication, was over $20 million.

Increased demand for diatomite led to the opening of a new quarry in the Lompoc area, Santa Barbara County, Calif., by the Dicalite Division of Great Lakes Carbon Corp.

The Eagle-Picher Co. developed a new open-pit mine of filter-grade diatomite at its Trinity Mountain, Nev., property.

TABLE 1.—Diatomite sold or used by producers in the United States, 3-year totals

	1942–44	1945–47	1948–50	1951–53	1954–56	1957–59
Domestic production (sales)..short tons..	524,872	640,764	722,670	908,448	1,105,279	1,349,340
Average value per ton..............	$18.85	$20.17	$25.55	$29.97	$39.21	$45.73

CONSUMPTION AND USES

Despite the low industrial activity in 1960, consumption of diatomite increased.

Filtration uses dropped from 54 percent of total consumption of diatomite in 1951 to 48 percent in 1960; filler uses decreased from 27 to 25 percent; and insulation uses declined from 12 to 5 percent. During the same period, miscellaneous uses increased from 7 to 22 percent. Miscellaneous uses were for abrasives, absorbents, carriers

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for catalysts, herbicides, pesticides, fungicides, fireproofing, glazes, enamels, flatting agents for paint, sodium and calcium silicate manufacture, and pozzolanic material.

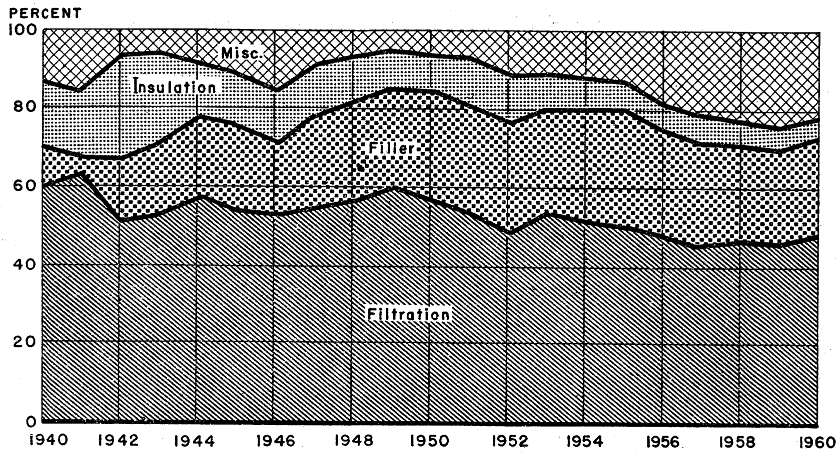

FIGURE 1.—Relative quantity of diatomite consumed in the United States for each principal class of use, 1940–60.

PRICES

Prices were generally higher in 1960 but varied with quality, quantity, method of purchase (whether in bulk or bagged), and use. The average value per ton for fillers used in industry decreased, whereas the value of all other uses increased.

The average increase in price of diatomite was about 4 percent over 1959.

TABLE 2.—Average annual value per ton of diatomite, by uses

Use	1959	1960	Use	1959	1960
Filtration	$57.59	$58.50	Fillers	$49.39	$46.39
Insulation	41.08	49.29	Miscellaneous	28.11	32.92
Abrasives	137.31	138.14	Weighted average	47.59	49.50

FOREIGN TRADE

Filter-grade diatomite continued to be exported in substantial quantities, but the amount exported is not reported separately by the U.S. Department of Commerce.

WORLD REVIEW

Australia.—During a joint regional geological survey in 1958 by the Bureau of Mineral Resources and the Geological Survey of Queensland, five deposits of diatomite were surveyed and recorded. One deposit, at Conjuboy, was mentioned in previous reports, but the other four, at Cashmere Station, Gleneagle Station, Princess Hill, and Lake Walters were new discoveries.[3]

Canada.—A large deposit of pozzolanic shale, probably diatomaceous shale because of its high (94 percent) silica content, estimated at 100 million tons was discovered and developed on Vancouver Island, British Columbia. In 1959, a $500,000 processing plant was planned.[4]

TABLE 3.—World production of diatomite by countries [1] [2]

(Short tons)

Country [1]	1951–55 (average)	1956	1957	1958	1959	1960
North America:						
Canada	48	2	120	27	5	5
Costa Rica	1,055	6,737	[3] 1,800	2,205	2,425	2,425
Guatemala	[3] 13,000	[3] 16,600	20,600	21,190	------	------
Nicaragua	------	------	------	------	1,887	2,249
United States	329,060	[4] 368,426	[5] 449,780	[5] 449,780	[5] 449,780	[5] 449,780
South America:						
Argentina	3,959	2,682	4,084	4,457	[3] 4,400	[3] 4,400
Chile	125	------	------	------	------	------
Colombia	------	------	276	220	331	[3] 330
Peru	[6] 1	34	39	117	254	1,284
Europe:						
Austria	4,000	5,490	3,823	4,086	4,497	4,431
Denmark:						
Diatomite	[3] 25,500	31,331	33,859	28,403	[3] 28,600	[3] 28,600
Moler [7]	[3] 39,900	40,080	41,074	46,486	[3] 46,300	[3] 46,300
Finland	1,626	2,535	1,874	2,315	1,520	[3] 1,650
France [8]	72,436	69,546	86,240	111,884	110,011	[3] 110,000
Germany, West [8]	52,645	67,416	71,918	115,319	111,826	[3] 108,000
Italy	10,820	9,651	29,707	49,828	57,077	[3] 55,000
Portugal [8]	1,580	1,985	1,613	1,159	2,075	[3] 1,650
Spain [8]	10,770	13,048	13,856	12,858	11,561	[3] 14,500
Sweden	1,582	1,243	1,317	1,260	[3] 1,100	[3] 1,100
United Kingdom:						
Great Britain	19,794	25,940	25,548	28,154	[3] 18,700	[3] 22,000
Northern Ireland	7,925	6,577	6,842	7,206	5,227	[3] 5,500
Yugoslavia	[9] 3,770	[3] 4,400	[3] 4,400	[3] 4,400	[3] 5,000	[3] 5,000
Asia: Korea, Republic of	1,003	3,912	1,472	518	1,865	2,646
Africa:						
Algeria	28,466	29,201	19,605	28,629	31,722	[3] 25,300
Kenya	4,645	5,418	4,737	3,892	4,041	3,748
Mozambique	[9] 11	------	------	61	------	------
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	------	------	------	------	148	164
Union of South Africa	660	635	606	359	397	[3] 400
United Arab Republic (Egypt Region)	915	320	708	397	327	[3] 330
Oceania:						
Australia	6,723	6,484	6,968	4,749	5,700	[3] 5,500
New Zealand	258	152	3,537	6,336	8,152	[3] 8,300
World total (estimate) [1] [2]	690,000	760,000	880,000	980,000	960,000	960,000

[1] Diatomaceous earth is believed to be produced in Brazil, Hungary, Japan, Rumania, and U.S.S.R., but complete data are not available; estimates are included in total.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Average annual production, 1954–56.
[5] Average annual production, 1957–59.
[6] Average, 1953–55.
[7] A clay-contaminated diatomite used principally for lightweight building brick.
[8] Includes Tripoli.
[9] Average, 1952–55.

Compiled by Helen L. Hunt, Division of Foreign Activities.

[3] Bureau of Mines, Mineral Trade Notes: Vol. 50, January 1960, pp. 14–15.
[4] Rock Products, Canadians Develop Big Vancouver Pozzolan Deposit: Vol. 62, July 1959, p. 47.

Colombia.—Three diatomite deposits were discovered in 1958. One deposit, near Valle de Cauca, was estimated at 65 million cubic yards; another, in the Bagota Plateau, contained over 1 million cubic yards; the third, near Tunja, Boyaca, contained an unestimated quantity. A small plant was established in Bogotá to process the diatomite.[5]

Egypt.—An estimated 297 short tons of diatomite was produced in 1959, compared with 360 tons in 1958. Proposals were made under a second 5-year plan to increase production within 2 years.[6]

Nicaragua.—Production of diatomite in 1960 was nearly 2,250 short tons, valued at US$12,850, a very slight increase in production over 1959.[7]

Union of South Africa.—Diatomite production in 1959 was 397 short tons, compared with 359 tons in 1958. Most of the output was domestically consumed. The principal producer was Fincham's Base Mineral Mines (Pty.) Ltd., Postmasburg, Cape Province.[8]

United Kingdom.—Diatomite, mined in the partly drained Lock na Cuilc at Kirkibost on the Island of Bernera, Scotland, was used in automobile polish.[9]

TECHNOLOGY

A book on the geology of industrial rocks and minerals contained information on diatomite. Data included description and location of occurrences, chemical and physical properties, production, uses, and 27 references.[10] A high-temperature industrial insulation material made with diatomite, asbestos, and lime was claimed to have a wide use in the petroleum, chemical, and marine fields.[11]

The U.S. Corps of Engineers tested the effectiveness of diatomite as a filter medium to reduce the radioactivity of contaminated drinking water. Radioactivity of 6,000 micro-microcurie units per liter was lowered to 5,000 units by chemical coagulation and diatomite filtration.[12]

A method of recovering diatomite from spent filter cake resulting from filtration of raw sugar liquor was patented. The organic-bearing diatomite is fired with a deficiency of air at 700° to 1,100° F. to carbonize the organic material then with an excess of air at 1,200° to 1,800° F. to oxidize the carbonaceous matter completely.[13]

A method was patented for using diatomite in oil-well cements to offset the adverse effects of sodium chloride when drilling through salt formations.[14]

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[5] Bureau of Mines, Mineral Trade Notes: Vol. 50, January 1960, p. 15.
[6] U.S. Embassy, Cairo, Egypt, State Department Dispatch 525, Jan. 11, 1961, encl. 1, pp. 1–2.
[7] U.S. Embassy, Managua, Nicaragua, State Department Dispatch 354, Mar. 8, 1961, encl. 1, p. 1.
[8] Bureau of Mines, Mineral Trade Notes: Vol. 51, No. 6, December 1960, p. 26.
[9] Chemical Trade Journal and Chemical Engineer (London), Items of Interest,, Scottish Diatomite: Vol. 146, No. 3800, Apr. 1, 1960, p. 744.
[10] Bates, R. L., Geology of Industrial Rocks and Minerals: Harper and Brothers, New York, N.Y., 1960. pp. 360–370.
[11] Rock Products, Insulation Product Uses Rock Products: Vol. 63, January 1960, p. 58.
[12] Engineering News-Record, Three Ways to Reduce Radioactivity in Water: Vol. 165, No. 25, Dec. 22, 1960, p. 118.
[13] Frankenhoff, C. A., Recovery of Diatomaceous Earth: U.S. Patent 2,946,755, July 26, 1960.
[14] Shell, F. J. (assigned to Phillips Petroleum Co.). Cement Compositions and Process for Cementary Wells: U.S. Patent 2,961.044, Nov. 22, 1960.

A patent was granted on a method of making building construction material in sheet form from portland cement, diatomite, and asbestos fiber.[15]

A patent was granted for making acoustic fireproof ceramic tile from a mixture of diatomite, clay, carbonaceous material, and glazing frit.[16]

A method of producing an insecticide composition absorbed onto diatomite or a similar material was patented.[17]

Several other U.S. patents granted during the year mentioned diatomite as a suitable material in processes or products. Included were patents on the beneficiation of ores,[18] filter aid,[19] cement composition,[20] and an insecticide carrier.[21]

A British patent was granted for a filter containing a mixture of diatomite, cellulose, and asbestos fibers. The filter had a high capacity for retaining solids.[22] A process for making artificial marble of cement, diatomite, marble powder, borax, alum, and metallic oxide pigments was patented in Italy.[23] A catalyst carrier containing a mixture of clay and diatomite was patented in Japan. This catalyst was suitable for liquid-phase reactions at high temperatures and pressures.[24] A paint filler patented in Canada, consisting of diatomite and wet-ground mica, could be used in a paint suitable for application to asphalt surfaces.[25] Diatomite and cellulose fiber, used for making a sheet or mat for filtering beer, was patented in Australia.[26] Porous ceramic ware containing a mixture of diatomite and clayey material was patented in West Germany.[27] Other foreign patents issued during the year, most of which were similar to patents granted previously in the United States, consisted of processes or products containing diatomite and included: An additive in a polyethylene composition,[28]

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[15] Seipt, W. R. (assigned to Keasbey & Mattison Co., Ambler, Pa.), Composite Building Unit: U.S. Patent 2,946,158, July 26, 1960.

[16] Heine, H. W., Manufacture of Acoustic Fireproof Tiles: U.S. Patent 2,934,789, May 3, 1960.

[17] Trademan, L., Malina, M. A., and Wilks, L. P. (assigned to Velsicol Chemical Corp., Chicago, Ill.). Insecticide Formulations and Methods of Making Same: U.S. Patent 2,927,882, Mar. 8, 1960.

[18] Snow, R. E. (assigned to International Minerals & Chemical Corp., Chicago, Ill.), Process for Beneficiating Ores: U.S. Patent 2,961,092, Nov. 22, 1960.

[19] Lappla, P. W. (assigned to Great Lakes Carbon Corp., New York, N.Y.), Mineral Filter Aid Composition: U S. Patent 2,956,016, Oct. 11, 1960.

Stedman, R. E. (assigned to Imperial Chemical Industries, Ltd., London), Process for the Recovery of Uranium Values: U.S. Patent 2,926,992, March 1, 1960.

Frohmader, S. H. (assigned to Research Products Corp., Madison, Wis.), Mineral Coated Liquid-Gas Contact Pad: U.S. Patent 2,955,064, Oct. 4, 1960.

[20] Muttart, L. E. (assigned to Owens-Corning Fiberglas Corp., Feeding Method and Apparatus for the Extrusion of Shaped Bodies of Cementitious Materials: U.S. Patent 2,953,834, Sept. 27, 1960.

[21] Albert, C. G. (assigned to Minerals & Chemicals Corp. of America, Menlo Park, N.J.). Toxicant Carrier: U.S. Patent 2,941,923, June 21, 1960.

[22] Hobson, A. G., and Marmoy, F. B. (assigned to British Filters, Ltd.): British Patent 820,286, Sept. 16, 1959.

[23] Violi, F., Artificial Marble Blocks: Italian Patent 555,329, Jan. 23, 1957; Chem. Abs., vol. 54, No. 3, Feb. 10, 1960, col. 2692g.

[24] Tamate, E., Araki, Y., and Sagara, S. (assigned to Nitto Chemical Industry Co., Ltd., and Nitto Physico-Chemical Research Institute): Japanese Patent 4467, May 30, 1959.

[25] Ramsay, K. A. (assigned to Building Products, Ltd.): Canadian Patent 598,949, May 31, 1960.

[26] Hobson, A. G., and Marmoy, F. B. (assigned to British Filters, Ltd.): Australian Patent 221,222, Apr. 16, 1959.

[27] Cramer, F. W., and Cramer, F. (assigned to Dr. C. Otto and Co.): West German Patent 965,937, July 4, 1957; Chem. Abs., vol. 54, No. 8, Apr. 25, 1960, col. 8022i.

[28] British Patent 851,975, Oct. 19, 1960.

an abrasive,[29] cementitious insulating material,[30] absorbent material,[31] insulation blocks,[32] filter material,[33] cellular pozzolan,[34] and a carrier for pesticides.[35]

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[29] British Patent 838,697, June 22, 1960.
[30] Canadian Patent 606,428, Oct. 4, 1960.
[31] Canadian Patent 601,221, July 5, 1960.
[32] Canadian Patent 598,880, May 31, 1960.
[33] Canadian Patent 596,399–400, Apr. 19, 1960.
[34] Canadian Patent 595,081, Mar. 29, 1960.
[35] Canadian Patent 594,818, Mar. 22, 1960.

Feldspar, Nepheline Syenite, and Aplite

By Taber de Polo[1] and Gertrude E. Tucker[2]

DOMESTIC production of crude feldspar and flotation concentrate declined 8 percent in 1960 because of decreased demand from the glass and pottery industries and increased use of competitive commodities. Flat-glass shipments were 15 percent below 1959 totals; however, there was increased demand for glass containers and new construction uses such as glass curtain walls, cellular glass, and glass block. Excess production capacity and continued competition from substitutes kept the price at a depressed level.

Some glass-grade feldspar sold for as low as $8.50 per short ton, f.o.b. producers' plants in the North Carolina area.

TABLE 1.—Salient feldspar statistics

	1951–55 (average)	1956	1957	1958	1959	1960
United States:						
Crude:						
Sold or used by producers[1] long tons	519,696	560,074	498,057	469,738	548,390	502,380
Value thousands	$4,307	$5,829	$4,935	$4,278	[2] $5,372	$4,779
Average per long ton	$8.29	$10.41	$9.91	$9.11	[2] $9.79	$9.51
Imports for consumption long tons	5,758	258	72	73	45	44
Value thousands	$55	$9	$7	$5	$5	$5
Average per long ton	$9.47	$36.09	$92.03	$63.82	$100.49	$106.95
Consumption, apparent long tons	525,454	560,332	498,129	469,811	548,435	502,424
Ground:						
Sold by merchant mills[3] short tons	567,051	608,661	503,170	469,602	560,105	528,348
Value thousands	$7,716	$8,957	$7,062	$6,540	[2] $7,659	$7,079
Average per short ton	$13.61	$14.72	$14.04	$13.93	[2] $13.67	$13.40
World: Production long tons						

[1] See table 2 for distribution of feldspar by derivation.
[2] Revised figure.
[3] See table 4 for distribution of feldspar by derivation.

DOMESTIC PRODUCTION

Crude Feldspar.—North Carolina continued as the leading producer, accounting for over 50 percent of total production, and California ranked second. The quantity of feldspar produced by flotation in Georgia and North Carolina in 1960 constituted almost 87 percent of

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[2] Statistical assistant, Division of Minerals.

the feldspar from the area. Countrywide, flotation accounted for 55 percent of the total feldspar output.

Crude feldspar figures include hand-cobbed feldspar, flotation concentrate, and the feldspar content of feldspar-silica mixtures.

Spar-Mica Corp., Ltd., the parent corporation of Golding-Keene Co., went out of business during the year, but Golding-Keene Co. continued under new ownership and produced a high-grade potash feldspar product in New Hampshire.

International Minerals & Chemical Corp. operated the first full year since rebuilding its plant at Custer, S. Dak., with one-third increased capacity.

The Feldspar Corp., which produced a third of the Nation's feldspar, completed a new modern flotation plant with a 7,000-ton-a-month capacity in Middletown, Conn., raising the number of plants the company operated to five. This plant was ready to ship glass- and pottery-grade feldspar, and mica and silica as byproducts, by the end of the year. The percentage of feldspar produced by flotation, which has shown an upward trend for 15 years, will be further increased by output from this plant.

Officials of the Keystone Mill Division of Northwest Defense Materials, Inc., announced that potash feldspar would be produced as a byproduct of their beryllium flotation operation.

TABLE 2.—Crude feldspar sold or used by producers in the United States

Year	Derivation of feldspar[1]							
	Hand-sorted		Flotation concentrate		Feldspar-silica mixtures[2]		Total	
	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)
1951-55 (average)	(3)	(3)	430,053	$3,680	[4] 89,643	[4] $627	519,696	$4,307
1956	234,993	$1,729	250,307	3,441	74,774	659	560,074	5,829
1957	227,826	1,958	208,984	2,449	61,247	528	498,057	4,935
1958	198,460	1,346	218,178	2,450	53,100	482	469,738	4,278
1959	169,473	1,508	293,356	[5] 3,114	85,561	[5] 750	548,390	[5] 5,372
1960	147,912	1,123	278,503	2,881	75,965	775	502,380	4,779

[1] Partly estimated, 1952-60.
[2] Includes feldspar content only.
[3] Included with flotation concentrate.
[4] Average for 1952-55 data.
[5] Revised figure.

Ground Feldspar.—Fourteen States reported production of ground feldspar from 24 mills. Ground feldspar sold by merchant mills in the United States decreased 6 percent in quantity and 8 percent in value. North Carolina, California, South Dakota, Georgia, and Colorado were the leading producers, in that order. Four Southeastern States (Georgia, North Carolinia, Tennessee, and Virginia) produced 64 percent of the entire tonnage of ground feldspar. Ground feldspar figures include flotation concentrate and the feldspar content of feldspar-silica mixtures. Statistical data have been broken down to show the origin of the feldspar (hand-cobbed, flotation concentrate, and feldspathic sands and rocks).

TABLE 3.—Ground feldspar sold by merchant mills[1] in the United States

Year	Active mills	Domestic feldspar		Canadian feldspar		Total	
		Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1951-55 (average)	24	560,291	$7,551	[2] 6,760	[2] $165	567,051	$7,716
1956	25	608,661	8,957			608,661	8,957
1957	23	503,170	7,062			503,170	7,062
1958	24	469,602	6,540	(3)	(3)	469,602	6,540
1959	26	560,105	[4] 7,659	(3)	(3)	560,105	[4] 7,659
1960	24	528,348	7,079	(3)	(3)	528,348	7,079

[1] Exclude potters and others who grind for consumption in their own plants.
[2] Average for 1951-54 data.
[3] Included with domestic feldspar.
[4] Revised figure.

CONSUMPTION AND USES

Crude Feldspar.—Virtually all crude feldspar was ground by the producing company or sold to merchant grinders. Some pottery, enamel, and soap manufacturers purchased crude feldspar for all or part of their requirements and ground it to company specifications in their own mills.

TABLE 4.—Ground feldspar sold by merchant mills in the United States, by derivation[1] and uses

(Short tons)

Year	Hand-sorted					Flotation concentrate				
	Glass	Pottery	Enamel	Other	Total	Glass	Pottery	Enamel	Other	Total
1951-55 (average)	(2)	(2)	(2)	(2)	(2)	231,893	196,610	20,395	17,752	466,650
1956	65,357	136,144	24,732	23,356	249,589	183,267	62,451		29,607	275,325
1957	54,283	109,910	26,052	16,742	206,987	166,933	58,131		6,170	231,234
1958	48,376	93,805	21,734	13,519	177,434	171,002	53,205		8,489	232,696
1959	40,365	88,233	36,929	24,662	190,189	219,139	72,496		10,558	302,193
1960	31,171	59,546	21,418	32,267	144,402	206,784	87,133	1,315	12,870	308,102
	Feldspar-silica mixtures					**Grand total**				
	Glass	Pottery	Enamel	Other	Total	Glass	Pottery	Enamel	Other[4]	Total
1951-55 (average)[3]	97,988	1,182		1,231	100,401	329,881	197,792	20,395	18,983	567,051
1956	74,900			8,847	83,747	323,524	198,595	24,732	61,810	608,661
1957	58,643			6,306	64,949	279,859	168,041	26,052	29,218	503,170
1958	49,003	4,767		5,702	59,472	268,381	151,777	21,734	27,710	469,602
1959	55,809	5,323		6,591	67,723	315,313	166,052	36,929	41,811	560,105
1960	56,727	5,872	2,416	10,829	75,844	294,682	152,551	25,149	55,966	528,348

[1] Partly estimated, 1952-60.
[2] Included with flotation concentrate.
[3] Includes data for 1952-55 only, for feldspar content of feldspathic sands.
[4] Includes soaps, abrasives, and other miscellaneous uses.

Ground Feldspar.—Most feldspar consumers bought material already ground, sized, and ready for use in their manufactured products. In 1960 the glass, pottery, and enamel industries consumed 89 percent of the ground feldspar sold by merchant mills. Other uses, including soaps and abrasives, other ceramic uses, and poultry grit, increased substantially. The major consuming States, California, Ohio, Pennsylvania, and Illinois, in that order, accounted for over 50 percent of the ground feldspar consumed in the United States.

TABLE 5.—Ground feldspar shipped from merchant mills in the United States

(Short tons)

Destination	1956	1957	1958	1959	1960
California	120,941	75,012	77,407	87,332	91,452
Illinois	73,067	56,853	48,385	57,952	54,089
Indiana	(1)	(1)	16,353	34,212	28,426
Maryland	18,835	15,930	14,000	17,572	16,017
Massachusetts	5,647	4,746	3,738	4,229	5,101
New Jersey	41,144	29,358	24,306	28,577	25,989
New York	23,169	21,849	20,883	16,463	19,701
Ohio	79,757	61,834	56,367	71,293	67,324
Pennsylvania	69,506	64,302	60,322	56,332	60,907
Texas	19,235	20,934	(1)	22,057	21,440
West Virginia	(1)	44,893	(1)	51,965	36,216
Wisconsin	10,813	9,822	8,664	10,823	9,677
Other destinations [2]	[3] 146,547	[3] 97,637	139,177	[3] 101,298	92,009
Total	608,661	503,170	469,602	560,105	528,348

[1] Included with "Other destinations."
[2] Includes Alabama (1960), Arkansas, Colorado, Connecticut (1956 and 1958-60), Florida (1960), Georgia (1960), Kansas (1958), Kentucky, Louisiana, Maine (1957-60), Michigan, Minnesota, Mississippi, Missouri, New Hampshire (1956), North Dakota (1956), Oklahoma, Rhode Island, Tennessee, Utah (1960), Vermont (1960), Washington (1956-57 and 1959-60), shipments that cannot be separated by States, and shipments to States indicated by footnote 1. Also includes exports to Canada, Cuba (1959-60), England (1956-59), Mexico, Panama (1957-60), Puerto Rico (1956-59), Venezuela (1956-57 and 1959-60), West Germany (1957-58), and small quantities to other countries.
[3] Revised figure.

PRICES

Prices of crude feldspar do not appear in the trade publications. The average value of crude feldspar was $9.51 per long ton, compared with $9.79 in 1959.

The average selling price of ground feldspar was $13.40 per short ton, a decrease of 2 percent from 1959.

The following producing States had the highest selling price per short ton: Illinois, $24.87; New Hampshire, $20.79; Arizona, $20.75; Georgia, $20.67; Tennessee, $20.16; New Jersey, $19.93; and Connecticut, $19.84.

The highest average value by uses was reported for soaps and abrasives at $24.32 per short ton. Of the larger uses, enamel had the highest average value, $18.09.

Quotations on ground feldspar in E&MJ Metal and Mineral Markets for December 1960 were as follows: North Carolina, bulk carlots, 325-mesh, $20.50–$23.50 per short ton; 200-mesh, $17–$20.50 per short ton; 40-mesh, glass grade, $13.50; and 20-mesh semigranular, $9.

FOREIGN TRADE[3]

According to reports from grinders, ground-feldspar exports increased 7 percent. Principal countries of destination were Canada,

[3] Figures on imports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

Mexico, and Venezuela. Small quantities were shipped to other destinations.

Cornwall Stone.—Imports for consumption of ground cornwall stone (from England and Canada) decreased from 35 long tons in 1959 to 20 in 1960.

TABLE 6.—U.S. imports for consumption (all from Canada) of feldspar

Year	Crude		Ground		Year	Crude		Ground	
	Long tons	Value	Long tons	Value		Long tons	Value	Long tons	Value
1951–55 (average)	5,758	$54,557	450	$11,390	1958	73	$4,659	6,584	$100,564
1956	258	9,311	1,374	33,589	1959	45	4,522	5,160	81,849
1957	72	6,626	3,969	66,548	1960	44	4,706	6,980	109,547

Source: Bureau of the Census.

WORLD REVIEW

Estimated free world production increased 5 percent, and the United States furnished 40 percent of the output. Distribution of production by countries remained virtually the same as in 1959.

TECHNOLOGY

A report was published presenting the results of a study of the relationships of sodium, potassium, and calcium feldspars used in ceramics to the viscosities of their glasses and the properties of fired products.[4]

Determinations of compositional variations were made on heated alkali feldspars by means of X-ray study of the spacings to determine if there is a genetic relationship between magnetic crystallization and ore concentration.[5]

The technical and commercial implications of experiments on replacing bone with blends of feldspars and other materials to produce a white translucent dinnerware resistant to breaking and chipping were discussed. Manufacturing methods were briefly described.[6]

Results were published on experiments made on decomposition of feldspars.[7]

A study was made on the mechanical properties of feldspar bonds used in abrasive wheels. Shrinkage during heating and progressive vitrification were continually observed.[8]

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[4] Sundius, Nils [Feldspar and Its Influence on the Reactions in Ceramics During Burning]: Acta Polytechnica Scandinavica (Stockholm), Chem. Met. Ser., No. 8, 1960, 29 pp.; Ceram. Abs., vol. 43, No. 8, August 1960, p. 200f.

[5] Kuellmer, F. J., Compositional Variation of Alkali Feldspars in Some Intrusive Rocks Near Globe-Miami, Arizona: Econ. Geol., vol. 55, No. 3, May 1960, pp. 557–562.

[6] Pottery Gazette, English Translucent China Introduced: Vol. 85, No. 991, 1960, pp. 184–185; No. 992, pp. 264–268; Ceram. Abs., vol. 43, No. 7, July 1960, p. 162f.

[7] Erametra, Olavi [Decomposition of Feldspar]: Acta Polytech. Scand., Chem. Met. Ser., No. 3, 1959, pp. 3–17; Ceram. Abs., vol. 43, No. 8, August 1960, p. 200c.

[8] Ito, Yukito, and Kato, Shigeru [Vitrified Abrasive Wheels, Melting and Softening State of Bonds]: Nagoya Kogyo Gyutsu Shikensho Hokoku, vol. 2, No. 11, 1953, pp. 23–31; Ceram. Abs., vol. 39, No. 1, January 1960, p. 27f.

TABLE 7.—World production of feldspar by countries [1] [2]

(Long tons)

Country [1]	1951-55 (average)	1956	1957	1958	1959	1960
North America:						
Canada (shipments)	20,805	16,208	18,259	18,203	16,030	9,633
United States (sold or used)	519,696	560,074	498,057	469,738	548,390	502,380
Total	540,501	576,282	516,316	487,941	564,420	512,013
South America:						
Argentina	8,600	7,999	4,271	3,621	[3] 3,900	[3] 3,900
Brazil	[3] 12,800	(4)	(4)	(4)	(4)	(4)
Chile	1,192	826	369	[3] 400	[3] 400	[3] 400
Colombia	----------	----------	5,905	3,936	14,763	14,763
Peru	26	----------	----------	----------	----------	242
Uruguay	681	----------	168	267	352	713
Total [3]	23,300	29,000	35,000	38,000	54,000	64,000
Europe:						
Austria	2,442	2,677	2,612	2,613	3,445	4,573
Finland	10,295	8,799	9,055	13,188	8,191	9,158
France	62,945	75,966	65,224	81,104	78,737	[3] 78,700
Germany, West	116,068	164,181	167,278	187,504	186,011	237,648
Italy	30,964	50,479	63,970	55,160	59,940	78,977
Norway	29,014	52,437	55,423	41,618	[3] 54,000	64,958
Portugal	360	912	1,161	544	837	[3] 885
Spain	8,952	3,524	4,472	5,199	10,722	[3] 9,800
Sweden	56,736	52,500	52,968	42,785	[3] 44,000	[3] 44,000
Yugoslavia	----------	5,476	9,608	12,466	19,309	28,050
Total [1] [3]	325,000	420,000	440,000	450,000	470,000	565,000
Asia:						
Hong Kong	[5] 120	60	1,156	1,653	1,716	2,472
India	4,199	3,909	7,872	8,432	9,740	10,287
Japan [6]	27,764	48,665	43,417	44,507	60,196	[3] 59,000
Philippines	----------	----------	49	74	1,684	3,896
Viet-Nam, South	[7] 1,772	----------	----------	----------	----------	----------
Total	33,855	52,634	52,494	54,666	73,336	[3] 75,655
Africa:						
Eritrea	5	12	394	413	[3] 400	[3] 400
Kenya	----------	----------	120	26	----------	----------
Malagasy Republic (Madagascar)	5	203	----------	----------		
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	226	----------	----------	447	----------	----------
Union of South Africa	5,215	9,730	11,381	7,708	10,447	15,600
Total	5,451	9,945	11,895	8,594	10,847	16,000
Oceania: Australia [8]	14,506	18,629	8,820	7,016	6,643	[3] 7,900
World total (estimate) [1] [2]	945,000	1,110,000	1,060,000	1,050,000	1,180,000	1,240,000

[1] Feldspar is produced in China, Czechoslovakia, Rumania, and U.S.S.R., but data are not available; no estimates included in total except for Czechoslovakia.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Data not available; estimate by senior author of chapter included in total.
[5] Average for year only, as 1955 was first year of commercial production.
[6] In addition, the following quantities of aplite and other feldspathic rock were produced: 1951-55 (average), 68,326 tons; 1956, 63,723 tons; 1957, 82,670 tons; 1958, 76,856 tons; 1959, 88,451 tons; 1960, 93,251 tons.
[7] Average for 1954-55.
[8] Includes some china stone.

Compiled by Liela S. Price, Division of Foreign Activities.

A method was developed for a quick analysis of quartz-feldspar mixtures by using a calibrated curve for comparison.[9]

Experiments were conducted on differential staining of feldspars as a means of analyses. The orthoclase feldspars are stained yellow by cobaltinitrite, and the plagioclases are stained red by barium rhodizonate, thus allowing for rapid and accurate modal analyses of granitic rocks.[10]

Studies were made by X-ray quantitative analysis on the vitreous phase of porcelain to determine the effect of dissolved quartz on the mechanical properties of porcelain.[11]

NEPHELINE SYENITE

Domestic Consumption.—Domestic consumption in the glass and ceramic industries of imported nepheline syenite from Canada increased 6 percent in 1960, but the total value decreased slightly. Nepheline syenite unsuitable for the glass and ceramic industries was mined in Arkansas for use as roofing granules, and production statistics are included in the Stone chapter.

TABLE 8.—U.S. imports for consumption of nepheline syenite

Year	Crude		Ground		Year	Crude		Ground	
	Short tons	Value	Short tons	Value		Short tons	Value	Short tons	Value
1951-55 (average)	37	$157	86,202	[1] $1,304,150	1958	160	$2,696	164,814	$2,253,062
1956			140,306	[1] 2,136,092	1959	808	18,652	184,464	2,403,079
1957			166,989	[1] 2,505,248	1960	900	18,585	195,166	2,370,040

[1] Data known to be not comparable with other years.

Source: Bureau of the Census.

Prices [12].—Prices of processed nepheline syenite per short ton were quoted as follows, f.o.b. works, bags, carlots: Glass grade (30-mesh), $15; pottery grade (200- to 325-mesh), $21.50 to $28; and byproduct grade (100-mesh), $10 (add $3 per short ton to bulk quotations for bags and bagging).

Foreign Trade.—Imports of ground nepheline syenite from Canada, mostly for use in the glass industry, increased 6 percent in quantity and decreased 1 percent in value. About 900 short tons of crude nepheline syenite was imported from Canada.

World Review.—Canada, with a substantial increase in production, continued to be the major producer of nepheline syenite for the ceramic industry.

[9] Oehme, Friedrich [Analysis of Mixtures of Quartz and Feldspar by an Immersion Method of Determining the Dielectric Constant]: Keram. Z., vol. 11, No. 4, 1959, pp. 180–182; Ceram. Abs., vol. 39, No. 3, March 1960, p. 63b.

[10] Bailey, E. H., and Stevens, R. E., Selective Staining of K-Feldspar and Plagioclase on Rock Slabs and Thin Sections: Am. Mineral., vol. 45, Nos. 9–10, September-October 1960, pp. 1020–1025.

[11] Petrova, V. Z., Avgustinki, A. I., Konovalov, P. F., and Konovalova, Ye. P. [Dissolution of Quartz in Feldspar Melts]: Zhurnal Prikladnoy Khimu (U.S.S.R.), vol. 32, No. 10, 1959, pp. 2351–2354.

[12] Reeves, J. E., Nepheline Syenite: Canada Dept. Mines and Tech. Surveys, Ottawa, No. 44, April 1959, p. 5.

American Nepheline Ltd., Toronto, incorporated a new subsidiary under the name of American Nepheline Corp., Columbia, Ohio, to provide a U.S. headquarters for ceramic research and technical services.

Christiana Spigerverk was scheduled to start mining nepheline syenite near Hammerfest in northern Norway early in 1961. Capacity was to be 45,000 tons annually for the glass and ceramic industries.[13]

Belgium and Luxembourg exported small quantities of nepheline syenite.

Deposits occur in Finland, India, and Korea, but no production had been reported. The U.S.S.R is the only country other than Canada where a ceramic raw material containing nepheline was produced abundantly. Part of this product was used as a source of alumina.

TECHNOLOGY

Two large nepheline syenite deposits were discovered in the interior of Kazakhstan, U.S.S.R. The output was expected to be used in the local aluminum industry,[14] eliminating expensive haulage of raw material.

In the U.S.S.R. it was reported that nepheline mixed with limestone increased cement production by 25 percent.[15]

In Armenia the Scientific Research Institute of Chemistry planned to utilize the nepheline syenites in the Tezhsarskiy deposit for production of alumina, portland cement, potash, and secondary products.[16]

APLITE

Production of crude aplite, primarily used for making amber glass, decreased almost one-third in 1960. The glass industry consumed about 70 percent of the ground aplite sold.

Aplite was mined only in Virginia by: Riverton Lime & Stone Co. Division, Chadbourn Gotham, Inc., in Amherst County; Consolidated Feldspar Department, International Minerals & Chemical Corp., Nelson County; Buffalo Mines, Inc., Piney River, Va.; and Metal & Thermit Corp., Hanover County, Va.

The first shipment of aplite by Metal & Thermit Corp., a new producer, was made in August 1960. All of the output was used for testing.

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[13] Mining World, What's Going on in Mining: Vol. 23, No. 1, January 1961, p. 63.
[14] Engineering and Mining Journal, vol. 161, No. 5, May 1960, p. 165.
[15] Comte, J. M. A., Russia Gets World's Largest Cement Kiln; Rock Products, vol. 62, No. 5, June 1959, pp. 128–131.
[16] Ekonomicheskaya Gazeta (Moscow), Scientific Plans Utilization of American Nepheline Syenites, July 12, 1960.

Ferroalloys

By H. Austin Tucker,[1] Gertrude C. Schwab,[2] and Hilda V. Heidrich [2]

THE DOMESTIC output of ferroalloys in 1960, increased 10 percent, but the quantity and value of shipments decreased 3 and 10 percent, respectively. Significantly, producers' stocks increased 39 percent. The ferroalloy industry produced 2.1 million tons of products in 1960 and shipped 1.9 million tons.

DOMESTIC PRODUCTION

In 1960, 50 producers in 18 States made 2.1 million tons of ferroalloy in 59 plants, of which 42 were electric-furnace, 10 blast-furnace, and 7 aluminothermic. Ohio was the leading State with 619,085 short tons, and Pennsylvania was next with 519,900 tons. Producers also reported from Alabama, Florida, Idaho, Illinois, Iowa, Kentucky, Montana, New Jersey, New York, Oregon, South Carolina, Tennessee, Texas, Virginia, Washington, and West Virginia.

Vanadium Corporation of America closed its oldest plant at Niagara Falls, N.Y., in June.

Manganese Alloys.—The 10 producers of ferromanganese made 34 percent more alloy and shipped 10 percent more than in 1959. This commodity was produced in 12 States in 5 blast-furnace and 15 electric-furnace plants. The average unit value of the electric-furnace product dropped from 15.4 cents per pound of contained manganese to 11.3 cents. Tennessee Products & Chemical Corp. closed its blast furnace at Rockwood, Tenn., on January 1, 1960. Pittsburgh Coke & Chemical Co., Neville Island (Pittsburgh), Pa., a 1959 producer, did not produce ferromanganese in 1960, but did make spiegeleisen.

Silicomanganese was made by 7 firms in 15 electric-furnace plants in 9 States. Production and shipments decreased slightly, with the average unit value down from 19.9 cents per pound of contained weight of manganese to 17.6 cents.

Silicon Alloys.—Eleven companies continued to produce silicon alloys in 26 electric-furnace plants in 11 States. Output increased 9 percent, and shipments, 1 percent.

Silvery Iron.—Five companies continued to manufacture silvery iron in three blast-furnace plants and three electric-furnace plants in four States. Production decreased 1 percent, and shipments decreased

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

23 percent from the 1959 figures. The unit value remained nearly the same.

TABLE 1.—Ferroalloys produced and shipped from furnaces in the United States

Alloy	1959				1960			
	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:								
Blast furnace	402,698	76.90	454,319	$107,863	570,817	77.47	534,135	$122,162
Electric furnace	226,609	78.05	255,677	61,497	272,001	78.17	247,874	43,700
Total	629,307	77.32	709,996	169,360	842,818	77.69	782,009	165,862
Silicomanganese	106,340	65.42	107,396	27,930	101,330	65.49	104,380	23,983
Ferrosilicon	336,702	54.94	338,913	63,298	367,371	55.33	342,210	63,610
Silvery iron:								
Blast furnace	183,682	8.79	205,477	15,314	221,236	8.65	166,711	12,365
Electric furnace	161,450	15.77	157,941	14,566	120,855	15.75	113,011	10,261
Total	345,132	12.05	363,418	29,880	342,091	11.16	279,722	22,626
Chromium alloys:								
Ferrochromium	[1] 249,054	66.30	246,368	109,843	[1] 193,747	65.26	193,807	78,851
Other chromium alloys	[2] 69,210	42.13	67,331	24,118	[2] 86,477	41.96	79,036	26,736
Total	318,264	61.04	313,699	133,961	280,224	58.07	272,843	105,587
Ferrotitanium	4,782	32.02	4,655	3,812	3,268	28.95	3,366	2,755
Ferrophosphorus	85,198	24.35	64,810	2,675	91,388	24.00	68,868	3,048
Ferrocolumbium and ferrotantalum-columbium	607	58.48	564	2,247	730	58.08	691	2,700
Ferronickel	22,631	44.50	22,979	} 48,815	24,364	44.50	24,359	} 44,056
Other	[3] 75,401	27.71	68,708		[3] 64,886	28.29	60,175	
Grand total	1,924,364	53.55	1,995,138	481,978	2,118,470	55.60	1,938,623	434,227

[1] Includes low- and high-carbon ferrochromium and chromium briquets.
[2] Includes ferrochrome-silicon, exothermic chromium additives, and other chromium alloys.
[3] Includes alsifer, ferroboron, ferromolybdenum, ferrotungsten, ferrovanadium, simanal, spiegeleisen, zirconium-ferrosilicon, ferrosilicon-zirconium, aluminum-silicon alloy, and other miscellaneous ferroalloys.

Chromium Alloys.—Eleven companies continued to make ferrochromium in 19 electric-furnace plants in 10 States. Production and shipments decreased 12 and 13 percent, respectively. The average unit value of contained chromium declined from 35.2 cents to 33 cents per pound.

Molybdenum Alloys.—Three companies continued to produce ferromolybdenum in three plants, mostly by the aluminothermic method, although in one plant the electric-furnace method was also used. The average unit value increased from $1.53 to $1.82 per pound of contained molybdenum. Reading Chemicals continued to make molybdenum-aluminum with 54 percent contained molybdenum.

Titanium Alloys.—Five companies produced ferrotitanium. One of these, Shieldalloy Corp., reported no output in 1959, but had produced in 1958. These companies made ferrotitanium in five electric-furnace plants and two aluminothermic plants in four States.

Ferrophosphorus.—Eight companies produced ferrophosphorus as a byproduct of the electric-furnace process for smelting phosphate rock to make elemental phosphorous. The average value increased from $41.27 to $44.26 per ton. Central Farmers Fertilizer Co., Georgetown, Idaho, was a new producer in 1960. Westvaco Chemical Division, Food Machinery and Chemical Corp., changed its name to Mineral Products Division.

Ferrocolumbium and Ferrotantalum.—Six companies continued to produce ferrocolumbium in four States in three electric-furnace plants and in three aluminothermic plants. They made and shipped over 30 percent more alloy than in 1959. The average unit value decreased slightly to $3.42 per pound of contained columbium from $3.50.

Two companies continued to manufacture ferrotantalum-columbium in plants which also made ferrocolumbium. Production decreased 37 percent, and shipments decreased 8 percent. The average unit value remained unchanged.

Ferronickel.—Hanna Nickel Smelting Co., Riddle, Oreg., continued as the only ferronickel producer.

Vanadium Alloys.—Four producers made ferrovanadium in four States using one electric-furnace plant and three aluminothermic plants. Reading Chemicals made ferrovanadium for the first time in 1960.

Zirconium Alloys.—One company, with three electric-furnace plants in three States, continued to make zirconium-ferrosilicon containing 13 percent zirconium. The unit value remained constant.

Ferroboron.—Ferroboron was produced in four States by four companies using four electric-furnace plants and one aluminothermic plant. The average boron content increased from 11.7 percent in 1959 to 16.7 percent. The average unit value decreased from $7.33 to $6.60 per pound of contained boron.

Tungsten Alloys.—In two States, two companies continued to produce ferrotungsten in two electric-furnace plants, and one company continued to produce nickel-tungsten in an aluminothermic plant. Production of tungsten alloys declined 57 percent; shipments declined 45 percent. The average unit value of contained tungsten was $2.10 per pound, compared with $2.14 per pound in 1959.

CONSUMPTION AND USES

As in previous years, most of the ferroalloys were consumed by the steel industry. The total tonnage of the major ferroalloys used in the United States in 1960 was 1,739,000 tons. The total included consumption by iron foundries, and by aluminum, copper, nickel, and chemical industries, the results of which are shown in tables 2, 3, 4, and 5. The American Iron and Steel Institute (AISI) showed that 1,495,000 tons of alloying metal, including graphite, cobalt, and other minor products not included in the Bureau's total, was consumed in 1960 by the steel industry alone.[3]

Most of the ferroalloys listed in table 4 were consumed in alloy-steel ingot production. The AISI reported that 8.4 million tons of alloy ingot steel was produced in 1960, compared with 8.9 million tons in 1959. Included in the 8.4 million tons was 5.2 million tons of heat-

[3] American Iron and Steel Institute, Annual Statistical Report, 1960, pp. 20–21.

treatable engineering steel, 940,000 tons of low-alloy, high-strength and non-heat-treated engineering and constructional steels, 921,000 tons of silicon electric sheets, 572,000 tons of nominal 18–8 nickel-chromium stainless steels (AISI 300 series), 343,000 tons of essentially nickel-free chromium stainless steels (AISI 400 and 500 series), and 400,000 tons of miscellaneous alloy-steel ingot. Of the latter, 297,000 tons of heat-treatable steel ingot containing boron was made, which was 15,000 tons more than in 1959. Also, ferroalloys were used in 1.2 million tons of cast steel and 12.4 million tons of cast iron in foundries independent of the steel producers.

Manganese Alloys.—Consumption of manganese alloys other than silicomanganese increased 43,000 tons over that of 1959. This gain was largely in engineering alloy steels and in carbon steels. The quantity of manganese alloy used in stainless steels was only half that used in 1959. This was partly reflected by the AISI report that the quantity of manganese-containing stainless steels (AISI 200 series) produced was only 21,575 ingot tons compared with 28,170 ingot tons in 1959.

Silicomanganese consumption was almost the same as in 1959 both in quantity and by end uses. However, the minor use of silicomanganese in gray and malleable castings decreased to less than half the quantity consumed in 1959, and miscellaneous uses were down 25 percent. These decreases were compensated by relatively small increases in the remaining uses.

Silicon Alloys.—Consumption of silicon alloys was down 65,000 short tons from 1959, all of it being accountable in the reduced consumption of silvery pig iron, particularly in gray and malleable castings. On the other hand, nearly 8,000 tons more ferrosilicon briquets were used in these castings than in 1959, and inventories of silicon alloys at consumers' plants were down 25,000 tons, indicating delay in purchasing, perhaps in anticipation of price reductions.

Titanium Alloys.—Only 81 percent as much titanium alloy was consumed in 1960 as in 1959. Most of the decrease occurred in carbon steels.

Ferrophosphorus.—An 11-percent rise in consumption of ferrophosphorus was attributed to increased use in alloy and carbon steel.

Ferroboron.—The use of boron in steels to increase hardenability and thermal-neutron absorption cross section continued to grow. The quantity used in alloy steels other than stainless or tool was nearly twice as much in 1960 as in 1959; but that used in gray and malleable castings was only one-third as much. One ferroalloy producer announced development of a new vanadium-boron alloy which confers nonaging properties to cold-rolled sheet when added to the rimming steel from which the sheet is made.[4] The nominal composition of the new alloy is 42 percent vanadium, 8 percent boron, 2 percent aluminum, 0.10 percent carbon, and the remainder iron. An alternate grade contains 5 percent titanium.

Chromium Alloys.—Consumption of chromium alloy decreased 18,000 tons, or 11 percent, from 1959. The quantity used in stainless steels was 13,000 tons less.

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[4] American Metal Market, VCA Develops New Vanadium Boron Alloy: Vol. 66, No. 120, June 20, 1959, p. 7.

TABLE 2.—Consumption by end uses of silicon alloys, and stocks, in the United States in 1960

(Short tons, gross weight)

Alloy	Silicon content, percent	Stainless steels	Other alloy steels [1]	Carbon steels	Tool steels	Steel mill rolls	Gray and malleable castings	Aluminum-base alloys	High temperature alloys	Other nonferrous alloys [2]	Miscellaneous uses	Total	Stocks, Dec. 31
Silvery pig iron	5–13	2	7,125	898	----------	679	127,682	31	----------	1	----------	136,418	11,968
Do	14–20	----------	8,769	13,789	----------	137	89,978	----------	----------	39	[3] 7,237	119,949	14,588
Ferrosilicon	[4] 21–55	6,393	40,631	79,319	486	781	31,532	34	180	1,730	[5] 19,610	180,696	25,646
Do	56–70	346	9,376	20,812	1	----------	436	----------	----------	1	----------	30,972	1,940
Do	71–80	8,052	15,379	4,862	745	68	6,781	----------	53	25	[6] 4,651	40,616	4,511
Do	81–89	66	641	1,405	----------	46	2,636	----------	----------	30	10	4,834	665
Do	90–95	16	3,156	171	1	24	313	2,775	437	35	73	7,001	973
Silicon metal	96–99	13	5	2	3	----------	37	20,703	97	529	[7] 5,870	27,259	2,441
Ferrosilicon briquets	40–50	5	351	283	----------	21	36,368	----------	----------	----------	25	37,053	8,514
Miscellaneous silicon alloys [8]	----------	301	4,353	7,468	51	67	2,738	219	39	28	2,955	18,219	2,375
Total	----------	15,194	89,786	129,009	1,287	1,823	298,501	23,762	806	2,418	40,431	603,017	73,621

[1] Includes quantities of carbon steels because some firms failed to specify individual uses.
[2] Includes cutting and wear-resistant materials, welding rods, alloy hard facing rods, permanent-magnet-alloys, copper-base alloys, nickel-base alloys, electrical resistance alloys, anodes, and other miscellaneous nonferrous alloys.
[3] Mainly in high-silicon iron, and to beneficiate iron ore.
[4] Mainly from 40 to 55 percent silicon.
[5] Mainly to produce ferronickel.
[6] Mainly in magnesium reduction, pig iron, etc.
[7] Mainly in silicones and other chemical compounds.
[8] Includes calcium-silicon, calcium-manganese-silicon, silicon-manganese-zirconium, ferrocarbo, alsifer, and other miscellaneous silicon alloys.

One company introduced two new chromium alloys in 1960. One, a ferrochrome-silicon, is used in producing stainless steels for chromium additions and for reducing metal oxides from slag back into the bath. It is composed of 43 to 46 percent chromium, 37.5 to 39.5 percent silicon, and 0.15 percent maximum carbon. The other, a low-carbon, blocking chrome, is used for open-hearth furnace additions in producing low-alloy steels. It contains 56 to 59 percent chromium, 18 to 20 percent silicon, and 2 percent maximum carbon.[5]

The U.S. Air Force disclosed that fine wire made from nickel-chromium and cobalt-chromium alloys was suitable for the manufacture of high-temperature fabrics used in reentry parachutes.

Molybdenum Alloys.—The metals industries consumed slightly less molybdenum alloys in 1960 than 1959, although more were used in stainless and other alloy steels. New glass-to-metal seals made from ferrous alloys of molybdenum and tungsten could withstand temperatures of 500° to 600° C.[6] These seals were applied in data processing computers and in military and commercial aviation equipment.

Tungsten Alloys.—Makers of high-speed tool steel and hot-work and die steels used 80 percent of the tungsten alloys consumed, as in 1959. All users consumed 31 percent less tungsten alloys than in 1959.

A steel producer developed a new wear-resistant alloy steel containing 4 percent tungsten, 1 percent molybdenum, 2 percent manganese, 0.90 percent chromium, 0.25 percent silicon, and 1.50 percent carbon. This alloy contains sharp-angled tungsten carbide particles that provide high wear resistance for punches, dies, and brick molds.

Vanadium Alloys.—About the same quantity of ferrovanadium was consumed in 1960 as in 1959. Nearly 60 percent of the ferrovanadium consumed went into alloy steels for engineering uses.

Vanadium-columbium alloys, with 20 to 50 percent columbium, were found intrinsically to increase the high-temperature strength, aqueous-corrosion resistance, and oxidation resistance of vanadium and to make it comparable to other available alloys.[7]

Ferrocolumbium and Ferrotantalum-Columbium.—Consumption of ferrocolumbium and ferrotantalum-columbium alloys increased 28 percent. Their use in stainless steels, where they apparently partially replaced ferrotitanium as a deoxidizer, increased more than 50 percent. Ferrocolumbium was used in larger quantities in carbon and alloy steels than in previous years to promote fine grain structure and to enhance yield strength, toughness, and weldability.

Zirconium Alloys.—The steel manufacturers reported to the AISI that they consumed 2,313 tons of ferrozirconium and 98 tons of the minor zirconium alloys, silicon zirconium, aluminum zirconium, and grainal. Consumption of the minor alloys nearly doubled, but that of ferrozirconium decreased 8 percent.

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[5] Foundry, Chromium Alloys: Vol. 88, No. 12, December 1960, p. 109.

[6] Electronic News, Hermatite Evolves High Temperature Glass-to-Metal Seal: Vol. 6, Whole No. 260, May 8, 1961, p. 66.

[7] Wlodek, S. T., Properties of Vanadium-Columbium Alloys: Jour. Electrochem. Soc., vol. 107, No. 11, November 1960, pp. 923–929.

TABLE 3.—Consumption by end uses of ferroalloys as additives in the United States in 1960 [1]

(Short tons, gross weight)

Alloy	Stainless steels	Other alloy steels [2]	Carbon steels	Tool steels [3]	Gray and malleable castings	Miscellaneous uses [4]	Total
Ferromanganese [5]	8,868	154,210	650,375	3,521	34,771	10,852	862,597
Silicomanganese	3,387	26,736	64,461	1,385	1,628	1,037	98,634
Silicon alloys [6]	15,194	91,609	129,009	1,287	298,501	67,417	603,017
Ferrotitanium	700	1,025	1,174	2	1	270	3,172
Ferrophosphorus	13	2,837	10,762	----------	416	185	14,213
Ferroboron	8	102	1	----------	23	7	141
Total	28,170	276,519	855,782	6,195	335,340	79,768	1,581,774

[1] Except for gray and malleable castings, other items may include steel castings as well as steel ingots.
[2] Includes steel mill rolls.
[3] Includes high-speed, hot-work, and other tool steels.
[4] Includes cutting and wear resistant materials, high-temperature alloys, welding rods, alloy hard facing rods and materials, permanent-magnet alloys, soft-magnetic alloys, nickel-base alloys, titanium-base alloys, wire, rod, and sheet.
[5] Includes spiegeleisen, manganese metal, and briquets.
[6] See table 2 for more detail on silicon alloys.

TABLE 4.—Consumption by end uses of ferroalloys as alloying elements in the United States in 1960

(Short tons of contained alloy)

Alloy	Stainless steels	Other alloy steels	Carbon steels	High-speed steels	Other tool steels [1]	Gray and malleable castings	High temperature alloys	Miscellaneous uses	Total
Ferrochromium [2]	101,272	[3] 38,055	--------	765	1,478	2,787	4,509	1,843	150,709
Ferromolybdenum [4]	909	913	--------	311	89	1,186	83	314	3,805
Ferrotungsten	----------	[5] 61	--------	265	112	----------	[6] 25	[7] 7	470
Ferrovanadium	29	[8] 880	116	254	141	18	15	35	1,488
Ferrocolumbium [9]	195	36	11	--------	--------	----------	38	16	296
Ferrotantalum-columbium [9]	46	1	--------	--------	--------	----------	14	4	65
Total	102,451	39,946	127	1,595	1,820	3,991	4,684	2,219	156,833

[1] Includes hot-work and die steels.
[2] Includes ferrochromium alloys and chromium metals.
[3] Includes quantities that were believed used in producing high-speed and other tool steels and stainless steels because some firms failed to specify individual uses.
[4] Includes calcium molybdate and molybdenum silicide.
[5] Includes steel mill rolls, stainless, and other alloy steels.
[6] Includes cutting and wear-resistant alloys.
[7] Includes diamond-drill bit matrices, electrical contact points, and welding rods.
[8] Includes steel mill rolls.
[9] See table 5 for more detail on end uses.

TABLE 5.—Consumption by end uses of ferrocolumbium and ferrotantalum-columbium in the United States

(Pounds of contained columbium and tantalum)

Product	1959	1960	Product	1959	1960
Stainless steels	313,590	482,360	High-temperature alloys	139,131	104,449
Other alloy steels	63,473	73,533	Permanent-magnet alloys	3,584	3,154
Carbon steels	10,760	21,482	Refractory alloys	--------	2,000
Tool steels	118	260	Miscellaneous uses	7,990	7,933
Welding rods	25,382	25,933			
Gray and malleable castings	1,390	383	Total	565,418	721,487

STOCKS

During 1960, producer stocks increased 39 percent because demand for ferroalloys dwindled, but producers continued to keep as much personnel and equipment working as possible. Stocks of ferrophosphorus continued to increase although the quantity held by the Tennessee Valley Authority decreased from 91,000 to 79,500 short tons. Producer stocks of silicon alloys showed the greatest increase with a 71-percent gain.

Consumer stocks declined 14 percent. Stocks of ferrochromium decreased 43 percent at users' plants.

TABLE 6.—Stocks of ferroalloys held by producers and consumers in the United States as of Dec. 31

(Short tons)

Alloy	Producers		Consumers	
	1959, gross weight	1960, gross weight	1959, gross weight	1960, gross weight
Manganese ferroalloys [1]	[2] 134,978	198,101	146,003	144,536
Silicon alloys [3]	[2] 121,189	208,099	98,660	[4] 73,621
Ferrochromium [5]	[2] 70,640	76,013	28,818	16,530
Ferrotitanium	[2] 1,079	981	969	690
Ferrophosphorus	139,624	164,520	4,535	3,666
Ferroboron	[2] 48	81	30	29
Total	[2] 467,558	647,795	279,015	239,072
	1959, contained alloy	1960, contained alloy	1959, contained alloy	1960, contained alloy
Ferromolybdenum [6]	(7)	(7)	735	574
Ferrotungsten	(7)	(7)	152	89
Ferrovanadium	(7)	(7)	269	259
Ferrocolumbium	114	163	73	87
Ferrotantalum-columbium	(7)	(7)	14	11
Total	[2] 1,145	1,493	1,243	1,020

[1] Includes manganese metal.
[2] Revised figure.
[3] Includes silvery iron, aluminum-silicon alloy, ferrosilicon-boron, ferrosilicon-zirconium, and silicon manganese-aluminum.
[4] For more detail on stocks see table 2.
[5] Includes other chromium ferroalloys and chromium metal.
[6] Includes calcium molybdate and molybdenum silicide.
[7] Figures withheld to avoid disclosing individual company confidential data.

PRICES

Prices, published periodically in the American Metal Market, changed frequently during the year with major revisions January 22, July 20 to 22, and August 18, whereas the last revision of prices previous to 1960 had been October 1, 1958. A major specific change, as of January 22, was the lowering of standard ferromanganese from $245 to $220 per net ton. Other manganese alloy prices declined proportionately. Price cuts were attributed to competition from foreign imports.

The price of bulk ferrochromium-silicon decreased from 28.25 to 26.25 cents per pound of contained chromium in January, and in August declined to 24.50 cents. The less-than-a-ton packed category declined 2 cents early in the year, then in August increased to slightly more than the price quoted at the beginning of the year. The contained-silicon price remained constant throughout the year. The prices of other chromium ferroalloys fluctuated similarly, but the trend was generally down, with price declines from 10 to 15 percent.

Other ferroalloys such as ferrosilicon and ferrovanadium remained at the same price throughout the year.

FOREIGN TRADE [8]

Foreign trade in ferroalloys, small compared with domestic business, increased for the third consecutive year. Ferromanganese imports from India increased sixfold as the result of barter for surplus agricultural products with the U.S. Department of Agriculture, Commodity Credit Corporation. Another item of note was the first importation of ferromanganese from the Union of South Africa.

TABLE 7.—U.S. imports for consumption of ferroalloys and ferroalloy metals

Alloy	1959			1960		
	Gross weight (short tons)	Content (short tons)	Value	Gross weight (short tons)	Content (short tons)	Value
Calcium silicide	459	(1)	$138,188	176	(1)	$50,899
Chromium metal	2,865	(1)	5,179,482	908	(1)	1,645,432
Ferroboron	13	(1)	22,553	17	(1)	28,033
Ferrocerium and other cerium alloys	8	(1)	58,808	11	(1)	78,370
Ferrochrome and ferrochromium:						
Containing 3 percent or more carbon	56,175	38,344	15,760,432	33,525	23,099	8,675,006
Containing less than 3 percent carbon	37,156	25,722	13,989,556	15,862	11,087	5,637,637
Ferrochromium-tungsten, chromium-tungsten, chromium-cobalt-tungsten, tungsten-nickel, and other alloys of tungsten, n.s.p.f. (tungsten content)	(1)	47	104,913	(1)	18	61,758
Ferromanganese:						
Containing not over 1 percent carbon	805	562	140,105	277	218	122,004
Containing over 1 and less than 4 percent carbon	23,744	19,121	4,634,841	10,635	8,601	2,278,644
Containing not less than 4 percent carbon	65,513	50,549	9,292,233	109,310	83,775	16,607,675
Ferromolybdenum, molybdenum metal and powder, calcium molybdate, and other compounds and alloys of molybdenum (molybdenum content)	(1)	1	4,993	(1)	12	21,612
Ferrosilicon	[2] 17,486	5,584	[3] 1,734,885	17,869	4,972	1,532,740
Ferrotitanium	126	(1)	69,870	83	(1)	41,456
Ferrotungsten	329	267	525,569	112	84	207,257
Ferrovanadium	16	(1)	38,598	15	(1)	44,182
Manganese metal (manganese content)	(1)	32	14,416	(1)	243	113,276
Manganese-silicon (manganese content)	(1)	12,495	2,296,397	(1)	10,046	1,885,619
Silicon-aluminum and aluminum-silicon				(4)	(1)	663
Silicon metal (silicon content)	3,142	3,095	804,745	301	297	80,706
Tungsten in combinations, in lump, grains, or powder (tungsten content)	(1)	98	425,494	(1)	80	369,711
Tungstic acid and other alloys of tungsten, n.s.p.f. (tungsten content)				(1)	(5)	264
Zirconium-silicon	1	(1)	262			

[1] Not recorded.
[2] Adjusted by Bureau of Mines.
[3] Revised figure.
[4] 780 pounds.
[5] 6 pounds.

Source: Bureau of the Census.

[8] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

Ferrophosphorus, the ferroalloy annually exported in the largest quantity from the United States, decreased from 73 percent of the total exports in 1959 to 64 percent, principally because ferrochrome exports increased 2½ times.

TABLE 8.—U.S. imports for consumption of ferromaganese and ferrosilicon, by countries

Country	Ferromanganese (manganese content), (excluding silicomanganese)				Ferrosilicon (silicon content)			
	1959		1960		1959		1960	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
North America:								
Canada	101	$40,821	615	$296,670	3,192	$1,033,064	2,318	$799,162
South America:								
Chile	1,233	244,297	448	72,967				
Europe:								
Belgium-Luxembourg	5,297	787,733	2,757	492,265				
France	17,198	3,245,611	18,041	2,771,736	169	30,000		
Germany, West	3,594	618,892	634	196,247	270	[1] 279,598	201	247,071
Italy	2,285	412,532	1,611	412,745				
Norway	12,780	2,626,543	2,232	432,949	1,721	333,362	2,176	424,955
Spain			1,422	231,262				
Sweden	1,005	175,911						
United Kingdom			852	168,080				
Yugoslavia	4,726	877,201	3,950	627,785			52	9,541
Total	46,885	8,744,423	31,499	5,333,069	2,160	[1] 642,960	2,429	681,567
Asia:								
India	4,143	721,075	27,850	6,374,379				
Japan	17,870	4,316,563	23,328	5,523,179	213	54,758	183	43,074
Total	22,013	5,037,638	51,178	11,897,558	213	54,758	183	43,074
Africa: Union of South Africa			8,854	1,408,059	19	4,103	42	8,937
Grand total	70,232	14,067,179	92,594	19,008,323	5,584	[1] 1,734,885	4,972	1,532,740

[1] Revised figure.
Source: Bureau of the Census.

TABLE 9.—U.S. exports of ferroalloys and ferroalloy metals

Alloy	1957		1958		1959		1960	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Ferrochrome	4,535	$2,419,102	1,920	$1,012,260	6,127	$2,095,978	15,588	$5,248,750
Ferromanganese	7,395	1,866,456	1,406	463,896	947	388,134	751	202,457
Ferromolybdenum	192	447,098	113	244,755	124	280,495	212	489,140
Ferrophosphorus	50,318	1,901,036	44,503	1,468,445	49,903	1,798,592	47,897	2,094,527
Ferrosilicon	2,649	502,401	2,177	391,621	10,558	980,658	5,501	867,140
Ferrotitanium and ferrocarbon-titanium	367	130,046	323	138,431	321	145,621	245	157,419
Ferrotungsten	2	10,092	1	3,508	38	57,147		
Ferrovanadium	134	519,955	76	294,933	152	529,697	162	506,624
Other ferroalloys	262	129,468	[1] 189	[1] 109,146	[1] 323	[1] 194,187	[1] 3,845	[1] 846,888
Spiegeleisen	29	2,735	834	79,243	380	37,862	148	15,056
Total	65,883	7,928,389	[1] 51,542	[1] 4,206,238	[1] 68,873	[1] 6,508,371	[1] 74,349	[1] 10,428,001

[1] Owing to changes in classifications by Bureau of the Census, data not strictly comparable with other years.
Source: Bureau of the Census.

WORLD REVIEW

NORTH AMERICA

Mexico.—Ferroaleaciones de Mexico, S.A., a subsidiary of Cía. Fundidora de Fierro y Acero de Monterrey, S.A., began producing ferromanganese, silicomanganese, and ferrosilicon in May 1960 at Estación Banda, a few miles north of Gomez Palacio, Durango, in the Laguna region. The plant, which cost U.S. $1.2 million, employed about 65 laborers and an engineering staff of 40. The 7,500-kilowatt-hour electric furnace operated continuously, producing 33 to 50 short tons of ferroalloy daily, depending upon the alloy. Estimated annual production was 10,000 tons minimum valued at about U.S. $2 million. The entire output was sold to the Mexican steel industry. Manganese ore was obtained from Minera del Norte, controlled by Cía. Fundidora, from mines in Michoacan and Durango. About one-fourth of the steel scrap was imported. Ferroalloys also were produced in Mexico by Fundicion de Acero Electrico, subsidiary of the Teziutlan Copper Co., in Teziutlan, Puebla.[9]

SOUTH AMERICA

Brazil.—In 1958, the following ferroalloys were produced in, or exported from, Brazil.[10]

Commodity:	*Short tons*
Ferromanganese	11, 700
Ferrochromium	568
Ferronickel	330
Ferrosilicon	3, 300
Silicomanganese	3, 070
Spiegeleisen	62

EUROPE

Hungary.—Ores containing 20 percent manganese dioxide (MnO_2) were upgraded to 40 to 43 percent MnO_2. The concentrate was used to smelt more than enough ferromanganese and manganese alloys to cover home demand. The remainder was exported to Western Europe. Experiments in concentrating iron carbonate ore containing 18 to 19 percent manganese for use as ferromanganese were promising.[11]

Italy.—Ferroalloy production was reported to be 155,400 short tons in 1960 as itemized in table 10.

Norway.—Ferrosilicon production was expected to exceed 160,000 tons despite below-average rainfall in north Norway and on the west coast that decreased waterpower, thus curtailing output.[12]

Sweden.—Scandinavia's largest ferroalloy producer, AB Ferrolegeringar, Trollhättan, began operating a new plant for producing ferrochromium. The plant cost US$4 million and doubled output to

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[9] Bureau of Mines, Mineral Trade Notes: Vol. 52, No. 6, June 1961, p. 12.
[10] U.S. Embassy, Rio de Janeiro, Brazil, State Department Dispatch 1044: Apr. 28, 1960, Encl. 2, p. 2.
[11] Mining Journal (London), vol. 255, No. 6517, July 15, 1960, p. 69.
[12] Mining World, What's going on in Mining-Europe: Vol. 23, No. 3, March 1961, p. 71.

TABLE 10.—Italy: Ferroalloy production in 1960

Ferroalloy	Short tons	Average metal content (percent)	Value per ton
Ferrotitanium	172		
Ferrovanadium	102		
Ferrotungsten	108		
Ferromanganese (refined)	5,550	70 to 80	US$166 to US$177
Manganiferous pig iron	7,300	10 to 12	185
Silicomanganese	1,720	Si 20 to 25; Mn 60 to 65	19
Silver pig iron	5,120		
Total ferroalloys [1]	155,400		

[1] The individual items do not add to reported total.

Source: U.S. Embassy, Rome, Italy, State Department Dispatch 941: Apr. 19, 1961, Encl. 1, p. 4.

20,000 tons a year. The product was low-carbon ferrochromium made by the Perrin method.[13]

U.S.S.R.—Exports and imports of ferroalloys in 1959 are given in table 11.

TABLE 11.—U.S.S.R.: Ferroalloys imports and exports in 1959

Ferroalloy	Imports: Short tons (thousands) Soviet Bloc	Imports: Short tons (thousands) Free world	Imports: Short tons (thousands) Total	Imports: Value (thousands)	Exports: Short tons (thousands) Soviet Bloc	Exports: Short tons (thousands) Free world	Exports: Short tons (thousands) Total	Exports: Value (thousands)
Ferromanganese					8.8	9.8	55.6	$10,215
Ferrosilicon	1.9		1.9	$326		13.2	48.8	4,158
Ferrochrome						6.8	20.6	6,035
Ferromolybdenum						.09	.09	144
Silicomanganese						1.0	1.0	120
Total ferroalloys [1]			2.6	890	74.6	54.9	144.5	31,417

[1] The individual items do not add to reported total.

Source: Bureau of Mines, Mineral Trade Notes: Vol. 51, No. 3, Special Suppl. 60, September 1960, p. 13.

Yugoslavia.—During 11 months of 1960, Yugoslavia produced a total of 4,300 short tons of ferroalloys, compared with 3,600 tons for the same period in 1959.[14]

ASIA

India.—Mysore Iron and Steel Works, India's only producer of ferrosilicon, planned to expand its ferroalloy plant in collaboration with Elektrokemisk A/S at a cost of about $2.7 million.[15] This should increase plant capacity from 5,600 to 22,400 short tons of ferrosilicon a year.

For ferromanganese activities, see the Manganese chapter of this volume.

[13] Foreign Trade (Ottawa), Ferro Chromium: Vol. 114, No. 9, Oct 22, 1960, p. 16.
[14] Mining Journal (London), Mining Miscellany: Vol. 256, No. 6549, Feb. 24, 1961, p. 221.
[15] World Mining, India: Vol. 13, No. 11, October 1960, p. 73.

Japan.—During the Japan fiscal year ending March 31, 1961, the Japanese ferroalloy industry smelted 460,000 short tons of products. This compared with 425,000 tons in the previous fiscal year. The total for 1960 and 1961 included 131,000 tons of high-carbon ferromanganese, 98,000 tons of silicomanganese, 63,500 tons of medium- and low-carbon ferrochrome, and 50,000 tons of ferrosilicon No. 2.[16]

Japanese efforts to produce larger quantities of ferroalloys were curtailed by a shortage of hydroelectric power caused by a drought in northern Japan.

The Japan Ferro Alloy Makers' Association reported that Japan exported 56,000 short tons of ferroalloy products in 1960. The United States received the largest quantity, a total of 35,000 short tons of ferroalloy products including 5,300 tons of low-carbon ferrochrome.[17] The Japanese firm, Nippon Kokan K.K., Japan's largest ferroalloy producer, sold 32 tons of ferrochrome to China, the first export of ferroalloys from Japan to China in more than 2 years.[18]

Philippines.—The Philippines' four steel mills and six foundries were furnished with ferroalloys made locally for the first full year. Late in 1959, the Maria Christina Chemical Industries, Inc., announced the successful production of standard ferromanganese, 75-percent grade of ferrosilicon, and silicomanganese. Quartz and manganese sources are local, and reductants are coconut shells and wood charcoal.[19]

Turkey.—For data on ferrochromium see Chromium chapter of this volume.

AFRICA

Rhodesia and Nyasaland, Federation of.—Rhodesian Alloys, Ltd., announced plans to double its capacity for making low-carbon ferrochrome in Gwelo, Southern Rhodesia. The company will spend US $3.5 million over a 2-year period on this expansion, the incentive for which is a large reduction in power cost expected in a few years.

Union of South Africa.—At Feralloys, Ltd., Cato Ridge, Natal, standard ferromanganese was produced in two electric furnaces, each with 9,000 kilovolt amperes connected load. Each furnace averaged 73 short tons per day, being tapped every 2½ hours.[20] Total annual production was expected to be 45,000 short tons.

Value of exports by the African Metals Corp., Ltd., (AMCOR) nearly doubled in the first 9 months of 1960 over the same period in 1959, rising from $7 to $12 million. The company operated the Kookfontein ferroalloy plant at maximum capacity, but production still lagged behind overseas demand. Ferroalloys exports rose from 32,000 short tons in the first 9 months of 1959 to 69,000 tons in the comparable 1960 period. Total ferroalloy production at Kookfontein for this period was 108,000 tons, 34,000 more than in 1959.[21]

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[16] American Metal Market, Ferroalloy Output in Japan Shows Rise for Year: Vol. 68, No. 85, May 4, 1961, p. 19.

[17] American Metal Market, Ferrochrome Output Reduced in Japan: Vol. 68, No. 65, Apr. 6, 1961, p. 19.

[18] Mining Journal (London), Japanese Ferrochrome Sold to China: Vol. 256, No. 6553, Mar. 24, 1961, p. 339.

[19] Mining Newsletter (Philippines), For The First Time Ferroalloys Made in P.I., Firm Bares: Vol. 11, No. 2, November–December 1959, p. 119.

[20] South African Mining and Engineering Journal (Johannesburg), Cascade Moulds for Ferro Alloy Plant: Vol. 71, No. 3542, Dec. 23, 1960, p. 1632.

[21] Iron and Coal Trades Review (London), African Notes: Vol. 181, No. 4813, Oct. 14, 1960, p. 855.

OCEANIA

Australia.—Broken Hill Pty. Co., Ltd. (BHP), Australia's only steel producer, began constructing a US$3.8 million ferromanganese plant at Bell Bay in Northern Tasmania. BHP established a new subsidiary in 1959, the Tasmanian Electro Metallurgical Company Pty., Ltd., to operate this plant. The plant, designed by Elektrokemisk A/S, Olso, Norway, had one electric furnace rated at 13,200 kilovolt amperes.[22] It will consume 160 tons of ore per day, with an expected output of 80 tons of ferromanganese per day.

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[22] Bureau of Mines, Mineral Trade Notes, Ferromanganese: Vol. 50, No. 4, April 1960, p. 8.
Mining and Chemical Engineering Review (Melbourne, Australia), Elektrokemisk Furnace For Bell Bay, Tas: Vol. 53, No. 1, Oct. 15, 1960, p. 63.

Fluorspar and Cryolite

By Robert B. McDougal [1] and Victoria M. Roman [2]

FLUORSPAR

IMPROVED market conditions in 1960 resulted in a moderate increase in fluorspar produced from domestic mines, but imports declined slightly. Prices remained fairly stable throughout most of the year, although a slight advance was quoted for domestic acid-grade fluorspar and Mexican metallurgical-grade fluorspar toward the end of the year. Industrial requirements for fluorspar in 1960 were slightly under the record established in 1957.

TABLE 1.—Salient fluorspar statistics

	1951–55 (average)	1956	1957	1958	1959	1960
United States:						
Production:						
Crude:						
Mine production short tons	769,134	922,100	861,500	818,100	[1] 404,900	575,700
Material milled or washed do	711,900	775,700	790,600	814,800	442,000	558,600
Beneficiated material recovered short tons	305,100	306,500	322,600	310,600	195,100	225,900
Finished (shipments) do	304,300	329,719	328,872	319,513	185,091	229,782
Value thousands	$14,077	$14,257	$15,777	$15,071	$8,680	$10,391
Imports for consumption short tons	310,017	485,552	631,367	392,164	555,750	534,020
Value thousands	$8,713	$11,225	$16,031	$9,777	$13,368	$14,393
Exports short tons	810	197	754	3,374	1,144	458
Value thousands	$56	$31	$81	$191	$69	$38
Consumption short tons	530,928	621,354	644,688	494,227	589,979	643,759
Stocks Dec. 31:						
Domestic mines:						
Crude [2] short tons	136,689	189,021	214,934	207,210	[1] 155,534	137,723
Finished do	24,490	19,161	17,317	18,677	21,417	16,013
Consumer plants do	186,644	189,679	227,990	185,291	179,771	216,330
Importers do	25,972	53,900	51,410	39,035	46,422	61,578
World: Production do	1,340,000	[1] 1,875,000	[1] 2,020,000	[1] 1,990,000	1,855,000	2,160,000

[1] Revised figure.
[2] This crude (run-of-mine) fluorspar in most cases is subjected to some type of processing before it can be marketed.

LEGISLATION AND GOVERNMENT PROGRAMS

The U.S. Tariff Commission's report to the Senate Finance Committee in February urged that no changes be made in the tariff structure and that quotas not be placed on imports.

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.

The Office of Minerals Exploration (OME) encouraged exploration programs by providing financial assistance. No exploration contracts were in force on December 31, 1960.

The Federal Government, under authority contained in the Agricultural Trade Development Act of 1954, acquired fluorspar through barter for surplus agricultural products. Barter contracts were executed by the Commodity Credit Corporation, U.S. Department of Agriculture.

DOMESTIC PRODUCTION

Fluorspar was produced in California, Colorado, Illinois, Kentucky, Montana, Nevada, and Utah. Shipments of finished fluorspar from mines totaled 229,782 short tons and comprised, by grade: Acid, 141,570 tons valued at $7,452,759; ceramic, 25,309 tons at $1,111,517; and metallurgical, 62,903 tons at $1,825,889. Producers in Illinois, which again was the principal producing State, supplied 59 percent of the domestic output.

Output of crude ore produced from domestic mines totaled 575,650 tons, an increase of 42 percent over 1959; 88 percent was obtained from mines that produced over 20,000 tons. In 1960, seven independent and consumer-operated mills processed 558,600 tons of crude ore from which was recovered 225,900 tons of finished fluorspar, including 161,526 tons of flotation concentrate. Gravel and lump-sized fluorspar comprised the remainder. In 1959, 13 mills operated by independent firms and consumers had processed 442,000 tons of crude ore and recovered 195,100 tons of finished fluorspar, of which 145,800 tons was flotation concentrate. Gravel and lump-sized fluorspar and material from reworked dumps comprised the balance. During 1960, 18,505 tons of crude fluorspar was marketed as mined, compared with 16,900 tons of material in 1959.

Captive mines produced 202,321 tons of ore, and their mills recovered 86,441 tons of concentrate from 203,091 tons of ore.

Effective February 1, the Rosiclare Works, Aluminum Company of America (Alcoa), Rosiclare, Ill., announced an ore-purchase program for about 3,000 tons of fluorspar per month from various producers in the district. The plan, under consideration for over 1 year, had a two-fold objective: To conserve the company's ore reserves and to aid the district's economy. Later in the year Alcoa reported that its plant would be closed within 3 years if the mine and mill costs could not be reduced to make its products competitive with Mexican fluorspar.

Minerva Oil Co. began transporting fluorspar from Cave-in-Rock, Ill., to its new river-rail-truck terminal at Wellsville, Ohio. Fluorspar shipped by barge to the Cleveland-Pittsburgh industrial area was competitive with European fluorspar shipped by ocean freight via the St. Lawrence Seaway. Minerva Oil Co. resumed mining operations at its Jefferson mine near Elizabethtown, Ill. Underground equipment had been removed when the mine shut down in September 1959.

Ozark-Mahoning Mining Co. closed its plant at Rosiclare, Ill., for part of August due to lack of orders. The mill operated only 4 days the first week in August.

TABLE 2.—Number and production of domestic crude fluorspar mines by size of operation

Annual production (short tons)	Mines	1959		Mines	1960	
		Short tons	Percent		Short tons	Percent
Less than 1,000 [1]	15	[2] 3,000	0.8	18	4,700	0.8
1,000–10,000	9	[2] 39,200	9.7	12	51,300	8.9
10,000–20,000	2	20,400	5.0	1	14,500	2.5
Over 20,000	6	342,300	84.5	7	505,200	87.8
Total	32	[2] 404,900	100.0	38	575,700	100.0

[1] Includes prospects and reworked dumps and trailings of previous mining and milling operations.
[2] Revised figure.

TABLE 3.—Shipments of finished fluorspar

State	1959			1960		
	Short tons	Value		Short tons	Value	
		Total	Average per ton		Total	Average per ton
Illinois	112,469	$5,908,307	$52.53	134,529	$6,935,511	$51.55
Kentucky	18,579	886,572	47.72	25,855	1,172,815	45.36
Montana	18,542	(1)	(1)	31,273	(1)	(1)
Nevada	16,743	407,300	24.33	18,505	387,842	20.96
New Mexico	200	6,900	34.50			
Utah	(1)	(1)	(1)	1,912	51,152	26.75
Other [2]	18,558	1,471,072	39.65	17,708	1,842,845	37.62
Total [3]	185,091	8,680,000	46.90	229,782	10,391,000	45.22

[1] Figure withheld to avoid disclosing individual company confidential data; included with "Other."
[2] Includes Colorado and States indicated by footnote 1.
[3] Total rounded.

Graighead and Coates concentrated work on a block of ore above the 150-foot level at its mine in Crittenden County, Ky. The mine operated two shifts and the washing plant one shift per day.

Design and operation of the Reynolds Mining Corp. fluorspar mill at Eagle Pass, Tex., were described. The article stated that the mill was one of the finest and most efficient of its type in the world.[3]

CONSUMPTION AND USES

Domestic fluorspar consumption reached a record high of 644,000 short tons in 1960. Fluorspar was reportedly consumed in 35 States, but reports from producers, brokers and dealers, and importers indicated shipments were made to consumers in several additional States. Illinois, Ohio, and Pennsylvania accounted for 35 percent of the fluorspar consumed.

Hydrofluoric acid producers used 11 percent more fluorspar than in 1959 as a result of increased demands. The acid was used by the aluminum and chemical industries.

Octafluorocyclobutane, a recently developed insulating gas for transformers and high-voltage electric cables, could become the first fluoro-

[3] Wick, K. E., The Reynolds Mining Corporation's Fluorspar Mill, Eagle Pass, Tex.: Deco Trefoil, vol. 24, No. 4, August-September-October 1960, pp. 7–18.

TABLE 4.—Fluorspar shipped from mines in the United States, by grades and industries

Grade and industry	1959				1960			
	Quantity		Value		Quantity		Value	
	Short tons	Percent of total	Total	Average per ton	Short tons	Percent of total	Total	Average per ton
Ground and flotation concentrates:								
Hydrofluric acid	113,982	80.0	$6,183,980	$54.25	138,320	81.4	$7,298,151	$52.80
Glass	16,877	11.9	721,211	42.73	18,999	11.2	827,605	43.56
Ceramic and enamel	3,957	2.8	180,339	45.57	4,031	2.4	185,707	46.07
Nonferrous	2,863	2.0	124,816	43.60	2,429	1.4	108,545	44.69
Ferrous	2,672	1.9	115,286	43.15	2,936	1.7	119,219	40.61
Miscellaneous [1]	1,983	1.4	94,233	47.52	3,131	1.9	147,079	46.98
Total	142,334	100.0	[2] 7,420,000	52.13	169,756	100.0	[2] 8,686,000	51.17
Fluxing gravel and foundry lump:								
Ceramic and enamel								
Nonferrous	96	.2	3,975	41.41	64	.4	2,880	45.00
Ferrous	[3] 35,967	84.1	[3] 1,099,847	30.58	49,406	82.3	1,452,070	29.39
Miscellaneous	6,694	15.7	156,464	23.37	10,556	17.6	248,909	23.58
Total	42,757	100.0	[2] 1,260,000	29.48	60,026	100.0	[2] 1,704,000	28.39
All grades:								
Hydrofluoric acid	113,982	61.6	6,183,980	54.25	138,230	60.1	7,298,151	52.80
Glass	16,877	9.1	721,211	42.73	18,999	8.3	827,605	43.56
Ceramic and enamel	3,957	2.1	180,339	45.57	4,031	1.7	185,707	46.07
Nonferrous	2,959	1.6	128,791	43.53	2,493	1.1	111,425	44.70
Ferrous	38,639	20.9	1,215,133	31.45	52,342	22.8	1,571,289	30.02
Miscellaneous [1]	8,677	4.7	250,697	28.89	13,687	6.0	395,988	28.93
Total	185,091	100.0	[2] 8,680,000	46.90	229,782	100.0	[2] 10,390,000	45.22

[1] Includes exports.
[2] Total rounded.
[3] Includes shipments to GSA.

carbon that the U.S. Food and Drug Administration will approve as a propellant in food aerosols.[4] Other fluorocarbon elastomers found increasing use as valve diaphragms, ring seals, and caulking compounds for aircraft and missiles. Tetrafluoromethane refrigerant was used to keep the Nation's Discoverer satellites positionally stable as they revolve around the earth. Along with nitrogen, it was used to provide the thrust in tiny reaction jet nozzles in the final stage of the Discoverer.

Fluorinated plastics, elastomers, oils, greases, and waxes have unusual thermal, mechanical, and corrosion-resistant properties.[5] The kinds of fluorocarbons available a decade ago were quite rare and nearly as costly as the "noble" metals; however, persons interested in overcoming corrosion saw the long-range economics of quality protection, and prices dropped as the usage increased.

A new anesthetic was developed at the University of Maryland's School of Medicine. The new drug, fluoromar, was said to act more quickly than ether and to produce less nausea and other side effects.

[4] Chemical and Engineering News, Fluorocarbons: Vol. 38, No. 29, July 18, 1960, pp. 92–96, 98, 100–102.

[5] Bringer, Robert P., and Sovia, Cedric C., Fluorocarbon Polymers Meet Corrosion Challenge: Chem. Eng. Prog., vol. 56, No. 10, October 1960, pp. 37–42.

The effect of stannous fluoride in reducing tooth decay was described in an article.[6]

TABLE 5.—Fluorspar (domestic and foreign) consumed and in stock in the United States by grades and industries

(Short tons)

Grade and industry	1959 Consumption	1959 Stocks at consumer plants, Dec. 31	1960[1] Consumption	1960[1] Stocks at consumer plants, Dec. 31
Acid grade:				
Hydrofluoric acid	324,519	40,814	372,654	38,938
Glass	3,864	591	3,874	221
Enamel	185	31	135	17
Welding rod coatings	818	44	861	77
Nonferrous	17	5	----------	----------
Special flux }				
Ferroalloys }	2,532	983	2,052	1,018
Primary aluminum }				
Total	331,935	42,468	379,576	40,271
Ceramic grade:				
Glass	25,560	3,306	22,396	2,952
Enamel	5,561	692	4,676	525
Welding rod coatings	1,188	120	1,192	100
Nonferrous	37	17	----------	----------
Special flux }	6,989	1,595	5,990	1,720
Ferroalloys }				
Total	39,335	5,730	34,254	5,297
Metallurgical grade:				
Glass	751	162	687	112
Enamel	5	3	4	2
Welding rod coatings	349	81	395	22
Nonferrous	7,692	1,228	738	370
Special flux }				
Ferroalloys }	2,153	1,004	1,732	8,043
Primary magnesium }				
Iron foundry	13,529	5,025	11,810	7,969
Basic open-hearth steel	157,660	}	168,733	}
Electric-furnace steel	36,377	124,070	45,613	154,244
Bessemer steel	193	}	217	}
Total	218,709	131,573	229,929	170,762
All grades:				
Hydrofluoric acid	324,519	40,814	372,654	38,938
Glass	30,175	4,059	26,957	3,285
Enamel	5,751	726	4,815	544
Welding rod coatings	2,355	245	2,448	199
Nonferrous	7,746	1,250	738	370
Special flux	5,293	1,047	4,166	1,466
Ferroalloys	3,381	1,443	2,543	1,148
Primary aluminum }	3,000	1,092	3,065	8,167
Primary magnesium }				
Iron foundry	13,529	5,025	11,810	7,969
Basic open-hearth steel	157,660	}	168,733	}
Electric-furnace steel	36,377	124,070	45,613	154,244
Bessemer steel	193	}	217	}
Total	589,979	179,771	643,759	216,330

[1] Glass, enamel, and other (including welding rod coatings, nonferrous, special flux, and ferroalloys), partly estimated from sample canvass of consumers who accounted for more than 95 percent of total usage in 1958.

[6] Chemical and Engineering News, Stannous Fluoride Blocks Tooth Decay: Vol. 38, No. 31, Aug. 1, 1960, pp. 40–41.

TABLE 6.—Production of steel and consumption and stocks of fluorspar (domestic and foreign) at basic open-hearth and electric-furnace steel plants

	1951–55 (average)	1956	1957	1958	1959	1960
Production of basic open-hearth steel ingots and castings at plants consuming fluorspar.........thousand short tons..	90,485	95,175	100,297	75,215	76,500	83,668
Consumption of fluorspar in basic open-hearth steel production thousand short tons..	224	228	212	150	158	169
Consumption of fluorspar per short ton of basic open-hearth steel made..pounds..	5.2	4.8	4.2	4.0	4.1	4.0
Stocks of fluorspar at basic open-hearth steel plants at end of year thousand short tons..	138	143	158	111	108	137
Production of electric-furnace steel ingots and castings at plants consuming fluorspar.........thousand short tons..	6,807	8,814	9,551	6,462	7,953	7,883
Consumption of fluorspar in electric furnace steel production thousand short tons..	32	36	30	24	36	46
Consumption of fluorspar per short ton of electric-furnace steel made.....pounds..	9.3	8.2	6.4	7.4	9.2	11.6
Stocks of fluorspar at electric-furnace steel plants at end of year thousand short tons..	6	12	6	8	16	17

TABLE 7.—Fluorspar (domestic and foreign) consumed in the United States, by States

(Short tons)

State	1959	1960 [1]	State	1959	1960 [1]
Alabama, Georgia, North Carolina, and South Carolina	10,107	12,927	Kentucky	35,187	33,691
Arkansas, Kansas, Louisiana, and Oklahoma	76,448	81,322	Maryland	6,367	5,212
California	13,774	14,086	Massachusetts	130	258
Colorado and Utah	16,387	19,859	Michigan	19,867	29,762
Connecticut	1,254	1,517	Missouri	2,779	3,393
Delaware and New Jersey	84,240	101,117	New York	15,819	16,152
Florida, Rhode Island, and Virginia	980	821	Ohio	69,644	66,280
Illinois	97,871	95,527	Oregon and Washington	826	753
Indiana	22,685	24,181	Pennsylvania	66,157	63,232
Iowa, Minnesota, and Wisconsin	3,880	4,329	Tennessee	1,043	504
			Texas	23,329	31,561
			West Virginia	21,205	37,275
			Total	589,979	643,759

[1] Consumption partly estimated from sample canvass of consumers who accounted for more than 95 percent of total usage in 1958.

TABLE 8.—Stocks of fluorspar at mines or shipping points in the United States by States, Dec. 31

(Short tons)

State	1958		1959		1960	
	Crude [1]	Finished	Crude [1]	Finished	Crude [1]	Finished
Illinois	147,657	7,377	108,892	10,311	114,470	8,972
Kentucky	11,334	4,125	7,293	3,847	3,654	3,819
Arizona,[2] California, Colorado, Nevada,[3] Montana, and Utah	48,219	7,175	[4] 39,349	7,259	19,599	3,222
Total	207,210	18,677	[4] 155,534	21,417	137,723	16,013

[1] This crude (run-of-mine) fluorspar usually is subjected to some type of processing before it can be marketed.
[2] 1958 only.
[3] Crude only.
[4] Revised figure.

STOCKS

Producers reported that fluorspar in stock at mines, mills, and shipping points on December 31, 1960, totaled 153,736 short tons, of which 137,723 tons was crude or mine-run fluorspar and 16,013 tons was finished fluorspar.

Consumers indicated that fluorspar stocks held at the end of the year totaled 216,330 tons. Fluorspar stocks on hand at steel plants approximated an 11-month supply based upon the December rate of consumption.

PRICES

E&MJ Metal and Mineral Markets reported that prices of fluorspar throughout 1960 were as follows: Domestic acid-grade concentrates, dry basis, per short ton, bulk, carlots, f.o.b. Illinois-Kentucky and Colorado, $49 spotlots and $45 contract from January to December 29 when spotlots were offered at $49–$50 and pellets for $55. The charge of $3 extra in 100-pound paper bags remained unchanged. European acid-grade fluorspar, c.i.f. U.S. ports, duty paid, per short ton was quoted at $50 contract and spotlots $1 more.

Ceramic fluorspar containing 95 percent CaF_2 was quoted at $45–$48 per short ton, bulk, f.o.b. Illinois-Kentucky throughout the year. Ceramic-grade fluorspar containing 93 to 94 percent CaF_2, variable amounts of calcite and silica, and 0.14 percent Fe_2O_3 was $43 to $46 per short ton, bulk, f.o.b. Illinois-Kentucky. The $3 extra bag charge for ceramic-grade fluorspar in 100-pound paper bags was unchanged.

Metallurgical-grade fluorspars with effective CaF_2 contents of 72½, 70, and 60 percent were quoted at $37 to $41, $36 to $40, and $33 to $36, respectively, per short ton, f.o.b. shipping point, Illinois-Kentucky.

European metallurgical-grade fluorspar that contained 72½ percent effective CaF_2, c.i.f. U.S. ports, duty paid, per short ton, was quoted at $33 to $34 for spotlots and $32 to $34 for contracts. Mexican metallurgical-grade fluorspar containing 72½ percent effective CaF_2, all rail, duty paid, f.o.b. border, was $26.50 to $27.50 per short ton until November 3, when it was quoted at $26.50 to $28.50. This grade, f.o.b. border, barge, Brownsville, Tex., was $28.50 to $29.50 per short ton and on November 3 was listed at $28.50 to $30.50 per ton.

FOREIGN TRADE [7]

Imports.—Fluorspar imports for consumption totaled 534,000 short tons valued at $14.3 million, a decrease of 4 percent from imports in 1959. Mexico, the principal foreign source, supplied 54 percent of the 1960 imports; Spain supplied 20 percent, and Italy 18 percent. The U.S. Government imported 83,000 tons duty free from Italy, Spain, and Mexico, compared with 79,300 tons in 1959.

Exports.—Fluorspar exports totaled 458 short tons valued at $38,000 compared with 1,144 tons valued at $69,204 in 1959.

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[7] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 9.—Price quotations on selected fluorine chemical compounds in 1960

	Jan. 4	Dec. 26
Aluminum fluoride, technical, anhydrous, bags, carlots, works..pound..	$0.17¼	[1] $0.16¼
Bags, less carlots, works....do....	0.18¼-0.20¼	[1] 0.17¼-0.19¼
Bulk, carlots, basis 80 percent....do....	0.14½	Unchanged.
In fiber drums 0.35 cent per pound higher.		
Boron trifluoride, gas, cylinders, truckload, works....do....	0.70	Do.
Cylinders, less truckload, works....do....	0.70	Do.
Hydrofluoric acid, aqueous, 70 percent:		
In 55-gallon drums, carlot, truckload, delivered [2]....100 pounds..	19.25	Do.
In 55-gallon drums, less carlots, less truckload, delivered....do....	20.75	Do.
In 20-gallon drums, carlots, truckload, delivered....do....	21.00	Do.
In 20-gallon drums, less carlots, less truckload, delivered....do....	22.50	Do.
Tanks, works, freight equalized....do....	15.50	[3] 13.40
Hydrofluosilicic acid, drums, works, 30 percent basis....pound..	0.06	[4] 0.07
Hydrogen fluoride, anhydrous, cylinders, delivered, E.[5]....do....	0.30½-0.32½	Unchanged.
Cylinders, delivered, W.[5]....do....	0.39	Do.
Tanks, works....do....	0.21	[3] 0.18
Lithium fluoride, drums, 20,000 pound lots, delivered....do....	2.15	[6] 1.75
Barrels, ton lots and more, delivered....do....	2.18½	[6] 1.85
Barrels, less ton lots, delivered....do....	2.23½	[6] 1.90
Magnesium silico fluoride, drums, works....do....	0.10½-0.12	Unchanged.
Potassium fluoride, drums, works....do....	0.37-0.38	[6] 0.36-0.37
Potassium silico fluoride, bags, works....do....	0.09½-0.10	Unchanged.
In drums, 0.4 cent per pound higher.		
Sodium fluoride, white, 97 percent fiber drums:		
Carlots, works, freight equalized....do....	0.1390	Do.
Less carlots, works, freight equalized....do....	0.1465	Do.
Sodium silicofluoride, bags, carlots, works....do....	0.065	Do.
Bags, less carlots, works....do....	0.725	Do.
In drums 0.4 cent per pound higher.		
Zinc fluoride, barrels, works....do....	0.49-0.50	Do.
Zinc silicofluoride, drums, works....do....	0.12½-0.14	Do.

[1] Decrease published April 4.
[2] Delivered prices apply to all States except Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Washington, and Wyoming. In those States add $2.70 per hundred weight for drum delivery.
[3] Decrease published Feb. 22.
[4] Increase published Nov. 21.
[5] E=East, W=West.
[6] Decrease published Nov. 21.

Source: Oil, Paint and Drug Reporter.

TABLE 10.—U.S. imports for consumption of fluorspar, by countries and customs districts

Country and customs district	1959						1960					
	Containing more than 97 percent calcium fluoride		Containing not more than 97 percent calcium fluoride		Total		Containing more than 97 percent calcium fluoride		Containing not more than 97 percent calcium fluoride		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
North America:												
Canada:												
Buffalo			420	$13,905	420	$13,905						
El Paso									85	$1,703	85	$1,703
Laredo	63	$1,882			63	1,882			588	8,760	588	8,760
Michigan			3,931	64,926	3,931	64,926			2,172	81,678	2,172	81,678
Ohio	1,077	24,287	2,554	55,451	3,631	79,738	3,909	$90,910	1,429	35,339	5,338	126,249
Philadelphia	444	14,825	2,951	73,780	3,395	88,605						
Total	1,584	40,994	9,856	208,062	11,440	249,056	3,909	90,910	4,274	127,480	8,183	218,390
Mexico:												
Arizona							1,730	54,797			1,730	54,797
Buffalo			8,362	138,398	8,263	138,398			15,717	345,934	15,717	345,934
El Paso	4,867	124,133	27,555	534,285	32,422	658,418	7,877	211,774	27,064	535,323	34,941	747,087
Galveston	629	19,741	53	1,147	682	20,888	333	10,730			333	10,730
Hawaii									18	1,341	18	1,341
Laredo	105,262	3,293,460	128,843	1,941,729	234,105	5,235,189	89,815	3,017,632	79,189	1,322,489	169,004	4,340,121
Los Angeles									102	2,041	102	2,041
Maryland	290	8,966	3,493	52,256	3,783	61,222			5,401	178,236	5,401	178,236
Massachusetts									113	2,256	113	2,256
Michigan	1,109	49,341	7,495	91,577	8,604	140,918			17,388	340,029	17,388	340,029
Minnesota			8	159	8	159						
Mobile									10,662	190,454	10,662	190,454
New Orleans	7,562	213,000			7,562	213,000						
Ohio			2,168	34,846	2,168	34,846			13,105	259,533	13,105	259,533
Philadelphia	7,876	249,491	21,522	348,234	29,398	597,725	3,492	100,335	15,363	262,957	18,855	363,292
St. Louis							92	3,016			92	3,016
San Diego	50	1,425			50	1,425						
Vermont							67	2,169			67	2,169
Total	127,645	3,959,557	199,400	3,142,631	327,045	7,102,188	103,406	3,400,453	184,122	3,440,583	287,528	6,841,036
Total North America	129,229	4,000,551	209,256	3,350,693	338,485	7,351,244	107,315	3,491,363	188,396	3,568,063	295,711	7,059,426

TABLE 10.—U.S. imports for consumption of fluorspar, by countries and customs districts—Continued

Country and customs district	1959						1960					
	Containing more than 97 percent calcium fluoride		Containing not more than 97 percent calcium fluoride		Total		Containing more than 97 percent calcium fluoride		Containing not more than 97 percent calcium fluoride		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Europe:												
France:												
New York							10	$647			10	$647
Ohio							4,872	152,500			4,872	152,500
Philadelphia	2,645	$70,800			2,645	$70,800	3,637	99,000			3,637	99,000
Total	2,645	70,800			2,645	70,800	8,519	252,147			8,519	252,147
Germany, West:												
New Orleans							7,031	216,305			7,031	216,305
Philadelphia							6,480	277,937			6,480	277,937
Puerto Rico							200	13,100			200	13,100
Total							13,711	507,342			13,711	507,342
Italy:												
Michigan	2,742	88,461			2,742	88,461	2,907	95,245			2,907	95,245
New Orleans	15,625	441,270			15,625	441,270	18,713	520,967			18,713	520,967
Ohio	5,097	133,342			5,097	133,342						
Philadelphia	111,767	3,356,165			111,767	3,356,165	74,504	2,333,577			74,504	2,333,577
Total	135,231	4,019,238			135,231	4,019,238	96,124	2,949,789			96,124	2,949,789
Spain:												
Maryland							28,335	975,648	2,213	$19,745	30,548	995,393
New Orleans	5,824	123,600			5,824	123,600						
Ohio	10,091	256,350			10,091	256,350	23,313	654,190			23,313	654,190
Philadelphia	49,642	1,226,939			49,642	1,226,939	50,783	1,769,531	3,988	39,874	54,771	1,809,405
San Francisco	6,059	147,500			6,059	147,500						
Total	71,616	1,754,389			71,616	1,754,389	102,431	3,399,369	6,201	59,619	108,632	3,458,988
Sweden: New York							1	145			1	145
United Kingdom: Puerto Rico	299	15,303			299	15,303	100	7,404			100	7,404
Total Europe	209,791	5,859,730			209,791	5,859,730	220,886	7,116,196	6,201	59,619	227,087	7,175,815

Africa:												
Mozambique: Buffalo			4,212	$73,882	4,212	73,882						
Union of South Africa:												
Buffalo			105	4,667	105	4,667						
Maryland									11,222	157,647	11,222	157,647
Ohio			2,701	67,902	2,701	67,902						
Philadelphia	456	10,847			456	10,847						
Total	456	10,847	2,806	72,569	3,262	83,416			11,222	157,647	11,222	157,647
Total Africa	456	10,847	7,018	146,451	7,474	157,298			11,222	157,647	11,222	157,647
Grand total	339,476	9,871,128	216,274	3,497,144	555,750	13,368,272	328,201	10,607,559	205,819	3,785,329	534,020	14,392,888

Source: Bureau of the Census.

TABLE 11.—Imported fluorspar delivered to consumers in the United States, by uses [1]

Use	1959			1960		
	Short tons	Selling prices at tidewater, border, or f.o.b. mill in the United States including duty		Short tons	Selling prices at tidewater, border, or f.o.b. mill in the United States including duty	
		Total	Average per ton		Total	Average per ton
Hydrofluoric acid [2]	190,104	$8,014,620	$42.16	164,512	$6,759,693	$41.09
Glass, ceramic, and enamel	24,376	1,183,862	48.57	9,003	359,490	39.93
Ferrous [2]	157,190	4,480,453	28.50	125,511	3,712,452	29.58
Nonferrous	683	30,950	45.31	2,000	73,770	36.89
Other	6,171	242,106	39.23	4	160	40.00
Total	378,524	13,951,991	36.86	301,030	10,905,565	36.23

[1] Estimated in part.
[2] Includes shipments to GSA.

TABLE 12.—U.S. exports of fluorspar

Year	Short tons	Value		Year	Short tons	Value	
		Total	Average per ton			Total	Average per ton
1951-55 (average)	810	$56,072	$69.18	1958	3,374	$191,386	$56.72
1956	197	31,275	158.76	1959	1,144	69,204	60.49
1957	754	80,703	107.00	1960	458	38,250	83.52

Source: Bureau of the Census.

WORLD REVIEW

NORTH AMERICA

Canada.—Output of fluorspar in 1959 increased in value to Can$2,084,387 from Can$1,542,589 (revised) in 1958.[8] An increase in the aluminum and steel industries resulted in an upswing in fluorspar production, consumption, and foreign trade. Newfoundland Fluorspar, Ltd., a subsidiary of the Aluminum Co. of Canada, St. Lawrence, Newfoundland, and the Huntingdon Fluorspar Mines, Ltd., Madoc, Ontario, operated in 1959. A former important producer, St. Lawrence Corp. of Newfoundland, Ltd., resumed operations near St. Lawrence after being closed since mid-1957. The company was reported to have dewatered its Hares Ears mine and was to deepen the shaft 100 feet.[9] Also, the company planned to dewater its Blue Beach mine and deepen one of the shafts on the property 100 feet. Work was halted temporarily to allow installation of better ventilating systems in two mines in St. Lawrence.

[8] Canada Department of Mines and Technical Surveys, Fluorspar in Canada, 1959 (preliminary): Ottawa, 8 pp.
[9] Northern Miner, St. Lawrence Corp. to Resume Output at Fluorspar Mines: Vol. 46, No. 1, Mar. 31, 1960, pp. 1, 4.

TABLE 13.—World production of fluorspar by countries [1] [2]

(Short tons)

Country [1]	1951–55 (average)	1956	1957	1958	1959	1960
North America:						
Canada	98,410	140,071	66,245	[3] 62,000	[3] 74,000	[3] 78,000
Mexico	171,140	344,541	471,478	462,049	362,456	399,859
United States (shipments)	304,300	329,719	328,872	319,513	185,091	229,782
Total	573,850	814,331	866,595	[3] 843,562	[3] 621,547	[3] 707,641
South America:						
Argentina	10,287	12,983	8,544	13,266	[3] 13,200	[3] 13,200
Bolivia (exports)	186	300				
Total	10,473	13,283	8,544	13,266	[3] 13,200	[3] 13,200
Europe:						
France	77,031	93,412	120,285	106,924	99,208	132,277
Germany:						
East [3]	86,000	90,000	68,000	72,000	72,000	83,000
West	171,153	161,332	149,289	129,966	126,280	133,403
Italy	77,841	137,675	159,405	162,916	174,091	167,454
Norway	666	198	331			
Spain	68,496	81,281	97,439	99,743	98,318	119,036
Sweden (sales)	4,181	976	2,966	3,188	[3] 3,200	[3] 3,200
United Kingdom [4]	89,222	102,536	104,467	86,694	93,078	109,249
Total [1] [3]	580,000	675,000	710,000	670,000	670,000	755,000
Asia:						
China [3]	([5])	145,000	165,000	165,000	220,000	275,000
Japan	5,696	8,911	8,542	6,069	5,684	10,006
Korea, Republic of	8,223	3,431	5,644	1,786	6,748	20,834
Turkey	82			88	75	359
U.S.S.R. [3] [6]	97,000	165,000	165,000	180,000	190,000	210,000
Total [1] [3]	150,000	335,000	400,000	410,000	480,000	570,000
Africa:						
Morocco: Southern zone	2,046	137				
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	219	942	97	6	10	19
South-West Africa	3,021		24	4	141	
Tunisia	994					
Union of South Africa	19,149	35,065	35,106	48,251	70,317	113,550
Total	25,429	36,114	35,227	48,261	70,468	113,569
Oceania: Australia	271	834	784	1,042	528	[3] 600
World total (estimate) [1] [2]	1,340,000	1,875,000	2,020,000	1,990,000	1,855,000	2,160,000

[1] Fluorspar is produced in Bulgaria and North Korea; estimates are included in the total.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Includes fluorspar recovered from old lead and zinc mine dumps.
[5] Data not avaliable; estimate included in total.
[6] U.S.S.R. in Europe included with U.S.S.R. in Asia, as the deposits are predominantly in Asiatic U.S.S.R.

Compiled by Helen L. Hunt, Division of Foreign Activities.

TABLE 14.—Production and trade of fluorspar in 1959, by major countries

(Short tons)

Exports, by countries of origin	Production	Exports	Exports by countries of destination: North America: Canada	North America: United States	South America	Europe: East	Europe: West	Asia: Japan	Asia: Other	Africa: Kenya	Africa: Other	Other countries
North America:												
Canada	[1] 74,000	3,774		3,774								
Mexico	362,456	341,186	19,826	304,589			106	13,082	3,252			331
United States	185,091	1,144	1,058		84		2					
South America: Argentina	[1] 13,200	957			957							
Europe:												
France	99,208	14,711		7,193			6,769					749
Germany:												
East	[1] 72,000	[2] 639					[3] 639					
West	126,280	[2] 13,889					[3] 13,558	[3] 331				
Italy	174,091	133,501		130,530	182	22	2,499		268			
Spain	98,318	69,616	10,663	57,721	11	110	871				240	
Sweden	[1] 3,200	348					311					37
United Kingdom	93,078											
Asia:												
China	[1] 220,000	[2] 79,917				[3] 79,917						
Japan	5,684	73							73			
Korea, Republic of	6,748	20,233						19,924	309			
U.S.S.R. [4]	[1] 190,000	9,733						[3] 9,733				
Africa: Union of South Africa	70,317	57,995		4,758			10,505	37,024	122	3,228	955	1,403
Oceania: Australia	528											
Other countries	60,801	[2] 42,054				[2] 41,116	24	772			142	
Total	1,855,000	789,770	31,547	508,565	1,234	121,165	35,284	80,866	4,024	3,228	1,337	2,520

[1] Estimate.
[2] Incomplete data.
[3] Imports.
[4] U.S.S.R. in Europe included with U.S.S.R. in Asia, as the deposits are predominantly in Asiatic U.S.S.R

Compiled by Corra A. Barry, Division of Foreign Activities.

Rexspar Minerals & Chemicals, Ltd., planned a drilling program at its Birch Island, British Columbia, property to delineate the deposit.[10] The firm also planned to complete a metallurgical test program, set up a pilot plant, build an aerial tramway from the deposit to the millsite, bring the deposit into production, and establish hydrofluoric acid and sulfuric acid plants.

A new 2,900-barrel-per-day alkylation unit, started during the summer, solved two problems for British American Oil Co. at the firm's Clarkson, Ontario refinery.[11] Hydrofluoric acid was the catalyst used at the plant. The facility not only helped the company increase the road octane of motor fuels but also provided an outlet for surplus butanes within the refinery in the process of reacting butylenes with isobutane to produce iso-octane.

Mexico.—A 100-ton-per-day pilot mill was scheduled to start operating in February at San Francisco Mines of Mexico, Ltd., San Francisco del Oro, Chihuahua.[12] Fluorspar was to be recovered by flotation from lead-zinc mill tailing averaging 15 percent CaF_2. Allied Chemical Corp. reportedly acquired additional reserves of more than 1 million tons of fluorspar.[13]

A new acid-grade fluorspar mill was completed by the Esqueda Co. at Esqueda, Sonora, to process ore from reopened area mines.[14] The mill, about 45 miles south of Agua Prieta, was built by the Esqueda Co. which bought the mines after they closed in 1955. Mine development consisted of sinking a 300-foot shaft and driving 3,000 feet of drifts and cross-cuts. Acid-grade fluorspar was produced in the mill; formerly metallurgical-grade fluorspar of 60 percent CaF_2 was shipped from the area.

Acid-grade fluorspar concentrate was shipped by truck from Dow Chemical Co.'s La Domincia mill to its Marathon, Tex., terminal.[15] Dow's mine is about 25 miles southeast of the mill in the Pico Etereo area of Coahuila. The hydrofluoric acid plant of Fluor-Mex, S.A., owned by Stauffer Chemical Co., neared completion in San Luis Potosi. Acid-grade fluorspar, obtained from Muzquiz, Coahuila, was to be used to manufacture hydrofluoric acid for use by Petroleos Mexicanos (PEMEX) as a catalyst in the production of high-octane gasoline.

EUROPE

Norway.—The Norwegian Government planned to submit a bill to the Storting which, if passed, would authorize local authorities to fluoridate drinking water to combat tooth decay.[16]

United Kingdom.—Laporte Industries, Ltd., acquired the Cupola Mining & Milling Co., Ltd., from Head Wrightson & Co., Ltd. Cupola primarily treated fluorspar and barite. To meet the increasing demand for acid-grade fluorspar, Laporte planned to expand pro-

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[10] Northern Miner, Rexspar to Drill Fluorspar Deposit: Vol. 46, No. 7, May 12, 1960, p. 8.
[11] Chemical Engineering, Alkylation Unit Yields Dual Benefit: Vol. 67, No. 25, Dec. 12, 1960, pp. 132–135.
[12] Mining World, vol. 22, No. 3, March 1960, p. 82.
[13] Chemistry and Industry (London), No. 18, Apr. 30, 1960, p. 504.
[14] World Mining, vol. 13, No. 9, August 1960, p. 61.
[15] Chemical Week, vol. 87, No. 17, Oct. 22, 1960, p. 78.
[16] Chemical Age (London), vol. 83. No. 2132, May 21, 1960, p. 854.

duction at a flotation plant at Stoney Middleton, Derbyshire, England. Laporte integrated Cupola's operation with those of another subsidiary, Glebe Mines, Ltd.[17] A new hydrofluoric acid plant, being constructed at Sheffield, England, by James Wilkinson and Sons, Ltd., part of the Laporte group, was expected to be in operation early in 1961.[18] Wilkinson perfected its own process to manufacture high-purity hydrofluoric acid for the electronics industry. The expansion was expected to result in a surplus available for export.

Fluorspar produced in 1960, reported by the Board of Trade, was as follows: Acid-grade, 37,639 short tons; metallurgical-grade, 68,594 tons; and crude or ungraded, 3,015 tons; the total was 109,248 tons.[19]

On March 14, 1960, new regulations prescribing lower maximum limits for the fluorine content of acidic phosphates used for food purposes and of food containing acidic phosphates, based on the recommendations of the Food Standards Committee, went into effect in England and Wales.[20] The new order rescinded the earlier Fluorine in Food Order 1947.

ASIA

India.—A project report by the Department of Mining and Geology called for the establishment of a mining and beneficiation plant to produce 15,000 tons of metallurgical-grade fluorspar yearly.[21] The plant would be constructed in the Durgapur district where in the past 3 years a geological survey and prospecting indicated the presence of 5 million tons of fluorspar ore averaging 30 percent fluorite. Development of the deposits would reduce considerably the need to import fluorspar for use in the steel industry.

U.S.S.R.—A 3-mile tunnel connected the U.S.S.R.'s largest fluorite deposit at Naugarzan with the Angren-Almalyk mining district of Uzbekistan.[22] The tunnel, cut through the Kuramin mountain ridge at an elevation of 6,000 feet in Western Tien Shan, was expected to double the fluorspar output at Uzbekistan.

AFRICA

Union of South Africa.—Fluorspar mining in South Africa was the subject of an article describing the mineral in general and operations of the Buffalo mine and mill near Johannesburg.[23]

OCEANIA

Australia.—In revised customs bylaws, the Australian Department of Customs and Excise was to admit, until further notice, imports of acid-grade or ceramic-grade fluorspar duty free under the British Preferential Tariff.[24] Consolidated Zinc Corp., Ltd., and Monsanto

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[17] Chemical Trade Journal and Chemical Engineer (London), vol. 147, No. 3833, Nov. 18, 1960, p. 1156.
[18] Chemical Age (London), vol. 84, No. 2154, Oct. 22, 1960, p. 663.
[19] U.S. Embassy, London, England, State Department Dispatch 2361: June 15, 1961, 1 p.
[20] Chemistry and Industry (London), No. 3, Jan. 16, 1960, p. 72.
[21] Mining World, vol. 22, No. 12, November 1960, p. 79.
[22] Mining Journal (London), vol. 255, No. 6533, Nov. 4, 1960, p. 508.
[23] Pit and Quarry, Fluorspar in South Africa: Vol. 52, No. 11, May 1960, pp. 172–175.
[24] Chemical Age (London), vol. 84, No. 2149, Sept. 17, 1960, p. 432.

Chemicals, Ltd. (Australia), were reportedly forming a new, jointly owned company to manufacture fluorine chemicals.[25] A new plant at Monsanto's Rozelle plant site in Sydney would produce Isceon fluorocarbons which have been manufactured in the United Kingdom by Imperial Smelting Corp., Ltd., for some time. Production was scheduled to begin by mid-1961.

TECHNOLOGY

Throughout the year many patents that pertained to fluorspar and fluorine compounds, their processing, recovery, removal, and uses were issued. A method of recovering fluorine from waste gases was described in one patent.[26] To the fluorine-containing waste gases from aluminum-producing electrolytic cells, air was added to burn carbon monoxide and tar products in a combustion chamber. Dust and carbon black were deposited in a cyclone, and the waste gases, cooled to about 40° C.–30° C., were washed with water. Gradually a solution which contained 3 to 10 percent hydrofluoric acid was obtained to which compounds containing aluminum and sodium were reacted, precipitating a double fluoride of sodium-aluminum cryolite.

A process for recovering synthetic anhydrite in the manufacture of hydrofluoric acid from fluorspar and sulfuric acid was patented.[27]

Reports on mining methods and costs at two Illinois fluorspar producing operations were issued during the year.[28] How Aluminum Company of America solved stoping problems on narrow veins in its Fairview mine through slusher operations was described in an article.[29]

An article described the efforts of five major industries in their search for new sources of fluorine in the face of dwindling domestic fluorspar supplies and an increasing demand for hydrofluoric acid, cryolite, and fluorine.[30] Apache Chemical Co. was to begin operating a new pilot plant which would make anhydrous hydrofluoric acid from metallurgical-grade fluorspar rather than from imported acid-grade fluorspar. At its wet-process phosphoric acid plant in Utah, United Heckathorn Co. recovered 1 to 3 percent fluorine from phosphate rock to make cryolite. A process which would recover the 2 to 6 percent fluorine content of local phosphate rock was being developed by the Tennessee Valley Authority in Alabama. Kaiser Aluminum and Chemical Corp. developed a method for synthesizing cryolite from sodium silicofluoride. American Cyanamid Co. developed a new method for making sodium silicofluoride. The com-

[25] Mining and Chemical Engineering Review (Melbourne), vol. 52, No. 10, July 15, 1960, p. 14.

[26] Moser, Erwin, Rheinfelden, Baden, Germany (assigned to Aluminum-Industrie-Aktien-Gesellschaft, Chippis, Switzerland), Method of Recovering Fluorine From Waste Gases: U.S. Patent 2,943,914, July 5, 1960.

[27] Hanusch, H. (assigned to Rofusa N.V., Willemstad, Curacao, Netherlands Antilles), Method of Preparing Synthetic Anhydrite: U.S. Patent 2,937,926, May 24, 1960.

[28] Montgomery, Gill, Daly, J. J., and Myslinski, Frank J., Mining Methods and Costs at Crystal-Victory and Minerva No. 1 Fluorspar Mines of Minerva Oil Co., Hardin County, Ill.: Bureau of Mines Information Circ. 7956, 1960, 45 pp.

Bailie, Harold, Powell, E., Melcher, William, and Myslinski, Frank J., Fluorspar Mining Methods and Costs, Ozark-Mahoning Co., Hardin County Ill.: Bureau of Mines Information Circ. 7984, 1960, 33 pp.

[29] Harrison, William H., Jr., Slusher Operation on Narrow Veins Solves Stoping Problem: Min. Cong. Jour., vol. 46, No. 10, October 1960, pp. 32–34.

[30] Chemical Engineering, New Sources of Fluorine: Vol. 67, No. 25, Dec. 12, 1960, pp. 79–80.

pany was able to recover the 4 percent fluorine content of Florida pebble phosphate rock during the conventional wet process of producing phosphoric acid.

Measures employed in American Cyanamid Co.'s new processing plant at Brewster, Fla., to monitor emission of gaseous fluoride were described in an article.[31] Newly installed pollution-control equipment at the plant removed fluorine fumes from the triple superphosphate operation.[32] Free fluorine released in a chain mill was drawn off by giant fans and blown into scrubbers four stories high where the gas was absorbed by sprayed water and carried to a disposal pond. Flourine was also drawn off at the tanks and a cone mixer, and in the curing building. When dust collectors are installed in 1961 to complete the equipment, the company will have spent over $2 million on pollution control.

Improvements in the anode connection of commercial fluorine cells increased cell life 2 to 5 times.[33] Electrolytic corrosion of the metal-to-carbon anode fastener had limited the life of the cell in the old type of connection by causing joint failure. In the most successful of several methods tried to prolong the life of the connection, the clamp was placed in a recessed hole in the carbon anode and covered with a carbon plug; however, occasional desludging was necessary to maintain cell-current efficiency as other cell components deteriorated.

Research on fluorocarbons was intensified during the year.[34] The industry's enormous excess capacity, twice existing requirements, was the main reason for the concerted push to develop new fluorocarbons.

Dixon Chemical and Research, Inc., announced plans to produce hydrofluoric acid in 1961.[35] An 11,000-ton-per-year HF unit to be erected adjacent to the company's sulfuric acid plant at Paulsboro, N.J., will utilize the Buss (Swiss) process, a new variation of the standard acid fluorspar-sulfuric acid method of making hydrogen fluoride. A coproduct, anhydrous calcium sulfate, also will be marketed.

More stringent pesticide regulations in California were discussed at public hearings in Sacramento in April to consider establishing residual pesticide tolerances identical to those prescribed under Federal law.[36]

CRYOLITE

The only cryolite deposit of commercial significance in the world was operated at Ivigtut, Greenland, by a Danish firm, Kryolitselskabet Oresund Ald, through a concession from the Danish Government. Part of the mine output was exported to the United States for processing into finished cryolite by Pennsalt Chemicals Corp. at its Natrona, Pa., mill. Reynolds Metals Co., at Bauxite, Ark.,

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[31] McHenry, Charles R., and Charles, Hoyt, Monitoring Fluoride Content of Air, Water, and Vegetation: Farm Chem., vol. 123, No. 8, August 1960, pp. 58–62.
[32] Mining World, vol. 22, No. 13, December 1960, p. 37.
[33] Industrial and Engineering Chemistry, An Improved Commercial Fluorine Cell: Vol. 52, No. 7, July 1960, pp. 46A–51A.
[34] Chemical and Engineering News, Fluorocarbons: Vol. 38, No. 29, July 18, 1960, pp. 92–96, 98, 100–102.
[35] Chemical and Engineering News, vol. 38, No. 17, Apr. 25, 1960, p. 27.
[36] Chemical and Engineering News, vol. 38, No. 12, Mar. 21, 1960, p. 17.

the Aluminum Company of America, at East St. Louis, Ill.; Kaiser Aluminum and Chemical Corp., at Chalmette, La.; and United Heckathorn Co., at Garfield, Utah, produced synthetic cryolite. The aluminum companies recovered cryolite from scrapped pot linings of aluminum reduction cells.

Cryolite prices quoted throughout the year in the Oil, Paint and Drug Reporter were as follows: Cryolite, natural, industrial, 100-pound bags, works, carlots, $13.00; less than carlots, $14.25. These listings, representing the lowest prices, were firsthand quotations prevailing on large lots, f.o.b. New York, and did not represent bid and asked prices or a range over the week.

Cryolite imports for 1951–60, shown in table 15, do not distinguish between natural and synthetic, although most of the imports from countries other than Denmark and Greenland are believed to have been synthetic cryolite.

Exports of both natural and synthetic cryolite in 1960 totaled 226 short tons valued at $66,294. Canada received 171 tons at $43,355, and Mexico received 29 tons at $15,210. Algeria, Brazil, Cuba, and the Union of South Africa received the remainder.

TABLE 15.—U.S. imports for consumption of cryolite

Year and country	Short tons	Value	Year and country	Short tons	Value
1951–55 (average)	29,960	$2,849,744	1960		
1956	23,122	2,901,355	North America: Greenland [1]	9,733	$429,650
1957	32,712	4,001,481			
1958	24,186	2,332,459	Europe:		
			Denmark	110	5,835
1959			France	513	88,362
North America: Greenland [1]	14,308	739,614	Italy	6,890	1,145,994
			Total	7,513	1,240,191
Europe:					
Belgium-Luxembourg	551	114,750	Grand total	17,246	1,669,841
Denmark	571	48,418			
France	150	23,490			
Germany, West	560	106,443			
Italy	5,945	959,039			
Netherlands	17	2,719			
Total	7,794	1,254,859			
Grand total	22,102	1,994,473			

[1] Crude natural cryolite.

Source: Bureau of the Census.

Numerous patents on the manufacture and use of cryolite, and its recovery from waste gases of aluminum reduction cells and phosphate rock processing, were issued. Two patents described the manufacture of synthetic cryolite by reacting an aqueous solution containing fluoboric acid with a double sodium salt and aluminum oxide or hydroxide.[37] Another patent pertained to the production of synthetic cryolite from an impure ammonium fluoride solution containing fluo-

[37] Kamlet, Jonas (assigned to Reynolds Metals Co., Richmond, Va.), Process for the Manufacture of Cryolite: U.S. Patents 2,925,324 and 2,925,325, Feb. 16, 1960.

rine, phosphorous, silicon, and iron compounds.[38] Results of recent findings on the texture of molten cryolite were used to evaluate several reaction mechanisms for the solution of alumina in cryolite.[39]

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[38] Tarbutton, Grady, Far, Thad D., Jones, Thomas M., and Lewis, Harry T., Jr. (assigned to Tennessee Valley Authority, a corporation of the United States), Alkaline Process for the Manufacture of Cryolite: U.S. Patent 2,963,344, Dec. 6, 1960.

[39] Foster, Perry A., Jr., and Frank, William B., The Structure of Cryolite-Alumina Melts: Jour. Electrochem. Soc., vol. 107, No. 12, December 1960, pp. 997–1001.

Gem Stones

By John W. Hartwell[1] and Betty Ann Brett[2]

GEM materials and mineral specimens produced in the United States during 1960 were estimated at $1,188,000—a $3,000 increase over 1959.

During the year the U.S. Customs Bureau auctioned 8,014 carats of confiscated diamonds, realizing over $1 million for the Government.

The Federal Trade Commission approved the use of the term "Chatham-created emerald" to describe the gem stone produced by the Chatham Research Laboratories, San Francisco, Calif. This term was developed to replace the word "cultured" formerly used. The Commission emphasized that this phrase was to be used only in describing the gems and not the jewelry in which the stones were mounted.

DOMESTIC PRODUCTION

Production information was collected by the Bureau of Mines by canvassing amateur and professional producers of gem stones, but it was not possible to contact all operations. Therefore, facts are based on only a partial survey.

Forty-four States reported production of gem stones, compared with 45 in 1959. Oregon again was the leading State. Thirteen States—Oregon, California, Arizona, Nevada, Texas, Washington, Utah, Wyoming, Colorado, New Mexico, Arkansas, Montana, and South Dakota—produced 89 percent of the total value.

Agate.—About 200 tons of agate, valued at $175,000, was produced in 29 States in 1960. This was a large increase in value and quantity over 1959. Principal States, in decreasing order of production, were Oregon, Utah, New Mexico, Arizona, California, Wyoming, Colorado, and Texas.

A large agate weighing 237 pounds was discovered in Idaho. It was 14 inches in diameter, contained alternate bands of blue and white quartz, and had a small portion in the center containing quartz crystals.

Fire agate production was valued at $5,000; moss, plume, and Turritella agate production was valued at more than $33,000.

Diamond.—Diamonds were still being found at the "Crater of Diamonds" near Murfreesboro, Ark. Production in 1960 was 141 carats

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.

valued at about $9,000. Kimberlite, valued at $7,500 and weighing 15,000 pounds also was sold.

Jade.—Production of jade from Alaska, California, Colorado, and Wyoming was 22,000 pounds, valued at $51,000. Wyoming was the leading State with 7,000 pounds, valued at $24,000. Some Alaskan jade was sent to West Germany for cutting and polishing; other jade was cut and polished locally by native craftsmen.

Petrified Wood.—Almost 150 tons of petrified wood valued at $90,000 was produced in 16 States during 1960. This was considerably less than in 1959. Arizona led with nearly 45 tons, followed by Utah, Oregon, Wyoming, and New Mexico. Twenty-five thousand pounds of petrified palm wood and petrified bone, valued at $20,000, was produced in 8 States. A large deposit of petrified wood, apparently buried under volcanic ash, was discovered in Crook County, Oreg.

Quartz Crystal.—An estimated 18 tons of quartz crystal, valued at $15,000, was produced in 15 States. Arkansas, with over 11 tons valued at nearly $7,000, was the principal producing State. Thirty-eight tons of rose quartz, valued at $5,000, was produced in 5 States. Arizona, with 35 tons, was the leading State. A small quantity of smoky quartz, valued at $1,500, also was produced.

Turquoise.—Production of turquoise from Arizona, Colorado, and Nevada was 16,000 pounds, valued at $60,000. The Villa Grove Turquois Lode, Saguache County, Colo., reported production of over 400 pounds, valued at $16,400. The American Gem Co. reported production from its Lone Mountain Turquois Mine, Esmeralda County, Nev., of 332 pounds, valued at $6,640.

Miscellaneous Gem Material.—Mineral specimens produced in the United States were estimated at nearly 300,000 pounds, valued at $125,000. Principal producing States were Arizona, Utah, California, Oregon, and Wyoming.

TABLE 1.—Estimated value of gem stone production in the United States

(Thousand dollars)

State	1959	1960	State	1959	1960
Alaska	$18	(1)	New Jersey	$6	$7
Arizona	88	$120	New Mexico	39	40
Arkansas	18	38	New York	8	9
California	150	150	North Carolina	9	4
Colorado	43	45	North Dakota	1	1
Connecticut	5	7	Ohio	2	3
Florida	3	----------	Oklahoma	(1)	1
Hawaii	(1)	(1)	Oregon	(1)	(1)
Idaho	5	5	Pennsylvania	3	4
Illinois	1	1	South Dakota	20	20
Kansas	1	----------	Tennessee	----------	1
Maine	10	15	Texas	100	100
Maryland	2	2	Utah	134	72
Massachusetts	(1)	1	Vermont	1	1
Michigan	1	1	Virginia	4	5
Minnesota	----------	2	Washington	75	75
Missouri	3	----------	West Virginia	1	1
Montana	35	35	Wyoming	76	68
Nebraska	3	4	Other States	209	235
Nevada	100	100			
New Hampshire	10	15	Total	1,184	1,188

[1] Included with "Other States."

Rough garnet production was 4,500 pounds, valued at $5,000. The garnet mine, North Creek, N.Y., reported sales of 1,440 carats of cut and polished stones valued at $3,600.

Fire opal from Nevada was valued at over $5,000; quantity was not reported, but one producer at Virgin Valley, Nev., reported 20 pounds valued at $800.

Lapis lazuli production from the Caseade Mine, San Bernardino County, Calif., was 250 pounds. The value depended upon the quality and was priced from $3.50 to $200 per pound.

The quantity and value of some other gem stones and mineral specimens produced were: Amethyst, 1,600 pounds, $2,200; beryl specimens, 1,000 pounds, $500; copper minerals, 8,000 pounds, $5,000; fluorite, 5,000 pounds, $8,000; geodes, 50,000 pounds, $10,000; howlite, 3,000 pounds, $1,500; jasper, 100,000 pounds, $30,000; kunzite, 50 pounds, $1,500; lepidolite, 1,500 pounds, $1,000; marcasite, 1,500 pounds, $1,500; onyx, 16,000 pounds, $4,500; peridot, 440 pounds, $1,000; rhodonite, 20,000 pounds, $6,000; rhyolite, 21,000 pounds, $3,000; and vesuvianite, 2,500 pounds, $1,500.

CONSUMPTION

Consumption of diamond ($166 million) was 8 percent lower than in 1959; sales of synthetic and imitation stones ($6 million) were 40 percent lower; and sales of natural and cultured pearls ($14.6 million) were 6 percent higher.

Apparent consumption (domestic production plus imports minus exports) of gem stones in the United States in 1960 was over $164 million, compared with $189 million in 1959.

PRICES

Prices of colored precious stones and some semiprecious stones have increased in the past few years. Some gem stones were difficult to find in wholesale and retail stores in the United States because of a greater demand from European countries.

Emeralds were in demand everywhere, but especially in Italy where the green stones are highly esteemed. Most natural emeralds sold originated in Colombia and Africa (good quality stone but small or dark), Brazil (pale), and India, where the mines were nearly exhausted.

Deep blue aquamarines, produced in Brazil, were scarce and priced higher than wholesalers in New York were willing to pay.

Large rubies, always high-priced, were rare, whereas the prices of small cheap stones rapidly increased. The large flawed crystals, usually sold as mineral specimens, were cut and polished for the jewelry trade. Large quantities of dull, dark, and flawed star rubies from India were sold.

Sapphires also gained in popularity, and prices increased considerably above the unusual low prices of former years. Production of fancy sapphires from Ceylon continued to decrease.

Prices of Ceylon cat's eye and alexandrite increased, but these gems were almost nonexistent in the markets. No alexandrites were available in European markets in late 1960, but a few small Russian stones at prices higher than diamonds of the same size were offered.

Wholesale prices of black opal increased 50 percent or more. Red tourmaline, in short supply, and green and blue tourmaline, in good supply, increased only slightly in price. Most quartz gems were abundant, but fine amethysts were rare, and even average-quality stones were hard to find.

Most other semiprecious and synthetic gem stones increased in price only slightly despite the increased labor costs of cutting and polishing.

Zircon was the only gem whose price decreased.[3]

FOREIGN TRADE [4]

Imports.—Imports of gem stones decreased nearly 10 percent in value from 1959. Gem diamonds accounted for 86 percent of the total imports but decreased about $6.8 million in value from 1959.

The value of natural and cultivated pearls imported increased $900,000 over 1959.

Emerald imports, cut but not set, decreased $1 million. Imports from Switzerland increased nearly 400 carats, but the unit value per carat dropped from $725 in 1959 to $134 in 1960, resulting in an $861,000 drop in value. Imports from Colombia and Ceylon dropped 12 percent and 83 percent, respectively, in quantity. There were

TABLE 2.—U.S. imports for consumption of precious and semiprecious stones (exclusive of industrial diamonds)

Item	1959		1960	
	Carats	Value (thousands)	Carats	Value (thousands)
Diamonds:				
Rough or uncut (suitable for cutting into gem stones), duty free	[1] 1,578,170	[1] $94,283	1,365,529	$87,510
Cut, but unset, suitable for jewelry, dutiable	[1] 916,824	86,366	801,945	78,037
Emeralds: Cut but not set, dutiable	88,875	2,450	81,207	1,463
Pearls and parts, not strung or set, dutiable:				
Natural		595		629
Cultured or cultivated		13,083		13,934
Other precious and semiprecious stones:				
Rough or uncut, duty free		678		620
Cut but not set, dutiable		3,990		3,967
Imitation, except opaque, dutiable:				
Not cut or faceted		64		74
Cut or faceted:				
Synthetic		243		334
Other		10,746		5,897
Imitation, opaque, including imitation pearls, dutiable		14		8
Marcasites: Real and imitation, dutiable		8		7
Total		[1] 212,520		192,480

[1] Revised figure.

SOURCE: Bureau of the Census

[3] Pough, Frederick H., Precious Stones: Scarcer, Costlier: Jewelers' Circ.-Keystone, vol. 131, No. 6, March 1961, pp. 76, 93–94.

[4] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

almost no imports from Thailand, whereas in 1959 nearly 2,500 carats were imported.

Imports of imitation gems, cut or faceted were nearly 55 percent under 1959.

TABLE 3.—U.S. imports for consumption of diamonds (exclusive of industrial diamonds), by countries

Country	1959				1960			
	Rough or uncut		Cut but unset		Rough or uncut		Cut but unset	
	Carats	Value (thousands)	Carats	Value (thousands)	Carats	Value (thousands)	Carats	Value (thousands)
North America:								
Canada	13,322	$1,259	817	$61	13,751	$1,004	936	$74
Mexico			15	1			173	16
Total	13,322	1,259	832	62	13,751	1,004	1,109	90
South America:								
Argentina	508	11						
Brazil	22,032	725	213	18	26,811	907	34	8
British Guiana	7,461	241	67	8	22,102	743	23	1
Colombia	216	5						
Surinam			25	3				
Venezuela	47,518	1,411	19	2	41,220	1,161		
Total	77,735	2,393	324	31	90,133	2,811	57	9
Europe:								
Austria			220	28			753	47
Belgium-Luxembourg	398,790	20,003	538,811	50,786	207,225	14,354	435,284	44,462
France	24,373	1,257	13,981	1,461	45,965	1,803	13,337	1,181
Germany, West	2,418	57	49,400	3,438	553	13	59,703	3,974
Italy	1,152	28	58	14			66	15
Netherlands	6,900	546	35,782	3,987	22,512	1,432	33,869	3,762
Switzerland	3,134	91	918	433	2,501	138	99	10
United Kingdom	877,236	[1] 63,749	7,398	1,016	829,523	59,547	7,133	1,094
Total	1,314,003	[1] 85,731	646,568	61,163	1,108,279	77,287	550,244	54,545
Asia:								
India			1,970	331			86	15
Israel	6,625	158	[1] 228,677	17,497	54,894	1,801	213,013	17,453
Japan			1,828	159			6,398	81
Lebanon			3	1				
Singapore, Colony of			32	13				
Total	6,625	158	[1] 232,510	18,001	54,894	1,801	219,497	17,549
Africa:								
Congo, Republic of the, and Ruanda-Urundi [2]					22	1		
Western Africa, n.e.c. [3]	5,546	224			7,180	259		
Western Equatorial Africa, n.e.c. [4]	1,796	85			3,494	105		
Ghana	43,508	404			7,104	47		
Liberia	30,384	905			23,567	879		
Union of South Africa	[1] 85,251	[1] 3,124	36,590	7,109	56,185	3,198	30,955	5,843
Total	[1] 166,485	[1] 4,742	36,590	7,109	97,552	4,489	30,955	5,843
Oceania: Australia					920	118	83	1
Grand total	[1] 1,578,170	[1] 94,283	[1] 916,824	86,366	1,365,529	87,510	801,945	78,037

[1] Revised figure.
[2] Effective July 1960; formerly Belgian Congo.
[3] Effective July 1960; formerly French West Africa and Republic of Togo.
[4] Effective July 1960; formerly French Equatorial Africa.

SOURCE: Bureau of the Census.

Exports.—Exports of gem stones, precious and semiprecious, were $7.6 million in 1960, compared with $5.3 million (revised) in 1959; and reexports were $21.7, compared with $19.7 million (revised) in 1959.

WORLD REVIEW

World diamond production decreased 700,000 carats below 1959. This decrease was due to the political unrest in the Republic of the Congo where loss in production was 1.8 million carats. Increases in other countries brought the total production to 26.1 million carats.

Gem-diamond production increased 300,000 carats, principally because of increased production from Angola, Sierra Leone, and the Union of South Africa (De Beers' Group).

Sales of gem diamonds, reported by the Central Selling Organization, London, which sold about 90 percent of the world total, were a record $178 million, compared with $177 million in 1959.

TABLE 4.—World production of diamonds, by countries

(Thousand carats)

Country	1959		1960	
	Gem	Industrial	Gem	Industrial
Africa:				
Angola	516	500	658	400
Central African Republic [2]	40	60	30	45
Congo, Republic of the	655	14,200	413	13,040
Ghana	876	2,200	873	2,400
Guinea [1 3]	} 200	} 400	447	670
Ivory Coast [3]			80	120
Liberia [3]	470	500	577	400
Sierra Leone	644	650	912	1,050
South-West Africa	841	90	866	70
Tanganyika	274	350	287	250
Union of South Africa:				
Premier	323	950	309	1,000
De Beers Groupe	562	500	717	580
Other "pipe" Mines [2]	30	70	30	70
Alluvial [2 4]	250	150	240	160
Other regions:				
Brazil [2]	180	170	150	150
British Guiana	22	40	41	60
Venezuela	15	80	14	57
India, Borneo, Australia, U.S.S.R., and Others [2]	5	10	10	20
World total	5,903	20,920	6,700	20,500

[1] Formerly French Guinea.
[2] Estimate.
[3] Exports only.
[4] Including State-owned mines.

NORTH AMERICA

Dominican Republic.—Amber, containing numerous insect and plant inclusions, from deposits in Dominican Republic was described. Some references to other world deposits known to contain animal and vegetable inclusions were made.[5]

[5] Science, Amber With Insects and Plant Inclusions from the Dominican Republic: Vol. 131, No. 3409, Apr. 29, 1960, p. 1313.

SOUTH AMERICA

Brazil.—Exploracao de Mineros Brasilia Ltd., a partnership of two Canadian corporations, prospected for diamonds and gold in several areas in the State of Minas Gerais during 1960. An alluvial deposit was found in central Brazil, but the quantity of gold was considered too low to risk the development of the property solely for diamonds.[6]

British Guiana.—A new diamond deposit was reported found near Ekereku.[7]

EUROPE

Spain.—The history and present production of "Spanish Topaz" mines near Velas Buenas, Spain, were given. These "topaz" crystals (brown quartz crystals or citrine) were valued in 1958 at US$35 per kilogram.[8]

U.S.S.R.—Gem diamond produced by the U.S.S.R. was to be sold exclusively by the Central Selling Organization of the Diamond Corp., London, under an agreement whereby the diamonds produced from Siberian deposits would be marketed for the first time in the free world.

The diamond mines in Yakut ASSR and their industrial development were described.[9]

ASIA

Fine precious gems of Burma, Ceylon, and Thailand became scarce because mining almost ceased. Sapphires were still found in these countries, but the Ceylon stones were less valuable than those of Burma or Thailand. The Thailand sapphires were easier to cut and polish than Burma stones but had less value.

Ceylon.—Gem stone mines in Ceylon produced alexandrite, amethyst, aquamarine, cat's eye, garnet, moonstone, ruby, sapphire, spinel, topaz, tourmaline, and zircon. The average annual output was estimated at US$420,000.[10]

India.—The Geological Survey of India reported discovery of a rare variety of diamond in the Majhagawan diamond mines in the Panna district. Diamond also was reported to occur in a conglommerate bed near Banganapalle in Andhra Pradesh.[11]

Indonesia.—A new diamond field was discovered in South Kalimantan near the Ulin airport at Bandjarmas. One diamond that was found weighed 12 carats.

Israel.—The history and status of the diamond industry were reported.[12] Israel, with nearly 150 small factories employing 4,000 people, cutting and polishing gem diamonds ranging from 1/15 carat

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[6] Mining World, Latin America: Vol. 13, No. 12, November 1960, p. 70.
[7] Diamond News, Diamond Rush in British Guiana: Vol. 24, No. 3, December 1960, p. 13.
[8] Pough, Frederick H., The "Spanish Topaz" Mines: Jewelers' Circ.-Keystone, vol. 130, No. 4, January 1960, pp. 62, 64.
[9] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 5, May 1960, pp. 7–12.
[10] Mining Journal (London), Diamonds, Gemstones, and Abrasives: Annual Review, May 1960, pp. 71, 73, 75, 77.
[11] Mining World, India: Vol 22, No. 12, November 1960, pp. 78–79.
Mining Journal (London), Mineral Discoveries in India: Vol. 255, No. 6530, Oct. 14, 1960, p. 413.
[12] Bureau of Mines, Mineral Trade Notes: Vol. 51, No. 5, November 1960, pp. 18–24.

to ½ carat, was the third largest diamond center in the world. Diamond exports in 1959 were valued at nearly US$47 million, and 42 percent of the total was exported to the United States.

AFRICA

Congo, Republic of the.—Most diamond mining in the Congo was suspended for about 2 months during 1960 because of political conditions. The Bakwanga mine produced about 95 percent of the total output. It was closed on August 28, resumed operations late in October, and production was expected to become normal early in 1961. Most other smaller mines of the Forminiere were partially shut down during the last half of the year.[13]

Guinea, Republic of.—In the first part of 1960, Soguinex, a subsidiary of De Beers, and another French company, produced two-thirds of the Guinean diamonds; the other third was produced by a large number of individual miners. In November 1960 a Government resolution decreed that all private exploitation should be nationalized. Diamond exploitation was placed under the control of a new organization, Societe Nationale d'Exploitation de Diamonts, which was run for the Government by Russian mining engineers. In 1960, 1,116,500 carats of diamond was exported compared with 643,000 carats in 1959.[14]

Alluvial diamond mining deposits near the Sierra Leone border were described.[15]

Ivory Coast.—The output of diamond in 1959 by the two principal producers was about 188,000 carats, a 13-percent increase over 1958. One producer erected a plant to treat the 1960 production by a new process tried in a pilot plant during 1959. This new plant will recover about 250,000 carats from old tailings.[16]

Malagasy Republic.—During 1959, 24,740 pounds of precious and semiprecious stones, valued at nearly US$9,000, was exported. In the first half of 1960, exports were 21,800 pounds valued at US$19,000. Most valuable gems exported were citrine and labradorite.[17]

Rhodesia and Nyasaland, Federation of.—Rhodesia Chrome Mines, Ltd., discovered a deposit of nephrite jade in the midlands of Southern Rhodesia during 1960. This was the first discovery of this mineral in Southern Africa.[18]

Sierra Leone.—A program, called the Sierra Leone Revolving Loan Scheme, was instituted by the Department of Information, Ministry of Mines and Labor, to help native diamond miners improve mining methods and secure equipment. This program, financed by a free grant from American Aid released to the British Territories in Africa, allocated Sierra Leone $140,000.[19]

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[13] Foreign Commerce Weekly, Strife-Torn Congo Struggles To Keep Mineral Output at Normal Rate: Vol. 64, No. 22, Nov. 28, 1960, pp. 32, 34.
U.S. Embassy, Leopoldville, Republic of the Congo, State Department Dispatch 226: Jan. 23, 1961, p. 1.

[14] U.S. Embassy, Conakry, Republic of Guinea, State Department Dispatch 225: Mar. 13, 1961, p. 15.

[15] Bruton, M. E., Diamond Mining in Guinea: Gemmologist, vol. 29, No. 348, July 1960, pp. 121–131.

[16] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 6, June 1960, p. 10.

[17] Bureau of Mines, Mineral Trade Notes: Vol. 52, No. 2, February 1961, pp. 10–11.

[18] Industrial Diamond Review (London), News in Brief: Vol. 20, No. 238, September 1960, p. 175.

[19] Bureau of Mines, Mineral Trade Notes: Vol. 52, No. 2, February 1961, p. 10.

South-West Africa.—Most of the 18 varieties of gem stones produced in South Africa come from an area near Namaland, and include agate, amazonite, amethyst, aquamarine, emerald, garnet, jade, topaz, and tourmaline.

Production of gem diamond in 1959 was nearly 875,000 carats, compared with 834,000 in 1958. Output in 1960 was estimated at 4 percent more than in 1959.

The Central Selling Organization reported that South-West Africa contributed about 24 percent of the total value of gem diamonds sold on the world market in 1959.

Consolidated Diamond Mines, a subsidiary of De Beers Consolidated Mines, Ltd., accounted for about 99 percent of the diamonds produced in this country.[20]

Tanganyika.—Tanganyika Corundum Corp, Ltd., continued to develop a ruby-corundum deposit near Longido, but no significant production or sale of gem material was reported.

Ruby and Sapphire were reported discovered in deposits in the Lushoto district, Tanganyika.[21]

Union of South Africa.—Income from the sale of gem diamond during 1960 decreased 7 percent from 1959 owing to a decrease in the quantity of diamonds sold. Production of semiprecious gems was amethyst, 2,000 pounds, and tourmaline, 5,700 pounds. Tiger eye continued to be exported (2,000 pounds), but production figures were not available.[22]

OCEANIA

Australia.—Nullamanna Sapphires Pty., Ltd., about 10 miles north of Inverell, New South Wales, began producing sapphire during 1959. In 2 months, 221 ounces of material was produced.

Opal was discovered near Helen Springs Station 90 miles north of Tennant Creek. Some black opal was produced. The Cretaceous rock formations in western New South Wales were reported to be favorable for opal discoveries.

Opal production was expected to exceed US$2.8 million in 1960, compared with US$1.9 million in 1959. Exports to Japan in 1959 were valued at over US$1 million; to West Germany, over US$400,000.

Information concerning Australia's gem stone deposits and production was published by the Australian Bureau of Mineral Resources.[23]

In an area between Southern Cross and York in Western Australia, mineral deposits were staked by several large mining companies. Included was a 30-square-mile tract 40 miles northeast of Hall's Creek staked for agate and other gem stones.[24]

A new syndicate was licensed by the State of Western Australia to operate cultured pearl farms in two areas in King Sound at Malumbo

[20] Bureau of Mines, Mineral Trade Notes: Vol. 52, No. 1, January 1961, pp. 15–17.
[21] Mining Journal (London), Mining in Tanganyike in 1960: Vol. 256, No. 6559, May 5. 1961, pp. 505, 507.
[22] U.S. Consulate, Cape Town, Union of South Africa, State Department Dispatch 110: Mar. 30, 1961, pp. 2, 6, encl. 2, pp. 1, 2.
[23] Mining Journal (London), Australia's Gemstone Industry: Vol. 255, No. 6521, Aug. 12, 1960, p. 173.
[24] Financial Standard (Melbourne), Mineral Interest Widens: Vol. 117, No. 2920, Jan. 26, 1961, p. 27.

Anchorage. The services of a Japanese technician and cultured pearl expert were to be obtained.[25]

ANTARCTICA

Antarctica.—Petrified wood of low-grade gem quality was found by a Bureau of Mines field engineer in perhaps the world's most remote location near the head of Mackay glacier west of the Ross Sea.

TECHNOLOGY

Newly developed prospecting techniques were mentioned as possible methods of searching for the original source of diamonds found in the Great Lakes glacial drift areas.[26]

Two publications on Maine minerals and mineral locations were issued during the year.[27]

The occurrence and description of 63 gem and ornamental stones in Washington was published.[28]

Descriptions and occurrences of many Malagasy minerals and gem materials were given.[29]

Each monthly issue of the Mine and Quarry Engineering (London) journal beginning with October 1953 described a mineral, giving the synonyms, nomenclature, varieties, composition, crystallography, physical and optical properties, tests, diagnoses, occurrences, and uses. Each mineral was illustrated in color. In the 1960 issues the minerals in chronological order were: Crocoite, lazurite, erythrite, manganite, serpentine, scheelite, stilbite, ulexite, brochantite, brucite, mispickel, and agate.

Deposits of minerals in Arkansas and Oklahoma, including diamond in peridotite, were described.[30]

A historical review and the characteristics of Brazilian diamonds were given, and the diamonds were compared with diamonds from other countries.[31]

A Russian book on the diamond fields of Yakutia, northern Siberia, was published in 1959. It contained 525 pages, 41 colored plates, and 305 photographs, drawings, and diagrams. The book was reviewed and abstracted in a British publication.[32]

A history of African diamond mining and recovery of diamond from alluvial and underground deposits were published.[33]

[25] Bureau of Mines, Mineral Trade Notes: Vol. 51, No. 5, November 1960, p. 28.

[26] Smith, Charles H., Diamonds in the Great Lakes Area—A Geological Enigma: Canadian Min. Jour., vol. 81, No. 7, July 1960, pp. 51–52.

[27] Morrill, Phillip, and others, Maine Mines and Minerals: Dillingham Natural History Museum, East Winthrop, Maine, vol. 1, Western Maine, 1960, 82 pp.; vol. 2, Eastern Maine, 1960, 82 pp.
Maine Geological Survey (Augusta), Maine Mineral Collecting: 1960, 23 pp.

[28] Valentine, G. M., and Huntting, M. J., Inventory of Washington Minerals, 2d Ed.: Wash. Dept. of Conserv., Div. of Mines and Geol., Bull. 37, vol. 1, pt. 1, 1960, pp. 43–46 (text); vol. 2, pt. 1, 1960, p. 35 (map).

[29] Behier, Jean, Madagascar Mineralogy: Rept. Malgache, Ann. Geol., Madagascar, No. 29, 1960, pp. 1–78; Chem. Abs., vol. 55, No. 2, Jan. 23, 1961, col. 1301e.

[30] Scull, B. J., The Age of Mineralization in the Ouachita Mountains of Arkansas and Oklahoma: Symposium on Geol. Ouachita Mts., Dallas Geol. Soc., Ardmore Geol. Soc. 1959, pp. 62–69; Chem. Abs., vol. 54, No. 1, Jan. 10, 1960, col. 178b.

[31] Reis, Esmaraldino, The Big Brazilian Diamonds: Brazil Dept. Natl. Prod. Mineral, Div. Geol. e Mineral., Rio de Janeiro, vol. 191, 1959, 65 pp.; Chem. Abs., vol. 54, No. 14, July 25, 1960, col. 13992i.

[32] Wilson, N. W., The Diamond Deposits of Yakutia: Min. Mag. (London), vol. 103, No. 4, October 1960, pp. 205–213.

[33] Daily, A. F., Africa's Key Role in Diamond Mining: World Mining, pt. 1, vol. 13, No. 10, September 1960, pp. 38–43; pt. 2, vol. 13, No. 11, October 1960, pp. 36–41; pt. 3, vol. 13, No. 12, November 1960, pp. 32–37.

Additional information on diamond mining, processing, and synthetic development may be found in the Abrasive Materials chapter of this volume.

Chemical, optical, and X-ray data on jadeite and associated minerals found in central Japan were given.[34] It was suggested that jadeite probably was formed under high pressure at a low temperature during metamorphism. Desilication of its host rock by the associated ultramafic rock might have promoted its formation.

The composition and structure of moonstones from Ceylon, Coimbatore, and Korea were studied, and results were given.[35]

The mechanism of quartz formation in the laboratory and some conclusions concerning the natural process was written.[36]

Equipment used by various research laboratories in the synthesis of diamond was described.[37]

The U.S. Air Force established a research laboratory at Bedford, Mass., to synthesize crystals, including diamonds. It was hoped that diamonds could be developed for making transistors that could be operated at high temperatures. Information on equipment used and results obtained was given.[38]

Diamond, kyanite, garnet, topaz, and jadeite were synthesized in the laboratory under ultra-high pressures.[39]

A new emerald substitute was manufactured in Austria. These emeralds, grown from a seed consisting of a faintly colored, faceted, beryl gem, were then coated with a thin layer of emerald by a hydrothermal or flux-fusion process. The result was an unpolished faceted gem.[40]

Star gem stones produced synthetically were described.[41]

Methods of producing quartz cat's eye,[42] garnet,[43] and unicrystalline bodies[44] were patented.

Cutting of jade minerals by diamond saws was compared with wire and disc cutting methods.[45]

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[43] Nielsen, James W. (assigned to Bell Telephone Laboratories), Method of Making Single Crystal Garnets: U.S. Patent 2,957,827, Oct. 25, 1960.

Wentorf, Robert H. (assigned to Union Carbide Corp.), Method of Making Garnet: U.S. Patent 2,941,861, June 27, 1960.

[44] Kebler, Richard W., Dutchess, Elmer E., and Hutcheson, Ralph L. (assigned to Union Carbide Corp.), Method for Making Synthetic Unicrystalline Bodies: U.S. Patent 2,962,838, Dec. 6, 1960.

[45] Shreve, R. Norris, Jade Cutting Today: Gems and Gemology, vol. 10, No. 3, Fall 1960, pp. 81–89.

The need for lapidary diamond saws, less costly than the circular type now being used, was discussed. It was suggested that hacksaw blades, diamond-charged and adapted to lapidary work, would be a good substitute since power tools suitable for operating this type of blade were already on the market.[46]

Cutting, grinding, and polishing techniques used in producing kunzite gem stones were described.[47]

A machine for faceting gems was patented in Switzerland. The patent was illustrated and showed details of the gem holder which was angularly adjustable but limited by stops.[48]

A brilliant-cut diamond with a new shape called the trilliant, having 44 facets and a polished girdle, was developed.[49]

Methods of testing pearls to determine if they are natural or cultured were described.[50]

A simple, quick, and cheap method of determining whether a diamond is naturally or artificially blue was developed.[51]

The color changes in diamond bombarded with neutrons and electrons in a high voltage accelerator were described.[52]

A method of preventing gem opal from cracking during processing was patented in Japan.[53]

A foldable device for use in examining transparent or translucent gem materials with polarized light was patented.[54]

An electrical detector was invented to sort transparent and translucent gem diamond from opaque gangue materials. The optical property of gem diamond to reflect light was used to develop this apparatus.[55]

Lists of reference books for gem collectors and lapidaries were given.[56] Some books on gems and gem materials were published in late 1959 and during 1960.[57]

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Lapham, Davis M., and Geyer, Alan R., Mineral Collecting in Pennsylvania: Pennsylvania Topographic and Geologic Survey Bull. G–33, 1959, 74 pp.

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Gold

By J. P. Ryan [1] and Kathleen M. McBreen [2]

DOMESTIC mine output of recoverable gold rose 4 percent to 1.7 million ounces, thus reversing the declining trend of the preceding 4 years, which had reduced gold to the lowest peacetime output in 68 years. World gold production rose for the 7th successive year to a new high of 45 million ounces, valued at $1,575 million.

The gain in domestic output resulted from increased production of byproduct gold after the strikes at major copper mines were settled. As in several preceding years, the increase in world gold production was attributed principally to expansion of output by the Union of South Africa, but in 1960 an increase in the estimated output of the U.S.S.R. also was an important contributing factor.

Domestic consumption of gold in the arts and industries increased for the sixth successive year with a gain of 19 percent to 3 million ounces. This quantity exceeded domestic mine production by 1.3 million ounces.

The heavy outflow of gold from the United States, resulting from continued balance-of-payments deficit and conversion of dollar credits by foreign central banks, was again a salient feature. Withdrawals for foreign account reduced the U.S. gold reserve $1.7 billion to $17.8 billion at yearend. Free-world monetary reserves were estimated at $40.5 billion, a gain of about $333 million for the year.

A sharp increase in activity and a wide fluctuation in prices marked the most significant year on the London gold market since the market reopened in 1954. Demand for hoarding, speculation on a possible rise in the official U.S. Treasury price, and a temporary shortage brought the London gold price to $40.50 an ounce in October before it again dropped below $36.00 near the end of the year as the supply of gold again became plentiful.

LEGISLATION AND GOVERNMENT PROGRAMS

Bills similar to those introduced in 1959 to permit free marketing of gold and to increase the price paid to domestic producers to $70 an ounce were again introduced in the 86th Congress, 2d Session, and referred to Committees on Banking and Currency of the House of Representatives and Senate. No further action was taken on these

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bills nor on the concurrent resolutions calling for a commission to investigate conditions affecting the gold-mining industry introduced in the 1st Session of the 86th Congress.

An amendment to the Mining Laws to permit location of millsites in connection with placer claims was passed by the 86th Congress. The amendment permits "nonmineral" land up to 5 acres needed for benefication operations to be included in patent applications.

TABLE 1.—Salient gold statistics

	1951–55 (average)	1956	1957	1958	1959	1960
United States:						
Mine production---thousand ounces--	1,910	1,827	1,794	1,739	[1] 1,603	1,667
Value---thousands--	$66,847	$63,951	$62,776	$60,874	[1] $56,103	$58,337
Ore (dry and siliceous) produced:						
Gold ore----thousand short tons--	2,325	2,255	2,359	2,411	2,289	2,267
Gold-silver ore---do----	171	245	116	107	137	347
Silver ore---do----	560	687	712	639	597	641
Percentage derived from—						
Dry and siliceous ores----	41	42	43	47	50	47
Base-metal ores----	37	39	38	32	28	37
Placers----	22	19	19	21	22	16
Imports, general--thousand ounces [2]--	5,764	3,730	7,701	8,120	8,485	9,322
Exports---do----	3,969	734	4,806	886	50	47
Stocks Dec. 31: Monetary [3]--millions--	----------	$21,949	$22,857	$20,582	$19,507	$17,804
Consumption in industry and the arts---thousand ounces--	1,890	1,400	1,450	1,833	2,522	3,000
Price: Average---per troy ounce [4]--	$35.00	$35.00	$35.00	$35.00	$35.00	$35.00
World: Production---thousand ounces--	34,600	38,400	39,600	40,600	[1] 42,700	45,000

[1] Revised figure.
[2] Excludes coinage.
[3] Owned by Treasury Department; privately held coinage not included.
[4] Price under authority of Gold Reserve Act of Jan. 31, 1934.

DOMESTIC PRODUCTION

After declining for 4 successive years to the lowest peacetime output in 68 years, U.S. mine production of recoverable gold rose 4 percent in 1960 to 1.7 million ounces valued at $58.3 million. The production gain for the year was attributed principally to increased output of gold-bearing copper ore at major mines in Utah, Arizona, and Montana following settlement, early in 1960, of labor strikes which reduced the 1959 output. The increased recovery of byproduct gold more than offset lower output from straight gold mines. Gold-mining operations continued to be adversely affected by rising costs for labor and supplies in relation to the fixed price for gold. Gold production from placers in California and Alaska continued to decline, reaching the lowest output since World War II. The sharp drop in Nevada's gold production resulted from the loss in output after the Round Mountain mine, the leading gold producer in the State, closed in 1959.

The four leading gold-producing States, South Dakota, Utah, Alaska, and Arizona furnished nearly three-fourths of the total domestic output. California dropped from fourth to sixth place. The Homestake mine in South Dakota contributed one-third of total gold production in the Nation. Nearly all of the gold produced in Utah was recovered as a byproduct of base-metal ores, chiefly copper ore at the Utah Copper mine. Alaska gold came almost entirely from placers and was recovered chiefly by bucketline dredging. Arizona gold production, like that of Utah, was almost exclusively a byproduct of base-metal ores, chiefly copper. Forty-eight percent of the total domestic gold production was recovered from gold ores, 16 percent from placers, and 36 percent as a byproduct of base-metal ores.

Of the 25 leading gold producers in the United States, 9 were lode gold mines, 4 placer gold mines, 8 copper mines, 3 lead-zinc mines, and 1 a copper-lead-zinc mine. The 25 leading mines supplied 92 percent of domestic output.

Homestake Mining Co., reported gold production of 554,770 ounces valued at $19.5 million, 3 percent below its record high of 1959. The 1960 output brought the total production of the Homestake to 25 million ounces valued at $875.1 million. Ore milled by the company increased to a record high of 1.77 million tons, but the value of recovered grade dropped $0.50 to $11.02 a ton. Operating costs increased about 11 cents per ton, but this increase was partly offset by increased efficiency as indicated by a rise in tons per man-shift from 3.41 in 1959 to 3.58 in 1960. The company reported an estimated ore reserve at yearend of 13.7 million tons and an estimated grade of $12.35 a ton above the 5,000 level, compared with 13.9 million tons and a grade of $12.40 a ton at the end of 1959.[3]

According to preliminary data compiled by the Bureau of Mines, approximately 4,000 persons were employed in the gold, and gold-silver mining industry in 1960 at 400 lode and placer mines and mining operations.

Ore production and classification, methods of recovery, and metal yields, embracing all ores that yielded gold in the United States in 1960, are given in tables 6 to 9.

The classification of ores, originally adopted in 1905 on the basis of smelter terminology, smelter settlement contracts, and metal recovery, has been used continuously in succeeding years, except for modification necessitated by the improvement in metallurgy and the lowering of the grade of complex ores treated. Details of the current basis of ore classification are given as follows:

Copper ores include smelting ores that contain 2.5 percent or more recoverable copper and ores and tailings concentrated or leached chiefly for their copper content. Ores leached in place or ores for which the tonnage cannot be calculated are excluded; slags smelted for their copper content are included.

Lead ores are those that contain 5 percent or more recoverable lead, irrespective of the precious metal content, and ores, tailings, or slags that are treated chiefly for their lead content.

Zinc-concentrating ores and tailings include those, from which a marketable zinc concentrate is made, irrespective of precious metal content. Virtually no zinc ore is now smelted directly except for cold slags, which when fumed are classified as smelting ore and may contain as little as 5 percent recoverable zinc.

The mixed ores are combinations of those enumerated above; they will be designated by the names of their constituent base metals in alphabetical order, irrespective of the predominance of value.

Gold, gold-silver, and silver ores with the base-metal content too small to be classified in accordance with the foregoing are dry ores,

[3] Homestake Mining Co., Eighty-Third Annual Report, Dec. 31, 1960, pp. 6–8.

irrespective of the ratio of concentration. The dry ores are thus ores, chiefly siliceous, valuable for their silver and gold content and in some instances for their fluxing properties, regardless of method of treatment. Dry gold ores are defined as those, in which the gold value equals or exceeds three-fourths of the combined gold and silver values; dry silver ores are those, in which the silver value equals or exceeds three-fourths of the combined gold and silver values. The gold and silver values in dry gold-silver ores equal or exceed one-fourth of the combined gold and silver values. Tailings and slags follow the same scheme of classification as ores.

The classifications are not to be modified by considerations of payments of metals by smelters or customs mills or by method of treatment by the smelters.

The lead, zinc, and lead-zinc ores in most districts in the States east of the Rocky Mountains carry no appreciable quantity of gold; such ores are excluded from this report unless otherwise indicated.

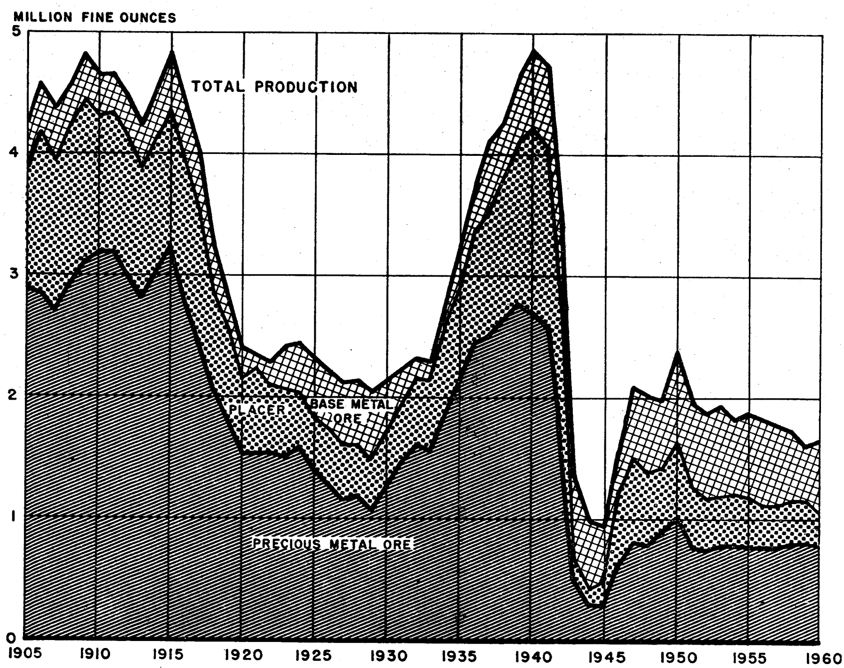

FIGURE 1.—Gold production in the United States, 1905–60.

TABLE 2.—Gold produced in the United States according to mine and mint returns

(Troy ounces of recoverable metal)

	1951–55	1956	1957	1958	1959	1960
Mine	1,909,904	1,827,159	1,793,597	1,739,249	[1] 1,602,931	1,666,772
Mint	1,905,511	1,865,200	1,800,000	1,759,000	1,635,000	1,679,800

[1] Revised figure.

TABLE 3.—Mine production of gold in the United States in 1960, by months

Month	Troy ounces	Month	Troy ounces
January	91,111	August	158,923
February	107,660	September	172,204
March	122,111	October	154,711
April	120,887	November	138,479
May	147,227	December	130,968
June	159,659		
July	162,832	Total	1,666,772

TABLE 4.—Twenty-five leading gold-producing mines in the United States in 1960, in order of output

Rank	Mine	District or region	State	Operator	Source of gold
1	Homestake	Whitewood (Lead)	South Dakota	Homestake Mining Co.	Gold ore.
2	Utah Copper	West Mountain (Bingham).	Utah	Kennecott Copper Corp.	Copper ore.
3	Knob Hill and Gold Dollar.	Republic	Washington	Knob Hill Mines, Inc.	Gold ore.
4	Yuba Unit	Yuba River	California	Yuba Consolidated Industries, Inc.	Dredge.
5	Fairbanks Unit	Fairbanks	Alaska	United States Smelting, Refining, and Mining Co.	Do.
6	Copper Queen-Lavender Pit.	Warren	Arizona	Phelps Dodge Corp.	Copper ore.
7	Liberty Pit	Robinson	Nevada	Kennecott Copper Corp.	Do.
8	Nome Unit	Nome	Alaska	United States Smelting, Refining, and Mining Co.	Dredge.
9	New Cornelia	Ajo	Arizona	Phelps Dodge Corp.	Copper, gold-silver ores
10	Gold King	Wenatchee River	Washington	Lovitt Mining Co., Inc.	Gold ore.
11	Ajax	Cripple Creek	Colorado	The Golden Cycle Corp.	Do.
12	Iron King	Big Bug	Arizona	Shattuck-Den Mining Corp.	Lead-zinc ore.
13	Treasury Tunnel-Black Bear-Smuggler Union.	Upper San Miguel	Colorado	Idarado Mining Co.	Copper-lead-zinc ore.
14	Mayflower and West Mayflower.	Renova	Montana	Estate of Peter Antonioli.	Gold ore.
15	San Manuel	Old Hat	Arizona	San Manuel Copper Corp.	Copper ore.
16	Magma	Pioneer	do	Magma Copper Co.	Copper, gold-silver ores.
17	Natomas	American River (Folsom).	California	The Natomas Co.	Dredge.
18	Berkeley Pit	Summit Valley (Butte).	Montana	The Anaconda Company.	Copper ore.
19	Goldacres	Bullion	Nevada	The London Extension Mining Co.	Gold ore.
20	United States and Lark.	West Mountain (Bingham).	Utah	United States Smelting, Refining, and Mining Co.	Lead-zinc, gold-silver ores.
21	Morenci	Copper Mountain	Arizona	Phelps Dodge Corp.	Gold-silver, copper ores.
22	Brush Creek	Downieville	California	Best Mines Co., Inc.	Gold ore.
23	Siskon	Klamath River	do	Siskon Corp.	Do.
24	Original Sixteen to One.	Alleghany	do	Original Sixteen to One Mine, Inc.	Do.
25	Kelley	Summit Valley (Butte).	Montana	The Anaconda Company.	Copper ore.

TABLE 5.—Mine production of recoverable gold in the United States, by States

(Troy ounces)

State	1951–55 (average)	1956	1957	1958	1959	1960
Alaska	246,326	209,296	215,467	186,435	178,918	168,197
Arizona	116,739	146,110	152,449	142,979	124,627	143,064
California	264,425	193,816	170,885	185,385	[1] 145,270	123,713
Colorado	109,008	97,668	87,928	79,539	61,097	61,269
Idaho	23,902	9,210	12,301	15,896	10,479	6,135
Montana	26,243	38,121	32,766	26,003	28,551	45,922
Nevada	98,404	68,040	76,752	105,087	113,443	58,187
New Mexico	2,996	3,275	3,212	3,378	3,155	5,423
North Carolina	81	882	1,373	876	965	1,826
Oregon	6,030	2,738	3,381	1,423	686	835
Pennsylvania	1,548	(2)	(3)	(3)	(3)	(3)
South Dakota	509,387	568,523	568,130	570,830	577,730	554,771
Tennessee	216	189	172	124	99	123
Texas	14					
Utah	439,152	416,031	378,438	307,824	239,517	368,255
Vermont	171	[2] 1,829	62			
Washington	65,168	70,669	[3] 89,708	[3] 113,353	[3] 118,394	[3] 129,012
Wyoming	94	762	573	117		40
Total	1,909,904	1,827,159	1,793,597	1,739,249	[1] 1,602,931	1,666,772

[1] Revised figure.
[2] Production in Pennsylvania and Vermont combined.
[3] Production in Pennsylvania and Washington combined.

TABLE 6.—Ore, old tailings, etc., yielding gold, produced in the United States, and average recoverable content in troy ounces of gold per ton in 1960

State	Gold ore		Gold-silver ore		Silver ore		Copper ore	
	Short tons	Average ounces of gold per ton	Short tons	Average ounces of gold per ton	Short tons	Average ounces of gold per ton	Short tons	Average ounces of gold per ton
Alaska	136	10.059	---	---	2	0.500	60	---
Arizona	19,716	.082	123,351	0.006	106,215	---	66,087,583	0.002
California	134,273	.208	---	---	177	.441	17,450	.192
Colorado	53,708	.594	1,220	.054	7,400	.006	9,649	.373
Idaho	8,565	.202	604	.093	358,610	.002	77,637	.010
Montana	9,187	2.399	9,624	.087	40,541	.017	11,974,566	.002
Nevada	165,169	.084	79	.241	55,881	.007	11,779,975	.003
New Mexico	---	---	51,843	.041	1,764	.001	7,556,660	---
South Dakota	1,767,135	.314	---	---	---	---	13	.077
Utah	(4)	---	160,633	.015	70,728	.010	28,074,455	.013
Undistributed [5]	109,450	1.167	67	.030	33	.030	292,217	.006
Total	2,267,339	.345	347,421	.018	641,351	.004	125,870,265	.004

State	Lead ore		Zinc ore		Zinc-lead, zinc-copper, and zinc-lead-copper ores		Total ore	
	Short tons	Average ounces of gold per ton	Short tons	Average ounces of gold per ton	Short tons	Average ounces of gold per ton	Short tons	Average ounces of gold per ton
Alaska	36	0.167	---	---	---	---	234	5.876
Arizona	4,280	.030	19,456	0.011	484,643	[1] 0.051	66,845,244	.002
California	2,294	.009	---	---	3,087	[2] .056	157,281	.200
Colorado	13,864	.074	---	---	722,903	.031	808,744	.073
Idaho	150,670	.010	38,508	---	470,712	.001	1,105,306	.005
Montana	14,095	.012	261,889	.011	[3] 7,519	[3] .024	12,317,421	.004
Nevada	11,451	.238	516	.012	131	.221	12,013,202	.005
New Mexico	12,676	.003	177,243	---	33,878	.002	7,834,064	.001
South Dakota	---	---	---	---	---	---	1,767,148	.314
Utah	350	.109	52,971	.001	485,952	[1] .027	28,845,089	.013
Undistributed [5]	---	---	---	---	2,389,042	(2)	[6] 2,790,809	[6] .047
Total	209,716	.027	550,583	.006	4,597,867	.013	134,484,542	.010

[1] Includes gold recovered from uranium ore.
[2] Includes gold recovered from tungsten ore.
[3] Includes manganese ore and gold therefrom.
[4] Less than 1 ton.
[5] Includes North Carolina, Oregon, Tennessee, Washington, and Wyoming.
[6] Excludes magnetite-pyrite-chalcopyrite ore and gold therefrom in Pennsylvania.

TABLE 7.—Mine and refinery production of gold in the United States in 1960, by States and sources

(Troy ounces of recoverable metal)

State	Mine production							Refinery production [1]
	Placers	Dry ore	Copper ore	Lead ore	Zinc ore	Zinc-lead, zinc-copper, lead-copper, and zinc-lead-copper ores	Total	
Alaska	166,822	1,369	----------	6	----------	----------	168,197	172,700
Arizona	127	2,334	115,658	128	217	[2] 24,600	143,064	158,300
California	92,179	27,996	3,344	20	----------	[3] 174	123,713	124,630
Colorado	2,051	31,992	3,597	1,023	----------	22,606	61,269	67,900
Idaho	843	2,339	741	1,576	7	629	6,135	6,450
Montana	135	23,574	19,090	167	2,779	[4] 177	45,922	46,300
Nevada	1,281	14,345	39,805	2,721	6	29	58,187	65,500
New Mexico	----------	2,126	3,189	35	18	55	5,423	5,450
North Carolina	----------	----------	1,660	----------	----------	[3] 166	1,826	1,770
Oregon	668	135	32	----------	----------	----------	835	820
Pennsylvania	----------	----------	----------	----------	----------	----------	([5])	1,300
South Dakota	----------	554,770	1	----------	----------	----------	554,771	551,340
Tennessee	----------	----------	----------	----------	----------	123	123	380
Utah	----------	3,099	352,039	38	77	[2] 13,002	368,255	313,840
Washington	----------	127,590	1,422	----------	----------	----------	[6] 129,012	163,080
Wyoming	3	37	----------	----------	----------	----------	40	40
Total	264,109	791,706	540,578	5,714	3,104	61,561	1,666,772	1,679,800
Percent	15.9	47.5	32.4	.3	.2	3.7	100	----------

[1] U.S. Bureau of the Mint.
[2] Includes gold recovered from uranium ore.
[3] Includes gold recovered from tungsten ore.
[4] Includes gold recovered from manganese ore.
[5] Included with Washington.
[6] Includes gold recovered from magnetite-pyrite-chalcopyrite ores in Pennsylvania.

TABLE 8.—Gold produced in the United States from ore and old tailings, in 1960, by States and methods of recovery, in terms of recoverable metal

State	Total ore, old tailings, etc. treated (short tons)	Ore and old tailings to mills					Crude ore to smelters	
		Short tons	Recoverable in bullion		Concentrates smelted and recoverable metal			
			Amalgamation (troy ounces)	Cyanidation (troy ounces)	Concentrates (short tons)	Troy ounces	Short tons	Troy ounces
Alaska	234	136	1,368	----------	----------	----------	98	7
Arizona	66,845,244	66,037,011	4	4,211	2,160,910	110,446	808,233	28,276
California	157,281	152,131	15,368	7,612	4,739	7,811	5,150	743
Colorado	808,744	790,009	5,596	31,219	106,018	18,317	18,735	4,086
Idaho	1,105,306	1,084,827	714	----------	148,909	4,102	20,479	476
Montana	12,317,421	12,196,878	74	----------	365,655	24,553	120,543	21,160
Nevada	12,013,202	11,920,576	1,038	12,932	265,036	38,767	92,626	4,169
New Mexico	7,834,064	7,685,890	----------	----------	274,496	3,266	148,174	2,157
South Dakota	1,767,148	1,767,135	413,955	140,815	----------	----------	13	1
Utah	28,845,089	28,544,500	1	----------	807,221	364,989	300,589	3,265
Undistributed [1]	[2] 2,790,809	[2] 2,749,969	89	13,565	[2] 144,836	82,101	40,840	35,410
Total	134,484,542	132,929,062	438,207	210,354	4,277,820	654,352	1,555,480	99,750

[1] Includes North Carolina, Oregon, Pennsylvania, Tennessee, Washington, and Wyoming.
[2] Excludes magentite-pyrite-chalcopyrite ore and concentrates therefrom in Pennsylvania.

TABLE 9.—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 from all sources (percent)			
	Amalgamation	Cyanidation	Amalgamation	Cyanidation	Smelting [1]	Placers
1951–55 (average)	441,961	260,579	23.1	13.6	40.7	22.6
1956	439,180	270,785	24.0	14.8	42.2	19.0
1957	435,387	257,008	24.3	14.3	42.3	19.1
1958	446,886	245,397	25.7	14.1	38.9	21.3
1959	459,857	236,046	28.7	14.7	34.3	22.3
1960	438,207	210,354	26.3	12.6	45.2	15.9

[1] Both crude ores and concentrates.

TABLE 10.—Gold production at placer mines in the United States, by methods of recovery

Method and year	Mines producing	Washing plants (dredges)	Material treated (thousand cubic yards)	Gold recoverable		
				Thousand troy ounces	Value (thousands)	Average value per cubic yard
Bucketline dredging:						
1951–55 (average)	28	43	68,781	362	$12,671	$0.184
1956	19	32	48,955	295	10,310	.210
1957	18	33	45,489	297	10,402	.229
1958	17	31	43,693	287	10,038	.230
1959	16	30	36,998	251	8,767	.237
1960	17	24	33,464	228	7,986	.239
Dragline dredging:						
1951–55 (average)	18	15	1,195	5	189	.158
1956	16	7	774	3	88	.113
1957	13	14	[1] 378	2	55	.145
1958	11	11	[1] 132	1	40	.301
1959	12	12	[1] 157	2	73	.464
1960	20	20	144	1	47	.329
Hydraulicking:						
1951–55 (average)	45	----------	257	2	72	.280
1956	36	----------	50	1	50	1.014
1957	30	----------	100	2	75	.752
1958	49	----------	348	3	115	.331
1959	35	35	102	3	87	.855
1960	33	33	282	3	93	.330
Nonfloating washing plants:						
1951–55 (average)	119	116	4,219	58	2,020	.479
1956	110	99	1,355	48	1,673	1.235
1957	94	111	[1] 2,188	40	1,381	.631
1958	107	118	[1] 2,601	77	2,698	1.037
1959	89	97	[1] 2,569	100	3,511	1.367
1960	80	80	938	30	1,045	1.114
Underground placer, small-scale hand methods, and suction dredging:						
1951–55 (average)	146	7	230	[2] 4	[2] 137	.596
1956	85	2	127	2	84	.655
1957	73	----------	63	2	81	1.270
1958	105	3	83	3	93	1.130
1959	79	4	47	[3,4] 2	[3,4] 82	[3] 1.732
1960	89	89	60	2	73	1.207
Grand total, placers:						
1951–55 (average)	356	181	74,682	[2] 431	[2] 15,089	.202
1956	266	140	51,261	349	12,205	.238
1957	228	158	[1] 48,218	343	11,994	.249
1958	289	163	[1] 46,857	371	12,984	.277
1959	231	178	[1] 39,873	[3,4] 358	[3,4] 12,520	[3] .314
1960	239	246	[1] 34,888	264	9,244	.265

[1] Does not include commercial sand and gravel operations recovering byproduct gold.
[2] Includes 1,476 ounces of gold valued at $51,660 recovered from unclassified placers.
[3] Revised figure.
[4] Includes 103 ounces of gold valued at $3,605 recovered from electrostatic separation.

CONSUMPTION AND USES

Industry and the Arts.—Net consumption of gold in domestic industry and the arts rose for the sixth successive year to 3 million ounces, a gain of 19 percent over 1959, according to data compiled by the Bureau of the Mint. The quantity of gold thus absorbed by domestic consumers exceeded production from domestic mines by 1.3 million ounces.

Traditional and established uses of gold in jewelry, watches, and decorative articles, and in dental supplies, scientific, chemical, and other equipment continued to absorb large quantities of gold. New industrial applications of gold continued to be developed.

Gold was used for gold coatings in steering jets for space vehicles to reflect cosmic radiation. The steering jets, manufactured by Bendix Corp. and plated with gold, 0.000040 of an inch thick, reflect 95 percent of all radiation to which an orbiting vehicle's surface is exposed. The small jet controllers, used to keep spacecraft from tumbling and rolling, are first sprayed with an epoxy and then placed in a vacuum chamber where vaporized gold is deposited on their surfaces. The coating is later baked for 30 minutes to complete the treatment.

Increased quantities of gold were used in matrix elements for semiconductor preforms. The material is electroneutral, wets readily to silicon and germanium, has excellent oxidation resistance, and its high thermal conductivity permits rapid heat dissipation from the junction. Gold-plated pressure-seal jackets were used in constructing large valves for a nuclear power station for protection against acid corrosion under high pressure at elevated temperature.

Increased use of gold coatings in architectural panels was reported by Hanovia Liquid Gold Division, Engelhard Industries, Inc., and greater use of gold alloys in manufacturing diodes, rectifiers, and transistors was noted. In a centrifuge built for testing instruments, electronic parts, and other assemblies at the Naval Underwater Ordnance Station, gold sliprings were used to obtain long life, superior power and signal connections, and lower noise level. A new radiation-resistant material, consisting of pure gold laminated to rubber-coated nylon, was developed for use in electronic devices and missiles.

Reports from domestic producers indicated that about 1,000 ounces of natural gold was sold on the open market.

Monetary.—The Bank of England, the largest seller of gold on the London market, was estimated to have sold over 50 percent more gold than in 1959. In addition to receipts of newly mined gold from South Africa, gold market supplies also came from Australia and Canada, and from the United States during the last part of the year. U.S.S.R. sales in London dropped to about 3 million ounces, compared with 7 million ounces in 1959. Direct sales by the South African Reserve Bank were estimated at three-fifths of the South African gold production. Central Bank purchases, again a major factor in the London market, were estimated to have dropped about 10 percent below those of 1959. Purchases of gold by U.S. interests were heavy in the latter part of the year, but it was estimated that total sales to U.S. buyers did not exceed 2.8 million ounces. Demand for gold in the Far East and Middle East increased, accounting for over 4.7 million ounces. Over 2.5 million ounces of gold went to France from the United Kingdom, partly for monetary uses and partly to meet demand from speculative purchasers. South American countries absorbed an estimated 1 million ounces, compared with 500,000 ounces in 1959.[4]

Demand for gold coins on the London market increased moderately, and premium prices, after declining slightly in the middle of the year, were appreciably higher in the last quarter.

TABLE 11.—Net gold consumption in industry and the arts, in the United States

(Troy ounces)

Year	Issued for industrial use	Returned from industrial use	Net industrial consumption
1951-55 (average)	2,809,168	919,050	1,890,118
1956	2,186,450	786,450	1,400,000
1957	2,241,892	791,892	1,450,000
1958	2,602,512	769,261	1,833,251
1959	3,175,386	653,586	2,521,800
1960	3,700,000	700,000	3,000,000

Source: U.S. Bureau of the Mint.

MONETARY STOCKS

The heavy flow of gold from the United States resulting from the deficit in balance-of-payments transactions continued for the third successive year, and the U.S. gold stock was reduced $1.7 billion to $17.8 billion at yearend.[5] This was the second largest annual outflow of gold in the Nation's history. The ratio of gold reserve to Federal Reserve note and deposit liabilities dropped 3 percent to 37 percent at the end of 1960 as against 25 percent required for legal cover.

The deficit in the U.S. balance of payments was $3.8 billion, about the same as in 1959. Although the U.S. trade surplus, based on goods and services rose sharply to $5.8 billion, this gain was more than offset by Government economic aid, military expenses, and the heavy flow of investment capital and short-term private funds abroad. Part of the overall deficit was met by payment in gold. The U.S. balance-of-payment and gold outflow from the United States in 1960 were discussed in a message to the Congress by the President.[6]

Short-term banking liabilities to foreigners increased $1,189 million to $17,418 million at yearend. These liabilities, payable in dollars, constitute a potential claim on the U.S. gold reserve. The significance of the relation between the U.S. gold stock and short-term dollar holdings of foreigners and international institutions was discussed in a U.S. banking publication.[7]

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[4] Samuel Montagu & Co., Ltd., Annual Bullion Review, 1960, pp. 8–10.
[5] Federal Reserve Bulletin, vol. 47, No. 3, March 1961, pp. 268, 370.
[6] U.S. Balance of Payments and Gold Outflow from United States, Message from the President of the United States: H.R. Doc. 84, 87th Cong., 1st Sess., Feb. 6, 1961. 12 pp.
[7] First National City Bank, Our International Balance Sheet; Monthly Letter, December 1960, pp. 138–140.

Gold reserves held by free-world central banks, governments, and international banking institutions were estimated at $40,520 million,[8] a gain of about $330 million for the year. The U.S. reserve of $17,804 million thus included about 44 percent of the total free-world gold reserve. Gold reserves of the principal foreign countries in the free world, were as follows: United Kingdom, $3,231,000,000; West Germany, $2,971,000,000; Switzerland, $2,185,000,000; France, $1,641,-000,000; Netherlands, $1,451,000,000; Belgium, $1,170,000,000; Canada, $885 million; and International Monetary Fund, $2,439,000,000.

PRICES

The continuing deficit in balance of payments of the United States and heavy outflow of gold again caused much speculation on the possible revaluation of gold in terms of dollars, but administration officials continued to assert that no charge in the official price of $35 an ounce was contemplated.

As in preceding years, mint institutions of the U.S. Treasury and licensed private refiners and dealers bought virtually all newly-mined gold and sold gold to industrial consumers at the official price plus or minus handling and refining charges.

The price of gold on the London gold market remained relatively stable for the first 7 months; most of the transactions were for the account of central banks. Heavy withdrawals of gold from the U.S. gold reserve together with increased demand for hoarding and speculation in the later part of the year brought a significant rise in price, which reached a peak of $40.50 an ounce on October 20. The London market price fluctuated in a moderate range from $35.07 to $35.10 an ounce until August when prices increased to $35.14–$35.16 as some central banks converted surplus dollars to gold on the London market in preference to purchasing gold from the U.S. Treasury stock at $35.08¾. Prices continued to rise to $35.23–$35.25 in the middle of September as concern over the continuing heavy outflow of gold from the United States prompted speculation that the official U.S. price of gold might be increased. Persistent demand from private sources and a temporary supply shortage forced the London price to rise to $40.50 an ounce, followed by a decline to $35.50–$35.25 late in October as ample supplies from the Bank of England again became available. Price quotation at yearend increased to $35.55–$35.70.

Gold prices in most of the world markets did not vary greatly from the London price except in a few markets where trading was in local inconvertible currencies that reflected local political conditions and monetary habits.

The average price[9] of "free" gold bars (12.5 kg.) per fine troy ounce in the principal trading centers outside London was as follows:[10]

Market:	Price	Market—Continued	Price
Manila	$36.15	Beirut	$35.43
Hong Kong	39.26	Paris	35.86
Bombay	52.10	Buenos Aires	36.36

[8] Work cited in footnote 5.
[9] Prices quoted at "free" or black-market value of U.S. dollar in local markets.
[10] Engineering and Mining Journal, vol. 161, Nos. 2–12, February–December 1960; vol. 162, No. 1, Jan. 1961. Markets section of each issue.

FOREIGN TRADE [11]

Net imports of gold continued to rise for the third successive year, gaining $30.9 million over 1959 to $333.4 million. Canada supplied 55 percent of the total imports; Venezuela, 36 percent; and the Philippines, 6 percent. About 70 percent of the gold exported went to Portugal and 20 percent, to the United Kingdom.

TABLE 12.—U.S. imports of gold in 1960, by countries

Country	Ore and base bullion		Refined bullion	
	Troy ounces	Value	Troy ounces	Value
North America:				
Canada	107,388	$3,745,792	5,137,059	$179,823,514
Cuba	348	12,210		
Dominican Republic	308	9,602		
El Salvador	1,353	47,484		
Honduras	2,172	75,997		
Mexico	37,587	1,308,884		
Nicaragua	131,970	4,612,881		
Panama	172	5,990		
Total	281,298	9,818,840	5,137,059	179,823,514
South America:				
Argentina	201	7,016		
Bolivia	67	2,346		
Chile	17,302	606,427		
Colombia	1,956	68,501		
Ecuador	15,134	527,860		
Peru	38,329	1,337,705	2,046	71,357
Venezuela			3,424,446	119,855,880
Total	72,989	2,549,855	3,426,492	119,927,237
Europe:				
Austria	29	1,052	32	1,149
Germany, West	969	34,759	32	1,189
Portugal	23,258	814,056		
Switzerland	59	2,082		
United Kingdom	420	14,778	4,149	145,756
Total	24,735	866,727	4,213	148,094
Asia:				
Japan	26	916	7,654	296,812
Korea, Republic of	6	177		
Philippines	67,553	2,356,038	286,298	18,755,995
Total	67,585	2,357,131	293,952	19,052,807
Africa:				
Morocco	2	54		
Rhodesia and Nyasaland, Federation of	2,142	75,179		
Union of South Africa	291	10,185		
Total	2,435	85,418		
Oceania: Australia	11,537	402,229		
Grand total	460,579	16,080,200	8,861,716	318,951,652

Source: Bureau of the Census.

[11] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 13.—U.S. exports of gold in 1960, by countries

Destination	Ore and base bullion		Refined bullion	
	Troy ounces	Value	Troy ounces	Value
North America:				
Canada			532	$18,679
El Salvador			2,636	97,161
Mexico	19	$665		
Total	19	665	3,168	115,840
Europe:				
Belgium-Luxembourg	475	16,625		
France			12	441
Portugal			26,270	921,111
United Kingdom	8,702	304,581	7,730	270,780
Total	9,177	321,206	34,012	1,192,332
Asia:				
Ceylon			26	900
Turkey			470	16,450
Total			496	17,350
Grand total	9,196	321,871	37,676	1,325,522

Source: Bureau of the Census.

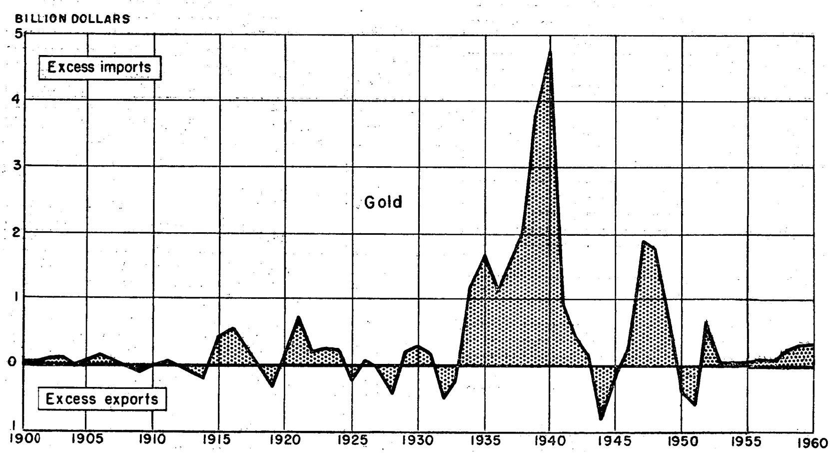

FIGURE 2.—Net imports or exports of gold, 1900–60.

WORLD REVIEW

World output of gold continued to rise for the seventh successive year, reaching a new record high estimated at 45 million ounces and valued at $1,575 million. The production gain of 2.3 million ounces for the year was attributed almost entirely to continued expansion of output in the Union of South Africa and to an increase in the estimated output of the U.S.S.R. Moderate gains were recorded for Canada, Colombia, Philippines, and the United States, which offset production losses in India, Republic of the Congo, Ghana, Southern Rhodesia, and Australia. Most of the major gold-producing countries continued to extend financial assistance to the gold-mining industry by granting subsidies or tax concessions to marginal producers to help offset rising costs and loss of economically recoverable reserves.

Sale of gold by the U.S.S.R. in international markets was about 6 million ounces, bringing the total free-world supply to about 40 million ounces. Of an estimated 24 million ounces available for nonmonetary uses, about 7 million ounces was absorbed by industry and the arts, and 17 million ounces went to hoarding and investment buyers.[12]

TABLE 14.—World production of gold, by countries [1] [2]

(Troy ounces)

Country [1]	1951–55 (average)	1956	1957	1958	1959	1960
North America:						
Canada	4,365,720	4,383,863	4,433,894	4,571,347	4,483,416	4,602,762
Central America and West Indies:						
Costa Rica [3]	----	535	705	310	----	----
Cuba [3]	1,120	1,008	915	804	615	348
Dominican Republic	153	290	286	780	513	[3] 308
Guatemala [4]	182	360	360	370	----	----
Honduras	26,390	1,611	2,025	1,714	[3] 2,798	[3] 2,172
Nicaragua	247,464	217,140	203,636	214,882	218,302	210,082
Panama	579	----	----	----	----	----
Salvador	16,771	2,983	2,508	2,372	2,474	1,121
Mexico	421,323	350,250	346,328	332,246	313,663	300,256
United States [5]	1,905,511	1,865,200	1,800,000	1,759,000	1,635,000	1,679,800
Total	6,985,000	6,823,000	6,790,000	6,884,000	6,657,000	6,797,000
South America:						
Argentina	6,469	11,381	7,732	3,054	[3] 1,782	[3] 201
Bolivia	19,403	35,549	27,685	[6] 19,115	[6] 35,246	[6] 45,457
Brazil [4]	161,000	162,000	150,000	186,000	125,000	120,000
British Guiana	21,478	15,815	16,490	17,500	3,448	2,364
Chile	146,917	94,459	103,590	110,952	76,294	[4] 60,000
Colombia	409,708	438,349	325,114	371,715	397,929	433,947
Ecuador	20,073	15,076	16,247	19,685	18,450	15,159
French Guiana	6,620	5,832	8,954	20,000	16,100	18,940
Peru	147,015	159,074	161,831	159,127	150,299	143,766
Surinam	6,617	6,736	6,516	4,258	5,826	4,932
Venezuela	30,435	69,826	89,654	76,009	53,766	46,868
Total [4]	976,000	1,014,000	914,000	987,000	884,000	892,000
Europe:						
Finland	18,622	18,229	22,377	22,152	23,374	20,351
France	49,556	30,608	35,173	35,559	48,226	41,796
Germany, West	3,682	4,369	3,681	[4] 4,000	[4] 4,000	[4] 4,000
Greece	[7] 5,441	3,504	7,877	5,787	4,340	4,823
Italy	10,627	5,726	6,334	4,802	3,261	3,400
Portugal	19,708	22,120	23,777	17,747	20,769	19,500
Spain	10,022	11,510	11,901	14,211	15,239	[4] 15,000
Sweden	86,730	95,745	97,063	127,574	103,000	[4] 110,000
U.S.S.R. [4] [8]	9,200,000	10,000,000	10,000,000	10,000,000	10,000,000	11,000,000
Yugoslavia	36,137	47,808	51,988	55,364	59,640	67,517
Total [1] [4]	9,600,000	10,400,000	10,400,000	10,400,000	10,400,000	11,400,000
Asia:						
Burma	231	179	104	190	212	[6] 304
Cambodia	----	482	1,608	322	4,823	4,180
India	230,610	209,251	179,182	170,090	165,383	160,593
Japan	218,118	241,422	252,563	260,630	261,547	262,350
Korea:						
North [9]	131,000	130,000	130,000	130,000	130,000	130,000
Republic of	28,432	49,903	66,578	72,071	65,690	65,812
Malaya	19,780	20,253	11,157	22,484	26,739	20,745
Philippines	435,760	406,163	379,982	422,833	402,615	410,618
Sarawak	642	599	883	864	2,450	3,326
Saudi Arabia	51,672	----	----	----	----	----
Taiwan	28,794	33,131	20,548	21,345	13,497	15,699
Total [1] [4] [8]	1,330,000	1,350,000	1,300,000	1,460,000	1,430,000	1,430,000

See footnotes at end of table.

[12] Work cited in footnote 4.

TABLE 14.—World production of gold, by countries [1] [2]—Continued

(Troy ounces)

Country [1]	1951-55 (average)	1956	1957	1958	1959	1960
Africa:						
Angola	43	34		26	42	42
Bechuanaland	925	590	190	215	198	203
Cameroun, Republic of	2,058	463	10,899	2,009	971	415
Central Africa, Republic of	[7] 630	338	614	932	495	291
Congo, Republic of the (formerly Belgian)	361,083	370,505	371,020	352,276	347,967	[4] 256,000
Congo, Republic of	[7] 11,298	7,289	7,404	6,048	3,665	2,628
Eritrea	876	3,215	4,501	6,430	16,718	5,144
Ethiopia	28,575	25,700	[4] 25,000	36,369	41,439	40,915
Gabon, Republic of	[7] 36,750	33,086	22,727	15,921	16,172	17,696
Ghana	719,065	637,755	790,381	852,834	913,200	878,800
Kenya	11,143	13,843	7,388	7,753	9,145	8,646
Liberia	2,685	[10] 500	[10] 381	[4] 400	1,401	1,036
Malagasy Republic	1,562	903	862	797	434	96
Morocco: Southern zone	3,298	265				104
Mozambique	1,200	1,247	1,080	695	295	[4] 300
Nigeria	1,003	439	389	646	950	994
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia	2,274	3,367	3,270	3,746	4,704	5,667
Southern Rhodesia	509,050	536,392	536,849	554,838	566,883	562,703
Ruanda-Urundi	4,417	3,343	3,215	3,858	3,119	1,566
Sierra Leone	2,017	6,452				
Sudan	1,659	3,100	1,158	1,571	2,300	2,605
Swaziland	65	252	7			806
Tanganyika [11]	69,349	69,699	63,485	68,250	95,794	106,954
Uganda (exports)	391	297	212	329	334	642
Union of South Africa	12,643,027	15,896,693	17,030,737	17,656,447	20,065,515	21,383,019
United Arab Republic (Egypt region)	14,335	7,697	3,026	1,812	2,486	[4] 2,500
West Africa (formerly French)	2,012	431	331	3,247	[4] 8,000	[4] 8,000
Total	14,430,000	17,620,000	18,890,000	19,580,000	22,100,000	23,290,000
Oceania:						
Australia	1,023,590	1,029,821	1,083,941	1,103,980	1,085,104	1,082,784
Fiji	78,237	67,475	75,150	86,794	72,565	72,203
New Guinea	99,452	79,085	68,564	43,254	46,663	45,019
New Zealand	48,216	26,063	30,195	24,981	36,758	[4] 37,000
Papua	346	391	466	558	156	132
Total	1,249,841	1,202,835	1,258,316	1,259,567	1,241,246	1,237,138
World total (estimate) [1]	34,600,000	38,400,000	39,600,000	40,600,000	42,700,000	45,000,000

[1] In addition to countries listed, gold is also produced in Austria, Bulgaria, China, Czechoslovakia, East Germany, Hungary, Indonesia, Rumania, and Thailand, but production data are not available; estimates for these countries are included in the total. For some countries accurate figures are not possible to obtain owing to clandestine trade in gold (as, for example, in former French West Africa).
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Imports into the United States.
[4] Estimate.
[5] Refinery production.
[6] Exports.
[7] Average for 1953-55.
[8] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.
[9] Estimate according to Minerais et Metaux (France), except 1960.
[10] Purchases. Production may be greater.
[11] Including gold in lead concentrates exported amounting to the following: 3,314 ounces in 1951-55 (average); 11,871 ounces in 1956; 9,192 ounces in 1957; 11,951 ounces in 1958; 10,391 ounces in 1959; and 8,930 ounces in 1960.

Compiled by Augusta W. Jann, Division of Foreign Activities

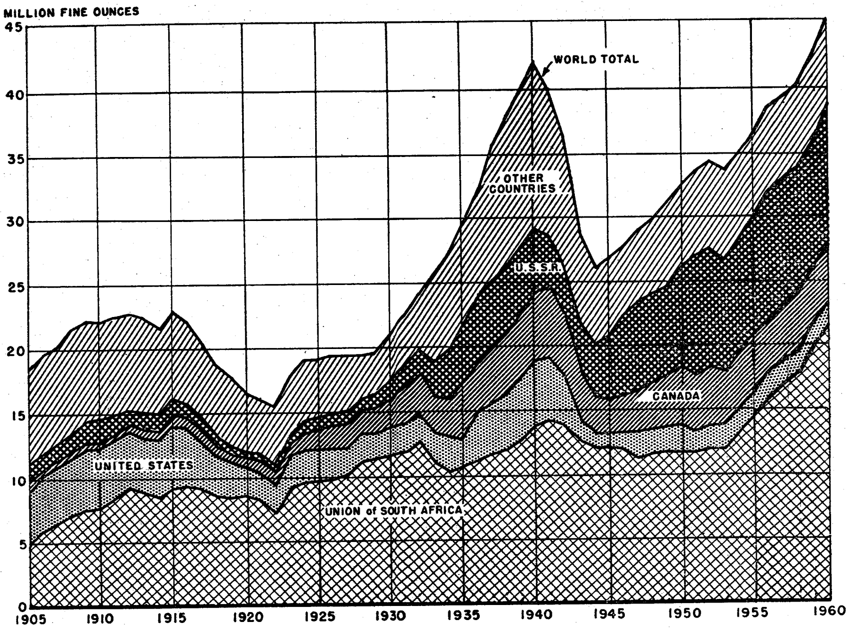

FIGURE 3.—World production of gold, 1905–60.

Australia.—Gold output in Australia declined slightly to 1.08 million ounces. The Commonwealth Government continued to provide financial aid to marginal gold producers through income tax exemptions and subsidy payments. The State of Western Australia also provided assistance to prospectors and small operators by furnishing facilities for crushing and assaying ores and by providing loans of mining equipment.

Western Australia contributed more than three-fourths of the total gold output of the Commonwealth; most of the production came from the Kalgoorlie field. Lake View and Star treated 763,540 tons of ore, recovered 164,880 ounces of gold, and reported a reserve of 3.5 million tons; Great Boulder reported an ore reserve of 2.1 million tons, grading 0.28 ounces per ton; North Kalguri increased its reserve to 2.3 million tons with a grade of 0.27 ounce per ton; Gold Mines of Kalgoorlie estimated its reserve at 1.3 million tons of 0.29 ounce ore, and Central Norseman reported a drop in its reserve to 0.5 million tons of 0.46 ounce ore. In Northern Territory, the Tennant Creek mine recovered 52,270 ounces of gold and reported a reserve of 152,000 tons of 1.26 ounce ore. In Queensland, the Mount Morgan mine milled 869,000 tons of ore and recovered 69,020 ounces of gold. Its ore reserve was estimated at 12 million tons at a grade of 0.12 ounce a ton gold and 1 percent copper. Gold mining continued to decline in Victoria. Only a few gold mines operated continuously during the year, the largest of which was Wattle Gully, treating about 3,500 tons a month.

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Canada.—Output of gold in Canada, the second ranking free-world producer, increased nearly 3 percent to 4.6 million ounces valued at Can$156.2 million. The production gain resulted essentially from improved economic conditions in the gold-mining industry, especially from the higher mint price for gold, which averaged nearly $33.93 an ounce compared with $33.57 in 1959. The higher mint price, which reflected a decrease in the premium on the Canadian dollar in relation to the U.S. dollar, helped to offset rising production costs due to the increased cost of labor, supplies, and power. An increase in the price of gold in the London market also was a significant factor contributing to increased earnings of gold mines not eligible to receive cost aid under the Emergency Gold Mining Assistance Act (E.G.M.A.). Amendment of E.G.M.A. in 1959, which granted a 25-percent increase in cost aid to lower-grade mines and extended its benefits to the end of 1963, also contributed significantly to offsetting increased operating costs and providing stability in the industry. The increased assistance thus provided made it feasible for these mines to continue profitable operation. Fifty-four lode gold mines operated during the year, 42 of which received cost aid under E.G.M.A. Three mines were closed, and two new mines began operating.

TABLE 15.—Canada: Geographical distribution of gold

Province or Territory	Troy ounces	
	1959 [1]	1960
British Columbia	184,312	202,822
Northwest Territories	405,922	411,492
Ontario	2,683,449	2,725,077
Prairie Provinces [2]	129,974	138,870
Quebec	999,388	1,033,249
Yukon	66,960	77,770
Newfoundland and Nova Scotia	13,411	13,482
Total	4,483,416	4,602,762

[1] Revised figures.
[2] Alberta, Saskatchewan, and Manitoba.

Source: Verity, T. W., Gold, 1960 (Prelim.): Mineral Resources Division, Dept. Min. and Tech. Surveys, Ottawa, Canada, February, 1961, 16 pp.

All provinces reported increased production of gold. Ontario, the leading gold-producing province, contributed 59 percent of the total output, followed by Quebec with 22 percent and the Northwest Territories with 9 percent. As in 1959, lode and placer gold mines supplied 87 percent of the total production; the remainder was recovered as a byproduct from base-metal ores. About 16,200 persons were employed in lode gold mines.

Kerr-Addison Gold Mines, Ltd., operating the leading gold mine in Canada, continued to expand production of gold for the seventh successive year with a record high of 592,244 ounces, valued at $20.4 million, an increase of 4 percent over 1959 output. Average gold recovery was $12.43 a ton, compared with $11.94 in 1959. Kerr-Addison's record output made it the leading gold producer in the Western Hemisphere. The proved ore reserve above the 4,500-foot level aggregated 9.1 million tons, having an average grade of 0.41 ounces a ton ($14.50). The H. G. Young Mines, Ltd., began operations in the Red Lake district of Ontario. Yukon Consolidated Gold Corp., operating six dredges and one hydraulic mine in the Dawson area of the Yukon Territory, reported a gravel reserve at the beginning of the year of 23.8 million cubic yards averaging 40 cents a cubic yard, enough for 4 years of operation. Decreased production in the older Porcupine and Kirkland Lake districts of Ontario was more than offset by increased output in other areas of the province.

Colombia.—Output of gold in Colombia increased 9 percent to 433,900 ounces, the third successive annual increase and the largest production since 1956. South American Gold & Platinum Co. recovered 166,200 ounces from dredging operations and underground mining, compared with 134,600 ounces in 1959 when a 2-month labor strike reduced ore production.

Output from its dredging operations in Choco and Narino declined slightly, but the reserve of developed gravel at yearend increased to 64.4 million cubic yards; the estimated recoverable value was 20 cents per cubic yard combined gold and platinum, a gain of 8.6 million yards during the year. Ore production from mines in Antioquia rose 40 percent, and developed ore reserves increased to 414,600 tons, averaging 0.75 ounces of gold per ton, compared with 398,800 ounces, averaging 0.78 ounces at the end of 1959.

Part of the company gold production was sold for pesos through the Colombian Mining Association at prices, yielding $35.21 an ounce, and the remainder was sold to the Banco de la Republica for dollars and pesos, yielding an average of $34.13 an ounce.[13]

Ghana.—After rising for three successive years, gold output in Ghana dropped about 4 percent in 1960 to 878,800 ounces. Ashanti Goldfields Corp., Ltd., the leading producer, established a new high output of 355,500 ounces, about 40 percent of the total production, but output at other principal mines, except Ghana Main Reef, declined. Ashtanti reported ore reserves of 2.56 million tons, averaging 0.82 ounces a ton, compared with 2.0 million tons, averaging 0.86 ounces a ton.

As a result of legislation increasing the minimum wage rate, the subsequent rise in the cost of labor, and the Government's denial of further financial aid, several marginal mines announced that they would close. The Government's offer to purchase these mines was ratified by the companies. Ashanti Goldfields Corp., Ltd., Ghana Main Reef, and Konongo Gold Mines, which mined higher grade ore, were not affected by the proposed transfer of ownership. About 25,400 Ghanian and 720 non-Ghanian persons were employed in the mining industry.

India.—Output of gold in India continued to decline for the sixth successive year, dropping 3 percent to 160,600 ounces. The Kolar Goldfields Mines in Mysore State contributed about 90 percent of the total production; the remainder came from the Hutti mines, also in Mysore. The decline was attributed to a lower grade of ore and the

[13] South American Gold & Platinum Co., 44th Annual Report, 1960, pp. 4–8.

adverse effects of rock bursts. The Indian Government bought all the gold from the mines at the international price, which was about half the Indian market price. The Government also paid a subsidy to the three producing Kolar Mines owned by the Mysore Government—the Nundydroog, Champion Reef, and Mysore—to meet the difference in production costs and the international price of gold.

Philippines.—Gold output in the Philippines increased 2 percent to 410,620 ounces, notwithstanding a rise in the cost of production and during the latter part of the year, a drop in the price received by domestic producers. Greater output from three of the four primary gold producers more than offset lower output from mines that recovered gold as a coproduct or byproduct. The effective price of gold for the first 7 months was 147 pesos, equivalent to $36.75 at the free-market rate of 4 pesos to $1. In the latter part of the year decontrol measures of the Central Bank reduced the bank's purchase price to 120.75 pesos, equivalent to $35.00 an ounce at a free-market rate of 3.45 pesos to $1. The average price of newly mined gold was 141.2 pesos an ounce, approximately equivalent to $36.15. Emergency concessions were made by the Central Bank to offset in part the lower gold price received by the mining industry, pending enactment of gold subsidy legislation.

Eleven mines reported gold production during the year. Of the straight gold-mining companies, Benguet Consolidated, Inc., treated 1.24 million tons of ore and produced 237,700 ounces, about 58 percent of the country's output; Itogon-Suyoc Mines, Inc., produced 52,100 ounces; Baguio Gold Mining Co., 22,600 ounces; and Benguet Exploration, Inc., 9,300 ounces. Of the remaining seven producers recovering gold as a coproduct or byproduct, Lepanto Consolidated Mining Co., Inc., produced 48,100 ounces from treating copper ore; Philex Mining Corp., produced 11,600 ounces as a byproduct of copper; and Peracale-Gumaus Consolidated Mining Co. recovered 10,580 ounces from gold-silver-copper-lead ore.

A bill authorizing a depletion allowance of 23 percent of the gross income from gold mining not to exceed 50 percent of the net income was passed by the Philippine Congress.

Rhodesia and Nyasaland, Federation of.—After rising for 4 successive years, Southern Rhodesia's gold production dropped slightly to 562,700 ounces. The number of producing mines was reduced from 122 in 1959 to 114 at the end of 1960. Some of the smaller operations closed as economically minable ore became depleted. The Cam and Motor mine, the leading producer, recovered 107,500 ounces; Dalney produced 47,430 ounces; and Globe and Phoenix, 36,290 ounces. Government assistance to small gold mine operators included the rental of small portable milling plants and other equipment. The Government also purchased arsenical ores from small mines for treatment in its roasting plant. About 9,840 tons of ore was purchased under this program, 25,580 ounces of gold was recovered and sent to the Union of South Africa for refining. Improved roasting practice at the Government plant increased gold recovery from about 80 to 92 percent.

Union of South Africa.—The gold-mining industry continued to expand its output for the ninth successive year, setting a new production record of 21.4 million ounces valued at US$748 million, 6 percent more than in 1959. The production gain resulted from an increase in the tonnage of ore treated at established mines and at younger mines of the Transvaal and Orange Free State and from an improvement in grade of ore milled. The supply of native labor continued to improve and contributed to the increased output and profits. Improvements in tonnage and grade increased the estimated working profit by US$33 million to a total of US$274.3 million. Minable reserves also were substantially increased.

TABLE 16.—Union of South Africa: Salient statistics of the gold mining industry

	1951-55 (average)	1956	1957	1958	1959	1960
Ore milled thousand tons	61,281	67,525	66,114	65,542	70,479	71,259
Gold recovered thousand troy ounces	[1] 12,310	[1] 15,374	16,541	17,666	20,067	21,386
Gold recovered ounces per ton	.198	.228	.250	.261	.278	.293
Working revenue (gold) thousands	$423,925	$555,799	$595,271	$613,650	$700,426	$750,550
Working revenue per ton milled	6.92	8.02	8.80	9.21	9.79	10.39
Working cost thousands	311,877	405,339	419,642	430,715	448,130	464,386
Working cost per ton	5.08	6.01	6.35	6.57	6.35	6.51
Working cost per ounce of gold	25.70	26.37	25.38	25.03	22.74	22.13
Estimated working profit from gold thousands	112,136	135,661	161,934	171,797	241,019	274,341
Estimated working profit per ton from gold	1.83	2.01	2.45	2.64	3.44	3.87
Premium gold sales	3,293	2,471	2,597	2,455		
Uranium and thorium exports	27,254	107,999	139,607	148,980	145,982	147,055
Estimated uranium profits	15,466	69,054	93,263	105,678	76,268	77,033
Dividends thousands	57,723	78,897	102,758	119,199	127,040	131,528

[1] Excludes gold produced by nonmembers of Chamber of Mines.

Source: Transvaal Chamber of Mines.

Union Corp., Ltd., reported an aggregate of 10.2 million tons that was milled by its gold-mining group of companies and yielded an average of 0.25 ounce per ton at a working cost of US $5.26 per ton.[14] Ore reserves were 31.4 million tons, averaging 0.28 ounce per ton, slightly lower than at the end of 1959. On the East Rand, East Geduld Mines milled 1.56 million tons, yielding 0.29 ounce per ton at a cost of US $5.06 per ton, and reported ore reserves of 6.1 million tons, averaging 0.29 ounce per ton across a stoping width of 54 inches. Development and production results at the Winkelhaak mine on the Far East Rand continued to exceed estimates, and operations and production capacity were expanded. Tonnage milled during the year increased to 1.06 million; the average yield was 0.32 ounce per ton. Working costs were reduced to US $6.80 per ton milled. Ore reserves at yearend were increased to 2.7 million tons, averaging 0.36 ounce per ton over an estimated stoping width of 60 inches. In the Orange Free State, St. Helena Gold Mines milled 2.0 million tons, yielding 0.34 ounce per ton at a cost of US $6.01 per ton, and reported ore reserves of 5 million tons averaged 0.40 ounce per ton across a stoping width of 56 inches.

Consolidated Gold Fields of South Africa, Ltd., reported that its Gold Fields group of companies milled 11.6 million tons of ore,

[14] Union Corp., Ltd., Reports and Accounts for the Year Ended 31st December, 1960, p. 22.

yielding 0.31 ounce per ton at a working cost of $22.31 per ounce.[15] Doornfontein Gold Mining Co., Ltd., milled 1.16 million tons at a working cost of US $21.12 per ounce and reported an increase in ore reserves. West Driefontein Gold Mining Co., Ltd., milled 1.36 million tons of ore at a working cost per ounce of US $10.96, returning a world record monthly working profit in February 1960 of over US $2.8 million and a total working profit for the year of US $31.8 million. The company reported an ore reserve at June 30 of 3.32 million ounces, averaging 0.78 ounce per ton gold and 0.24 pound uranium oxide per ton.

At Western Deep Levels, lateral development on the Ventersdorp Contact Reef at the 6,300 level was started. A new world shaft sinking record was established at the Hartbeestfontein mine in the Klerksdorp district with monthly advance of 1,106 feet.

TECHNOLOGY

Johnson, Matthey & Co., Ltd., London, announced the development of an improved gold-plating bath for use in printed circuits that overcomes the principal defect of conventional gold-plating baths—failure of the laminate bond because of the effect of the high free-cyanide content of the plating solution.[16] The new bath, Acid Hard Gold, produces gold deposits of optimum durability having a Vickers hardness in the range 120–130. Relatively stress-free deposits are obtained by operating the bath at 50° C. or above, with a current density of not less than 3 amperes per square foot. The weight deposited is 5.15 grams per ampere-hour.

Processes for coating gold on the interior of missiles for space flight to reduce heat radiation to the payload were described in a trade journal.[17] In the first of two processes, a sulfo-resinate of gold dissolved in toluol is spray-coated onto the cleaned surface, air-dried, baked at 375° F. for 15 minutes, and thermally decomposed by heating for 1 hour in air at 700° F. A second method, used principally to coat electrical printed circuits and contacts, uses ionic displacement in a nonelectrolytic immersion process. Cleaned parts are immersed 5 minutes in a commercial immersion gold solution maintained at a temperature between 120° and 160° F. and a pH between 7 and 8. Gold coatings may be applied to stainless steels by the first method, but other materials such as tool steels, aluminum, magnesium, copper, and chromium-base alloys must be plated with nickel before applying the gold. Gold coatings may also be applied over ceramic coatings, which are used as a diffusion barrier if exposed above 1,500° F. Typical coatings range in thickness from 0.000002 to 0.00001 inch and the cost of material ranges from 10 to 60 cents a square foot, making gold coatings economical for use as a reflective heat barrier in space vehicles.

A cyanide leaching process was developed to recover gold from molybdenum concentrates at the San Manuel Copper Corp. This unu-

[15] The Consolidated Gold Fields of South Africa, Ltd., Seventy-third Annual Report 1960, p. 22.

[16] Metallurgia (Manchester, England), Gold Plating of Printed Circuits: Vol. 62, No. 372, October 1960, p. 172.

[17] Wyatt, J. L., Gold Coatings: Metal Progress, vol. 78, No. 6, December 1960, p. 164.

sual application of cyanidation is reported to give excellent recovery of gold.[18]

An effective method of treating a complex arsenical gold ore from the Marietta mine near Townsend, Mont. was developed by Northern Milling Co., Inc.[19] The ore comprises massive sulfides—pyrite and arsenopyrite—with a little chalcopyrite and sphalerite carrying galena, gold and silver, and small amounts of bismuth and antimony. A rougher flotation concentrate is produced using Z–6 xanthate collector in a soda ash-sodium sulfite pulp. The concentrate is cleaned, using potassium permanganate ($KMnO_4$) as a depressant for arsenopyrite. Close control of the Z–6 and $KMnO_4$ is required for optimum results.

An improved method of extracting gold from acid cyanide solutions containing iron, copper, arsenic, zinc, and silver with isoamyl alcohol was reported in a Soviet technical journal.[20] The extraction of gold and impurities was measured with radioactive isotopes. Percentage extraction reached 98.5 using 0.1 mole per/liter of sulfuric acid and an organic-to-aqueous phase ratio of 1:5. The method may be applied to cyanide solutions from gold-electroplating baths as well as to those from ores.

Improved ion-exchange resins for use in recovering gold from cyanide liquors were developed at the National Chemical Laboratory [21] in England. Tests indicated that the new resins have greatly increased gold absorption capacity and that the gold can be eluted and recovered from the resin by an aqueous solution of sodium thiocyanate, which is passed continuously through a cycle containing the resin column and an electrolytic plating cell. The new resins also can be used to recover gold or silver from electroplating solutions.

A patent [22] was issued for a process to improve the extraction of cyanidable precious metals from carbon-containing ores, using organic chemical reagents of five different groups to minimize the reprecipitating effect of the carbon, and recover the extracted precious metals. The chemical groups comprise aralkyl mercaptans, diaryldithiophosphoric acids, diarylthioureas, mercapto-thiazole, and alkyl phenol.

A process was patented for extracting precious metals from ores using alpha-hydroxy nitriles.[23] Tests indicated that these chemicals are more effective than inorganic cyanides in extracting gold from some refractory ores.

Two new processes for electroplating gold were described at the 1960 annual meeting of the American Electroplaters' Society.[24] A

[18] Tveter, E. C., Annual Review—Minerals Beneficiation, Concentration: Min. Eng., vol. 13, No. 2, February 1961, p. 176.
[19] Wade, W. R., Arsenic Problem of Marietta Gold Ore Finally Solved by Selective Flotation: Min. World, vol. 22, No. 10, September 1960, pp. 38–41.
[20] Zvyagintsev, O. E., Zakharov-Nartsissov, O. I., Extraction of Gold from Cyanide Solutions Obtained by Treating Gold Ores: Jour. Appl. Chem. of the U.S.S.R., vol. 33, No. 1, January 1960, pp. 52–54.
[21] Chemical Trade Journal and Chemical Engineering (London), Gold and Silver Recovery: Vol. 147, No. 3829, Oct. 21, 1960, p. 18.
[22] Hedley, N., and Tabacknick, H. (assigned to American Cyanamid Co., New York, N.Y.), Extraction of Precious Metals From Carbon-Containing Ores: Canadian Patent 604,070, Aug. 23, 1960.
[23] Carpenter, E. L., and Hedley, N. (assigned to American Cyanimid Co., New York, N.Y.), Canadian Patent 592,038, Feb. 2, 1960.
[24] Materials in Design Engineering, What's New in Materials: Vol. 53, No. 3, March 1961, p. 166.

heavy gold-plating process for use in protecting nuclear reactor components uses a gold solution, containing small quantities of sulfonated castor oil and relatively large quantities of free cyanide. Currents of 4 to 10 amperes per square foot are used to make bright, dense plates up to 30 mils thick. A thin gold-plating process for gold plating copper-printed circuits uses sodium gold cyanide with citric acid and/or ammonium gold citrate. The electroplates range in thickness from 0.003 to 0.1 mil and have low porosity.

A new gold-antimony alloy with improved properties for transistors was developed by Baker Contact Division of Engelhard Industries, Inc., Newark, N.J. The alloy, consisting of high purity gold containing 1 percent antimony, was available in rod or whisker wire and in thin sheet.[25]

A two-stage roasting-cyaniding process for recovering gold from ore, concentrate, or residue containing iron and other metallic elements was described.[26] The process involves roasting the ore between 1,650° to 2,400° F., cooling, and treating with an aqueous solution of sodium cyanide and lime to extract the major portion of the gold. The residue is heated between 1,650° to 2,200° F., cooled, and again treated with an aqueous solution of sodium cyanide and lime to extract additional gold.

Several other significant articles pertaining to the technology of gold were published in 1960.[27]

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[25] American Metal Market, Gold-Antimony Transistor Alloy: Vol. 67, No. 2, Jan. 5, 1960, p. 6.

[26] Engineering and Mining Journal, What's New in Patents: Vol. 161, No. 9, September 1960, p. 140.

[27] Romanowitz, C. M., High Speed Bucket-Lines Boost Capacity of South American Dredges . . .: World Min., vol. 13, No. 8, July 1960, pp. 37–41.

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Clark, W. B., Skin Diving for Gold in California: Min. Inf. Service, vol. 13, No. 6, June 1960, pp. 1–8.

Graphite

By Harold J. Drake[1] and Betty Ann Brett[2]

THE PRINCIPAL suppliers of graphite to the United States in 1960 were Mexico, Malagasy Republic (formerly Madagascar), and Ceylon. Substantial increases in production were reported for Austria, Ceylon, Malagasy Republic, Mexico, and the Republic of Korea. Austrian production, which increased 200 percent in 1959, increased another 42 percent in 1960. These gains made it second only to the Republic of Korea in annual production and materially contributed to the record high production of 465,000 short tons of natural graphite established in 1960.

TABLE 1.—Salient graphite statistics

	1951–55 (average)	1956	1957	1958	1959	1960
United States:						
Consumption .... short tons	35,700	40,400	41,000	28,800	40,200	37,300
Value .... thousands	$4,918	$5,920	$5,568	$3,972	$5,395	$4,773
Imports for consumption ... short tons	47,600	47,900	41,500	27,100	37,000	47,500
Value .... thousands	$2,670	$2,594	$2,107	$1,203	$1,527	$1,739
Exports .... short tons	1,400	1,100	1,300	1,200	1,400	1,900
Value .... thousands	$182	$160	$226	$193	$222	$289
World: Production .... short tons	216,000	290,000	410,000	350,000	410,000	465,000

DOMESTIC PRODUCTION

Crystalline flake graphite was produced by Southwestern Graphite Co. at Burnet, Tex., and by Graphite Corporation of America at Chester Springs, Pa.

Manufactured (artificial) graphite products were produced by National Carbon Co., Division of Union Carbide Corp., at Niagara Falls, N.Y., Clarksburg, W. Va., and Columbia, Tenn.; by Great Lakes Carbon Corp., at Niagara Falls, N.Y., Morganton, N.C., and Antelope Valley, Calif.; International Graphite & Electrode Division, Speer Carbon Co., St. Marys, Pa., and Niagara Falls, N.Y.; and Stackpole Carbon Co., St. Marys, Pa. The Dow Chemical Co. produced graphite electrodes for its own use at Midland, Mich.

CONSUMPTION AND USES

Graphite consumption decreased in 1960 for all except five uses: Bearings, foundry facings, paints and polishes, pencils, and refractories. Foundry facings, steelmaking, lubricants, and crucibles continued to furnish more than three-fourths of the mineral used.

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.

TABLE 2.—Consumption of natural graphite in the United States

Year	Short tons	Value	Year	Short tons	Value
1951-55 (average)	35,679	$4,917,500	1958	28,823	$3,971,800
1956	40,401	5,920,300	1959	40,239	5,394,800
1957	41,029	5,568,000	1960	37,289	4,773,000

TABLE 3.—Consumption of natural graphite in the United States in 1960, by uses

Use	Crystalline flake		Ceylon amorphous		Other amorphous [1]		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Batteries	22	$14,904			791	$90,136	813	$105,040
Bearings			81	$38,433	80	25,537	161	63,970
Brake linings	424	165,988	216	60,465	231	65,332	871	291,785
Carbon brushes	72	28,250	327	160,351	173	28,298	572	216,899
Crucibles, retorts, stoppers, sleeves, and nozzles	2,987	500,028	40	10,556			3,027	510,584
Foundry facings	434	73,396	381	78,282	13,332	910,814	14,147	1,062,492
Lubricants	1,344	310,823	1,418	272,482	2,029	271,492	4,791	854,797
Packings	196	103,823	29	18,354	134	29,133	359	151,310
Paints and polishes			125	13,650	263	21,511	388	35,161
Pencils	493	125,200	602	182,019	638	92,870	1,733	400,089
Refractories					3,815	388,660	3,815	388,660
Rubber	[2]165	[2]40,924					165	40,924
Steelmaking	196	33,138			5,917	535,155	6,113	568,293
Other [3]	185	52,707	7	4,949	142	25,694	334	83,350
Total	6,518	1,449,181	3,226	839,541	27,545	2,484,632	37,289	4,773,354

[1] Includes small quantities of crystalline flake and Ceylon amorphous, and mixtures of natural and manufactured graphite.
[2] Includes some amorphous.
[3] Includes adhesives, carbon resistors, catalyst manufacture, chemical equipment and processes, electronic products, powdered-metal parts, roofing granules, specialties, and other uses not specified.

PRICES

Quoted prices for graphite merely indicate the range of prices; actual prices are negotiated between buyer and seller on the basis of a wide range of specifications.

Until December, prices for crystalline flake graphite quoted by E&MJ Metal and Mineral Markets included transportation costs from point of origin and importers' handling costs and commissions. During this period, quotations for crystalline flake were as follows per pound, carlots, c.i.f. U.S. ports: 86 to 88 percent carbon, crucible grade, 7½ to 14 cents; 94 percent carbon, normal and wire drawing, 20 to 27 cents; 96 percent carbon, special and dry usage, 22 to 27 cents; 98 percent carbon, special for such articles as brushes, 25 to 30 cents; Malagasy Republic, special grades, 85 to 87 percent carbon, 10 cents; special mesh, 13 cents; and special grade, 99 percent carbon, 40 cents. Prices for amorphous, crude, bulk carlots, f.o.b. point of origin were as follows: Mexican, 80 to 85 percent carbon, $15 to $19 per metric ton; Hong Kong, 78 to 85 percent carbon, $15 to $19 per long ton; and Korean, $18 per metric ton.

The December prices, all given at points of origin, were: Flake and crystalline graphite, bags, per metric ton, Malagasy Republic, $70 to $200; Norway, $80 to $140; and West Germany, $110 to $320. Ceylon graphite was listed at $95 to $250 per long ton. Amorphous graphite was quoted per short ton as follows: Mexico (bulk), $17 to $20; Republic of Korea (bulk), $15; Hong Kong (bags), $21.

FOREIGN TRADE[3]

Imports from Mexico, Ceylon, and Hong Kong increased; those from the Malagasy Republic decreased. The combined increase in

TABLE 4.—U.S. imports for consumption of natural and artificial graphite, by countries

Year and country	Crystalline				Amorphous				Total	
	Flake		Lump, chip, or dust		Natural		Artificial			
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1951–55 (average)	9,171	$1,342,506	266	$35,336	37,978	$1,278,822	232	[1] $12,866	47,647	[1] $2,669,530
1956	7,264	997,746	171	34,707	40,370	[1] 1,555,828	83	5,427	47,888	2,593,708
1957	5,456	636,684	47	14,870	36,019	1,453,051	8	2,197	41,530	2,106,802
1958	2,905	358,880	101	21,890	24,036	819,211	25	3,122	27,067	1,203,103
1959:										
North America:										
Canada					39	3,870	1	113	40	3,983
Mexico					25,760	497,933			25,760	497,933
Europe:										
Austria					15	599			15	599
France	17	6,154							17	6,154
Germany, West	402	71,848	66	19,168	759	84,019			1,227	175,035
Norway					1,834	142,095			1,834	142,095
Switzerland							4	1,507	4	1,507
United Kingdom	1	358	(2)	356					1	714
Asia:										
Ceylon			28	4,444	2,284	281,362			2,312	285,806
Hong Kong					994	28,210			994	28,210
Turkey	28	2,805							28	2,805
Africa:										
British East Africa	22	3,820			56	5,889			78	9,709
Madagascar	4,738	372,328							4,738	372,328
Total	5,208	457,313	94	23,968	31,741	1,043,977	5	1,620	37,048	1,526,878
1960:										
North America:										
Mexico					36,077	692,915			36,077	692,915
Europe:										
France	40	23,474							40	23,474
Germany, West	220	39,917	121	36,630	727	85,418	176	53,280	1,244	215,245
Norway					1,637	129,805			1,637	129,805
Switzerland							9	3,672	9	3,672
Asia:										
Ceylon					2,836	341,202			2,836	341,202
Hong Kong					2,027	45,347			2,027	45,347
India					1	180			1	180
Turkey	28	1,680							28	1,680
Africa:										
British East Africa					124	10,262			124	10,262
Malagasy Republic[3]	3,465	275,682							3,465	275,682
Total	3,753	340,753	121	36,630	43,429	1,305,129	185	56,952	47,488	1,739,464

[1] Owing to changes in tabulating procedures by the Bureau of the Census, some data known to be not comparable with other years.
[2] Less than 1 ton.
[3] Madagascar before July 1, 1960.

Source: Bureau of the Census.

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce. Bureau of the Census.

TABLE 5.—U.S. exports of natural graphite, by countries

Year and destination	Amorphous		Crystalline flake, lump, or chip		Natural, n.e.c.		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1959:								
North America:								
Bahamas	-	-	-	-	6	$2,250	6	$2,250
Canada	556	$52,488	35	$21,440	-	-	591	73,928
Cuba	11	1,847	4	1,252	-	-	15	3,099
Dominican Republic	-	-	3	1,620	-	-	3	1,620
Mexico	5	2,589	29	10,413	17	5,680	51	18,682
Netherlands Antilles	-	-	-	-	2	1,090	2	1,090
Panama	-	-	21	3,990	-	-	21	3,990
South America:								
Brazil	161	23,382	-	-	1	580	162	23,962
Chile	-	-	2	528	-	-	2	528
Colombia	5	692	7	3,490	52	2,875	64	7,057
Venezuela	23	5,666	59	11,449	64	4,725	146	21,840
Europe:								
Austria	5	953	-	-	-	-	5	953
Czechoslovakia	17	2,695	-	-	-	-	17	2,695
France	-	-	-	-	12	1,793	12	1,793
Germany, West	66	9,900	-	-	-	-	66	9,900
Greece	-	-	-	-	2	2,592	2	2,592
Netherlands	-	-	1	1,240	-	-	1	1,240
United Kingdom	130	20,737	-	-	11	3,426	141	24,163
Asia:								
India	5	952	-	-	-	-	5	952
Japan	-	-	-	-	1	2,160	1	2,160
Philippines	18	3,246	6	1,622	16	5,446	40	10,314
Saudi Arabia	-	-	2	3,570	-	-	2	3,570
Turkey	1	528	-	-	-	-	1	528
Viet-Nam	-	-	-	-	1	105	1	105
Africa: United Arab Republic (Egypt Region)	-	-	-	-	10	1,780	10	1,780
Oceania: Australia	-	-	-	-	1	1,350	1	1,350
Total	1,003	125,675	169	60,614	196	35,852	1,368	222,141
1960:								
North America:								
Canada	686	75,559	36	13,511	1	1,114	723	90,184
Cuba	10	1,466	25	5,089	-	-	35	6,555
El Salvador	-	-	3	620	-	-	3	620
Mexico	114	14,829	32	13,282	42	5,606	188	33,717
Netherlands Antilles	-	-	-	-	([1])	396	([1])	396
South America:								
Argentina	2	631	-	-	-	-	2	631
Bolivia	-	-	3	574	-	-	3	574
Brazil	110	16,055	-	-	169	24,672	279	40,727
Chile	3	448	2	868	2	825	7	2,141
Colombia	-	-	9	2,718	-	-	9	2,718
Peru	-	-	1	304	-	-	1	304
Venezuela	-	-	35	7,698	40	7,649	75	15,347
Europe:								
Austria	11	1,836	-	-	-	-	11	1,836
Czechoslovakia	12	1,978	-	-	-	-	12	1,978
Denmark	11	1,836	-	-	-	-	11	1,836
France	59	11,908	-	-	12	3,183	71	15,091
Germany, West	9	1,324	-	-	([1])	202	9	1,526
Greece	-	-	-	-	3	1,978	3	1,978
Italy	1	192	-	-	([1])	616	1	808
Netherlands	-	-	([1])	620	-	-	([1])	620
Sweden	5	952	-	-	-	-	5	952
United Kingdom	306	46,312	-	-	11	1,718	317	48,030
Asia:								
India	23	3,546	2	884	-	-	25	4,430
Pakistan	4	770	-	-	-	-	4	770
Philippines	11	1,708	16	4,621	18	5,595	45	11,924
Saudi Arabia	-	-	([1])	408	-	-	([1])	408
Turkey	-	-	-	-	1	824	1	824
Africa: United Arab Republic (Egypt Region)	-	-	-	-	15	1,911	15	1,911
Oceania: Australia	-	-	-	-	([1])	271	([1])	271
Total	1,377	181,350	164	51,197	314	56,560	1,855	289,107

[1] Less than 1 ton.

Source: Bureau of the Census.

imports from Ceylon and Hong Kong virtually offset the decrease reported from the Malagasy Republic. Thus, the rise in imports from Mexico was equivalent to the total increase in United States imports.

TABLE 6.—World production of graphite, 1896–1960

(Short tons)

Year	North America			South America		Europe					
	Canada	Mexico	United States	Argentina	Brazil	Austria [1]	Czechoslovakia [2]	France	Germany [3]	Italy	Norway
1896	789	876	1,028	--------	--------	39,652	--------	--------	5,785	3,470	--------
1897	436	837	1,752	--------	--------	42,439	--------	--------	4,255	6,228	--------
1898	660	1,505	2,070	--------	--------	36,442	--------	--------	5,060	7,093	--------
1899	1,310	2,541	3,774	--------	--------	35,076	--------	--------	5,728	11,012	--------
1900	1,922	2,823	3,366	--------	--------	37,107	--------	--------	10,196	10,714	--------
1901	2,210	840	2,792	--------	--------	33,069	--------	--------	4,889	11,368	--------
1902	1,095	1,581	3,268	--------	--------	32,548	--------	165	5,537	10,152	--------
1903	728	1,548	3,469	--------	--------	32,616	--------	139	4,101	8,730	--------
1904	452	1,069	4,541	--------	--------	31,548	--------	17	4,171	10,764	--------
1905	541	1,069	4,218	--------	--------	37,937	--------	110	5,424	11,651	--------
1906	387	4,316	5,544	--------	--------	42,016	--------	276	4,470	11,910	2,101
1907	579	3,530	5,274	--------	--------	54,482	--------	138	4,446	12,114	1,543
1908	251	1,186	2,587	--------	--------	48,970	--------	--------	5,340	14,236	1,192
1909	864	1,878	4,047	--------	--------	44,875	--------	--------	7,467	12,768	--------
1910	1,392	2,834	4,202	--------	--------	36,520	--------	606	8,174	13,790	--------
1911	1,269	3,362	3,618	--------	--------	46,855	--------	408	12,454	13,911	--------
1912	2,060	3,878	3,835	--------	--------	50,017	--------	661	13,314	14,517	285
1913	2,162	4,889	4,775	--------	[4] 3	54,516	--------	1,316	13,291	12,285	331
1914	1,647	4,695	4,335	--------	--------	42,897	--------	331	15,009	9,443	196
1915	2,635	4,618	4,718	--------	[4] 2	35,976	--------	--------	18,640	6,808	--------
1916	3,955	518	8,088	--------	[4] 1	54,330	--------	--------	33,785	9,019	--------
1917	3,714	463	13,592	--------	[4] 17	65,621	--------	1,819	41,290	13,357	--------
1918	3,114	6,824	12,991	--------	[4] 50	52,858	--------	2,350	45,190	12,845	--------
1919	1,360	4,435	7,422	--------	[4] 2	[1] 9,111	33,672	717	33,648	8,406	--------
1920	2,190	3,553	9,510	--------	--------	12,724	25,270	300	22,751	5,950	11
1921	937	3,209	2,437	--------	(7)	14,639	14,905	1,213	27,078	5,768	--------
1922	597	2,264	3,125	--------	--------	15,470	11,574	--------	35,651	5,011	--------
1923	1,113	6,051	6,038	--------	--------	10,365	10,883	209	22,990	6,273	--------
1924	1,334	8,844	4,971	--------	(7)	10,497	13,156	567	11,110	8,532	--------
1925	2,569	6,905	4,665	--------	--------	14,417	20,355	1,256	18,577	10,954	--------
1926	2,727	4,817	5,470	--------	--------	16,266	33,971	1,047	15,767	10,588	--------
1927	1,829	6,434	5,207	2	--------	19,906	45,319	893	19,591	9,254	--------
1928	1,097	5,795	5,611	--------	[4] 10	26,705	35,640	992	19,251	7,749	--------
1929	1,461	7,516	6,458	--------	[4] 17	27,884	26,071	863	23,533	[9] 7,837	--------
1930	1,535	6,452	[10] 1,940	--------	[4] 11	19,499	16,050	254	27,553	[9] 6,173	--------
1931	548	3,441	(11)	--------	[4] 10	13,294	2,017	--------	25,983	4,464	972
1932	346	2,254	(11)	--------	--------	11,682	1,016	--------	22,937	3,246	741
1933	405	2,960	(11)	--------	[4] 1	16,282	134	--------	21,776	3,527	2,186
1934	1,518	4,286	(11)	--------	--------	20,001	3,861	--------	19,329	4,308	2,746
1935	1,782	7,690	(11)	--------	[4] 2	21,484	2,061	--------	23,879	5,680	2,912
1936	--------	11,303	(11)	20	--------	23,931	3,225	--------	26,775	5,732	4,001
1937	--------	12,357	(11)	28	[4] 10	20,016	5,670	--------	25,953	5,965	4,010
1938	--------	10,594	(11)	31	--------	18,576	6,525	--------	30,982	6,046	4,191
1939	--------	10,819	(11)	--------	3	26,470	8,454	--------	31,063	6,300	4,776
1940	--------	13,588	(11)	110	--------	25,343	11,822	--------	32,949	5,507	2,917
1941	--------	18,660	2,748	149	[4] 66	26,746	9,583	--------	32,817	4,559	3,955
1942	--------	22,946	7,120	269	116	28,884	14,469	--------	36,725	6,044	3,233
1943	1,903	22,792	9,939	261	369	27,928	23,426	--------	38,537	6,954	3,503
1944	1,582	14,305	5,408	502	581	27,136	23,654	--------	40,077	3,316	4,171
1945	1,910	26,052	4,888	367	528	4,103	12,096	--------	(13)	2,509	1,229
1946	1,975	24,195	5,575	276	728	271	5,631	--------	[3] 4,189	2,858	729
1947	2,398	30,847	4,387	166	7,716	4,238	7,716	--------	5,434	5,010	2,735
1948	2,539	38,868	9,949	175	1,019	12,010	16,535	--------	6,095	7,993	1,194
1949	2,147	26,249	6,102	195	613	15,593	(12)	--------	5,346	5,114	2,488
1950	3,586	27,145	5,102	3	519	16,187	(12)	--------	7,937	4,984	2,708
1951	1,569	36,691	7,135	237	672	20,092	(12)	--------	11,358	4,976	3,806
1952	2,040	26,623	5,606	4	938	21,728	(12)	--------	9,272	4,837	4,144
1953	3,466	33,434	6,281	35	648	16,185	(12)	--------	7,901	5,731	3,255
1954	2,463	24,013	(11)	103	1,008	19,184	(12)	--------	10,044	4,165	3,993
1955	--------	32,343	(11)	96	855	19,637	(12)	--------	11,533	2,595	5,970
1956	--------	32,655	(11)	572	579	20,597	(12)	--------	12,878	3,191	5,562
1957	--------	25,938	(11)	451	890	20,857	(12)	--------	12,554	3,093	6,266
1958	--------	21,564	(11)	525	1,323	23,318	(12)	--------	12,021	4,393	4,927
1959	--------	30,684	(11)	[6] 550	[6] 1,300	68,440	(12)	--------	12,361	3,412	5,396
1960	--------	37,826	(11)	[6] 550	(12)	97,114	(12)	--------	12,800	4,098	[6] 5,500

See footnotes, p. 536.

TABLE 6.—World production of graphite, 1896–1960—Continued

(Short tons)

Year	Europe (Continued)			Asia							Africa
	Spain	Sweden	U.S.S.R.	Ceylon[4]	China	Hong Kong	India	Japan	Korea		Kenya
1896		15		11,533			67	237			
1897		110		21,247			66	225			
1898		55		[6]22,000			66	381			
1899		39		32,008			1,746	58			
1900		93		21,129			2,050	104			
1901		62		25,030			2,789	97			
1902		69		28,211			5,126	107			
1903		28		26,998			3,801	126			
1904		61		29,187			3,257	238			
1905		44		34,319			2,601	230			
1906		41		40,320			2,912	155			
1907		36		36,406			2,725	115			
1908		73		28,908			3,219	195			
1909		29		28,655			3,508	136			
1910		55		33,078			4,471	162			
1911		72		30,240	22		4,461	126			
1912		87		36,493				163			
1913		97		31,963				735	13,560		
1914		62		15,943				632	7,207		
1915	33	96	254	24,442			78	734	6,040		
1916	1,367	214	331	37,430			1,476	1,267	8,667		
1917	2,183	136	364	30,393			116	1,467	9,742		
1918	783	880	579	17,307			90	2,079	7,761		
1919	2,158		1,213	7,473			142	2,154	10,180		
1920	6,961			10,310			112	1,249	12,351		
1921	3,056		1,874	4,871			28	992	7,952		280
1922	584			12,152			22	1,153	16,581		
1923				11,949				883	15,727		
1924			[8]186	10,809			104	845	16,477		
1925	2,144		[8]2,739	17,278			244	1,113	15,518		
1926	665		[8]7,082	13,018				549	17,389		
1927	388		[8]7,559	14,430				698	19,778		
1928			[8]2,449	16,067				487	24,780		
1929			5,043	14,266			44	340	27,721		
1930			5,071	9,801				254	22,128		
1931			5,291	7,527			8	325	15,487		
1932			7,280	6,832			6	546	18,534		
1933		19	7,496	10,705				958	24,997		
1934		28	6,442	12,958			377	1,069	34,496		
1935		76	12,456	15,577	3,142		624	1,324	49,271		
1936		69	14,110	15,136	3,377		434	1,737	45,100		
1937		28	16,535	19,467	2,080		625	2,091	45,336		
1938		53	(12)	13,197	1,543		513	2,776	63,182		
1939		182	(12)	25,084	2,205		1,048	2,066	91,949		
1940		76	(12)	26,912	19,180		343	1,335	103,918		
1941		76	(12)	30,501	18,629		912	2,860	75,663		
1942		67	(12)	30,724	18,519		1,182	2,655	105,881		
1943	63	71	(12)	22,457	[6]11,000		1,270	3,553	106,341		(7)
1944	100		(12)	13,736	[6]11,000		1,038	3,925	113,875		11
1945	141	238	(12)	8,759	[6]11,000		1,451	6,758	35,723		3
1946	353		(12)	9,052	(12)		1,822	8,176	[6]6,800		
1947	341		(12)	10,086	(12)		1,383	11,671	[6]11,000		
									North Korea	*Republic of Korea*	
1948	266		(12)	15,676	(12)		1,846	10,065	(12)	17,035	
1949	282		(12)	13,709	(12)		1,089	6,248	(12)	44,832	
1950	342		(12)	14,363	(12)		1,776	4,420	(12)	18,058	
1951	302		(12)	14,136	(12)		1,943	5,361	(12)	26,074	1
1952	863		(12)	8,578	(12)		2,405	5,126	(12)	16,601	39
1953	352		(12)	8,084	(12)	220	859	4,488	(12)	21,416	205
1954	451		(12)	8,654	(12)	2,061	1,657	4,515	(12)	15,344	347
1955	349	309	(12)	11,064	(12)	1,722	1,807	3,441	4,288	99,151	241
1956	331	441	(12)	10,261	(12)	2,734		3,757	20,642	67,367	619
1957	304	822	[6]50,000	9,223	(12)	3,703		5,272	34,969	162,703	1,056
1958	227	593	[6]50,000	6,341	[6]35,000	3,680		3,817	[6]45,000	103,806	739
1959	457	700	[6]50,000	8,817	[6]45,000	3,676		4,453	[6]55,000	91,045	635
1960	[6]440	[6]700	[6]50,000	10,107	[6]45,000	4,255		5,139	[6]55,000	101,722	[6]1,100

See footnotes, p. 536.

TABLE 6.—World production of graphite, 1896–1960—Continued

(Short tons)

Year	Africa					Oceania—Australia	Other countries [5]	World total
	Malagasy Republic (Madagascar)	French Morocco	Spanish Morocco	South-West Africa	Union of Africa			
1896	---	---	---	---	---	---	---	65,000
1897	---	---	---	---	---	---	---	80,000
1898	---	---	---	---	---	---	---	75,000
1899	---	---	---	---	---	---	---	95,000
1900	---	---	---	---	---	---	---	90,000
1901	---	---	---	---	---	---	---	85,000
1902	---	---	---	---	---	---	---	90,000
1903	---	---	---	---	---	---	---	85,000
1904	---	---	---	---	---	---	---	85,000
1905	---	---	---	---	---	36	---	100,000
1906	---	---	---	---	---	34	---	115,000
1907	11	---	---	---	---	34	---	120,000
1908	90	---	---	---	3	22	---	105,000
1909	220	---	---	---	3	---	---	105,000
1910	601	---	---	---	40	---	---	105,000
1911	1,373	---	---	---	44	---	---	120,000
1912	3,011	---	---	---	42	---	---	130,000
1913	8,815	---	---	---	39	---	---	150,000
1914	12,381	---	---	---	34	8	---	115,000
1915	17,571	---	---	---	41	78	---	125,000
1916	29,238	---	---	---	60	79	---	190,000
1917	38,581	---	---	---	86	98	8,818	230,000
1918	16,119	---	---	---	79	229	16,535	200,000
1919	5,493	---	---	---	86	113	8,245	135,000
1920	15,905	---	---	---	73	59	1,375	130,000
1921	6,856	---	---	---	47	---	2,205	100,000
1922	7,358	---	---	---	42	56	476	115,000
1923	11,870	---	---	---	60	---	66	105,000
1924	14,382	---	---	---	55	3	2,555	105,000
1925	14,336	---	---	---	52	---	280	135,000
1926	17,530	---	---	---	51	---	898	150,000
1927	15,386	---	---	---	64	11	452	170,000
1928	19,842	---	---	---	56	---	---	165,000
1929	16,314	[4] 115	---	---	58	56	---	165,000
1930	11,464	[4] 154	---	---	56	---	238	130,000
1931	5,182	[4] 55	---	---	48	67	381	85,000
1932	2,976	[4] 110	---	---	54	78	450	80,000
1933	3,968	[4] 73	---	---	65	33	522	95,000
1934	9,370	[4] 202	---	---	70	7	502	120,000
1935	10,775	[4] 262	---	---	73	48	377	160,000
1936	8,110	441	---	---	65	25	387	165,000
1937	11,714	370	---	---	69	15	465	175,000
1938	16,033	338	80	---	60	11	20,926	195,000
1939	13,444	977	60	---	65	---	18,790	245,000
1940	16,877	583	388	78	86	121	18,105	280,000
1941	14,350	629	25	207	82	484	13,000	255,000
1942	10,540	1,176	277	200	729	336	5,880	300,000
1943	14,274	292	87	1,938	487	640	6,180	305,000
1944	15,959	235	---	1,800	357	493	6,005	290,000
1945	11,161	289	110	1,453	216	126	19,100	150,000
1946	6,961	705	---	1,315	306	389	20,380	105,000
1947	5,699	441	---	1,807	244	340	20,830	135,000
1948	9,921	320	28	1,793	190	259	24,355	180,000
1949	10,076	79	17	2,496	118	139	40,820	185,000
1950	15,447	82	3	1,521	269	162	49,500	175,000
1951	20,214	144	---	2,895	362	52	55,290	215,000
1952	20,368	23	19	1,305	389	89	62,030	195,000
1953	14,847	108	---	---	413	17	57,330	185,000
1954	13,284	---	---	115	1,396	78	73,630	185,000
1955	17,443	---	129	1,011	1,829	24	81,120	300,000
		Morocco						
1956	17,451	137		---	1,862	11	89,440	290,000
1957	16,989	---		---	1,750	---	52,800	410,000
1958	13,427	---		---	875	---	16,740	350,000
1959	12,614	132		---	617	---	15,620	410,000
1960	15,906	---		---	894	---	16,880	465,000

See footnotes, p. 536.

Total exports of natural graphite, 1956–58 were: 1956, 1,062 tons, $159,792; 1957, 1,349 tons, $225,536; and 1958, 1,166 tons, $192,859.

Amorphous graphite valued at $50 per ton or less was admitted to the United States free of duty if entered or withdrawn from warehouse for consumption within 2 years after May 13. (Public Law 86–453, approved May 13, 1960.) Before enactment of this law, all amorphous graphite imports were dutiable at 2½ percent ad valorem.

WORLD REVIEW

World graphite production increased sevenfold from 1896 to 1960. Most of the increases was recorded after 1955 and was attributable to low-value amorphous graphite, mainly from Austria and the Republic of Korea. A comprehensive historical table, showing production in the major countries, is published for the first time.

Austria.—The Austrian graphite mining industry, second only to that of the Republic of Korea in quantity of output, was composed of four companies and employed about 250 miners to produce ore, principally for steelmaking. About 200 short tons of natural graphite was imported, mostly from the West German mine of Graphitwerk-Kropfmuehl A.G. in Bavaria. Exports for 1957, 1958, 1959, and the first 9 months of 1960 were 16,000, 16,000, 18,000, and 15,000 tons, respectively.[4]

Canada.—Joseph Dixon Crucible Co., Jersey City, N.J., relinquished its lease on a large deposit of graphite in Leeds County, southeastern Ontario.

Ceylon.—Although the number of mines producing graphite decreased from 44 in 1955 to 12 in 1958, 3 other mines resumed operations in 1959. The reduction of export duty from 50 rupees (US$10.50) per long ton to 20 rupees (US$4.20) per long ton in November 1959 aided in increasing exports. In 1959, three large mines capable of producing more than 75 tons per month continued operations. Three other mines produced over 25 tons per month and nine produced less than 25 tons per month. Japan resumed second place in 1959, next to the United States, as a market for Ceylon graphite.[5]

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[4] Bureau of Mines, Mineral Trade Notes: Vol. 52, No. 5, May 1961, pp. 12–13.
[5] Bureau of Mines, Mineral Trade Notes: Vol. 52, No. 5, May 1961, pp. 14–16.

Footnotes for Table 6

[1] Includes Hungary through 1918.
[2] Bohemia and Moravia prior to 1918 included in Austria.
[3] Beginning 1946, West Germany only.
[4] Exports.
[5] Includes the following countries: Brazil 1960, Bulgaria 1939–40, Chile 1953, China 1946–57, Czechoslovakia 1949–60, Finland 1919–47, French Equatorial Africa 1938–46, Greenland 1920–37, Indochina 1917–44, Malaya 1942–45, Mozambique 1943–51, North Korea 1953–54, Peru 1946, Southern Rhodesia 1944–45, Taiwan 1952–60, Tanganyika 1951–60, U.S.S.R. 1938–56, United Arab Republic (Egypt Region) 1944–48, United States (1930 crystalline), 1931–40 and 1954–60; Uruguay 1942–47 and Yugoslavia 1952–60.
[6] Estimate.
[7] Less than 1 ton.
[8] Year ending September 30.
[9] Excluding anthracitic.
[10] Amorphous only; confidential data on crystalline included with "Other Countries."
[11] Confidential data, included with "Other Countries."
[12] Data not available, estimate included with "Other Countries."
[13] Data not available.

Compiled by Helen L. Hunt and Liela S. Price, Division of Foreign Activities.

TABLE 7.—Ceylon: Exports of graphite by countries

Short tons)

Destination	1959	1960	Destination	1959	1960
North America:			Asia:		
Canada	237	28	India	398	494
United States	2,721	2,380	Japan	2,487	3,105
Europe:			Pakistan	59	69
Czechoslovakia		158	Philippines	56	37
France	112	224	Oceania: Australia	371	480
Germany, West	198	129	Other countries	72	43
Netherlands	34	79			
United Kingdom	2,072	2,881	Total	8,817	10,107

Compiled from Customs Returns of Ceylon by Bertha M. Duggan and Cora A. Barry, Division of Foreign Activities.

TABLE 8.—Ceylon: Exports of graphite to the United States, by grades, in 1960 [1]

Grade	Short tons	Percent of total	Value per ton
97 percent carbon or higher	980	44	$141.00
90-96 percent carbon	1,081	48	100.05
Less than 90 percent carbon	168	8	97.50
Total	2,229	100	117.86

[1] Bureau of Mines, Mineral Trade Notes: Vol. 52, No. 5, May 1961, p. 16.

Czechoslovakia.—Czechoslovakia reportedly produced enough graphite for its needs from southern Bohemia and northern Moravia.[6]

Hungary.—Workmen discovered a graphite deposit at a depth of 525 feet in Szendro, northern Hungary, while sinking shafts for drinking water. The extent of this deposit was not determined.[7]

Italy.—Imports and exports, in short tons, were 6,259 and 1,386 in 1959; and 5,604 and 1,623 in 1958, respectively.[8]

Japan.—Nippon Electrode Co., Ltd., entered into an agreement for the 10-year use of processes and know-how developed by General Electric Japan, Ltd., Tokyo, Japan, for producing impermeable and

TABLE 9.—Malagasy Republic: Exports of graphite, by countries

(Short tons)

Destination	1958	1959	Destination	1958	1959
North America: United States	2,923	3,836	Africa: Union of South Africa	244	13
Europe:			Asia: Japan	112	121
Belgium-Luxembourg	69	46	Oceania: Australia	167	261
France	2,442	1,919	Other countries	39	12
Germany, West	3,425	2,472			
Italy	1,489	644	Total	12,236	12,144
Netherlands	14	10			
Poland	86	65			
Spain	66	203			
United Kingdom	1,160	2,542			

Compiled from Customs Returns of the Malagasy Republic by Bertha M. Duggan and Corra A. Barry, Division of Foreign Activities.

[6] Mining Journal (London), Graphite: Vol. 255, No. 6534, Nov. 11, 1960, p. 536.
[7] Mining Journal (London), Mining Miscellany: Vol. 254, No. 6489, Jan. 1, 1960, p. 18.
[8] Bureau of Mines, Mineral Trade Notes: Vol. 51, No. 4, October 1960, p. 30.

low-permeability manufactured graphite. The Japanese company will pay £50,000 (US$140,000) and royalties of 10 percent on the impermeable and 7.5 percent on the low-permeability material. Sales will be permitted anywhere except in the United Kingdom.[9]

Malagasy Republic.—The ratio of course flake (flake) to fine flake (fines) produced in 1957, 1958, and 1959 was 46 : 54, 42 : 58, and 40 : 60, respectively.[10] There were eight graphite-producing mines, all with headquarters in Tananarive.[11]

Morocco.—Moroccan-American Development Co. planned to invest $2 million in the first year, developing a graphite and vermiculite deposit. The concession area was leased from Mauretania S.A. in north Morocco, about 25 miles from Tetuan. The company expected to mine and mill approximately 1,000 tons of graphite ore monthly from a deposit containing 1.5 to 2 million tons of ore. The vermiculite ore body was to be developed later.[12]

Rhodesia and Nyasaland, Federation of.—The crystalline flake graphite deposit in the Petauke district of the Eastern Province of Northern Rhodesia attracted overseas interest, particularly among London metal and mineral dealers. Nearly 50 occurrences of graphite-bearing ore assaying up to 17 percent graphitic carbon were found in a 100-square-mile area. The quality of the flake was apparently good, and there was sufficient water and labor available. The cost of transportation to the coast and the possibility of obtaining a nonuniform concentrate were factors inhibiting the development of the area.[13]

Yugoslavia.—Slavonski Rudnici Nemetala graphite mine in Pakrak was expected to produce 1,600 tons in 1960. The construction of a flotation plant was planned to improve the grade of the graphite.[14]

TECHNOLOGY

Information on the occurrence, geology, mining, and preparation of graphite was presented.[15] The graphite districts of Montana, Texas, Alabama, Pennsylvania, and New York were described.

Armour Research Foundation, cooperating with the Atomic Energy Commission, developed a method of forming and graphitizing finished shapes from petroleum coke and furfuryl alcohol. This process, in which the alcohol hardens on heating, reduces the manufacturing time to about 2 hours. The mixture of coke and alcohol is heated to 5,000° F., where conversion to graphite occurs. Parts made in this manner do not require support during manufacture.[16]

High-purity low-porosity polycrystalline graphite, with the atoms arranged in planes so that sheets of crystals are oriented parallel to the

[9] Chemical Age (London), Japan Pays £50,000 for G.E.C. Graphite Know-how: Vol. 84, No. 2154, Oct. 22, 1960, p. 674.
[10] U.S. Embassy, Tananarive, Malagasy Republic, State Department Dispatch 60: Nov. 2, 1960, p. 1.
[11] Bureau of Mines, Mineral Trade Notes: Vol. 52, No. 2, February 1961, p. 12.
[12] World Mining, International, Africa, Morocco: Vol. 13, No. 1, January 1960, p. 61.
[13] Rhodesian Mining and Engineering, Overseas Interest in N.R. Graphite Find: Vol. 25, No. 7, July 1960, p. 42.
[14] Mining World, International, Europe, Yugoslavia: Vol. 22, No. 3, March 1960, p. 87.
[15] Cameron, Eugene N., and Weis, Paul L., Strategic Graphite—A Survey: Geol. Survey Bull. 1082-E, 1960, pp. 201–321.
[16] Ceramic Industry, New Binder Drastically Reduces Ceramic Graphite Process Time: Vol. 75, No. 3, September 1960, p. 115.
Chemical Engineering, New Process Slashes Graphite Molding Time: Vol. 67, No. 18, Sept. 5, 1960, p. 52.

surface of deposition, was produced by two companies. Oriented graphite is slightly ductile, has high strength and conducts both heat and electricity much better on planes parallel to the orientation of the crystals than on planes perpendicular to orientation. This type of graphite is produced by the thermal decomposition of a carbonaceous gas at or near a hot surface. Similar materials produced by the Raytheon Co. under the name of Pyrographite and by General Electric Co. under the name of Pyrolytic graphite may have numerous applications in missiles and space vehicles.[17]

Some properties of oriented graphite were compared with those of natural graphite, alumina copper, and tungsten.[18] Since the properties can be changed considerably by varying the conditions of formation, oriented graphite represents a family of materials rather than a single commodity.

Using a hot-working process more like those used in metallurgical than in ceramic processes, National Carbon Co. developed a recrystallized graphite in block form reported to have some properties similar to Pyrographite and Pyrolytic graphite.[19] Methods were advanced for making filamentary [20] and pure graphites.[21]

A new theory explained the reason for the lubricating properties of graphite,[22] and new lubricants [23] and uses [24] were described. Graphite was compacted with metals to make a strong, low-friction material.[25]

Graphite was used for speeding the brazing of stainless steel,[26] in heat exchangers,[27] and in ceramic protective coatings.[28]

The U.S.S.R. was reported to be producing high-tension cable with a core of polyvinylchloride, graphite, and other components instead of a metal strand.[29]

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[17] Ceramic Industry, New Developments in Pyrolytic Graphite by General Electric: Vol. 75, No. 5, November 1960, p. 94.
Metal Progress, Advances in Aircraft and Missile Technology Revealed at Dallas Meeting: Vol. 77, No. 6, June 1960, pp. 68A–68D.
Materials in Design Engineering, Two More Materials for High Temperatures: Vol. 51, No. 1, January 1960, pp. 170, 172.
Iron Age, How Oriented Graphite Copes With High Heat Problems: Vol. 185, No. 4, Jan. 28, 1960, pp. 92–93.

[18] Materials in Design Engineering, Oriented Graphite Produced by Commercial Process: Vol. 51, No. 2, February 1960, pp. 16, 170, 172.

[19] Materials Review, Super Graphites Successful in Rocket Motor Trials: Vol. 31, No. 11, November 1960, pp. 11–12.
Materials in Design Engineering, New High Density Graphite Looks Good for Rocket Nozzles: Vol. 52, No. 5, November 1960, p. 13.

[20] Bacon, Roger (assigned to Union Carbide Corp.), Filamentary Graphite and Method for Producing the Same: U.S. Patent 2,957,756, Oct. 25, 1960.

[21] Legendre, Andre, and Cornault, Pierre (assigned to Compagnie de Produits Chimiques et Electro Metallurgiques (Pechiney) and Commissariat a l'Energie Atomique), Process and Apparatus for Producing Pure Graphite: U.S. Patent 2,941,866, June 21, 1960.

[22] Bollmann, W., and Spreadborough, J., Action of Graphite as a Lubricant: Nature, vol. 186, Apr. 2, 1960, pp. 29–30.

[23] Arbocus, G. R., Synthetic Lubricant Holds Up on High Temperature Jobs: Iron Age, vol. 186, No. 7, Aug. 18, 1960, pp. 108–109.

[24] Iron and Steel Engineer, Graphite Lubricant Reduces Flange Wear on Crane Wheels: Vol. 37, No. 10, October 1960, p. 182.

[25] Humenik, M., Jr., and Van Alsten, R. L., New Family of Metal Graphites Handles Many Bearing Jobs: Iron Age, vol. 186, No. 19, Nov. 10, 1960, pp. 171–173.

[26] Steel, Graphite Cloth Speeds Heat Cycle: Vol. 146, No. 8, Feb. 22, 1960, p. 74.

[27] South African Mining and Engineering Journal (Johannesburg), The Graphite Heat Exchanger: Vol. 71, No. 3493, pt. 1, Jan. 15, 1960, p. 109.

[28] Journal of Metals, Ceramic-Graphite Material: Vol. 12, No. 8, August 1960, p. 600.

[29] E&MJ Metal and Mineral Markets, Russians Develop High-Tension Non-Metallic Cable: Vol. 31, No. 52, Dec. 29, 1960, p. 11.

Gypsum

By William V. Kuster[1] and Nan C. Jensen[2]

ALTHOUGH output of gypsum and gypsum products, closely related to the building industry, declined in 1960 from the pace established in the previous year, three new operations were begun in New Mexico to open up new market areas, while other facilities were expanding their mines and mills. Imports of gypsum also declined.

TABLE 1.—Salient gypsum statistics

(Thousand short tons and thousand dollars)

	1951-55 (average)	1956	1957	1958	1959	1960
United States:						
Active establishments [1]	87	88	84	85	93	96
Crude: [2]						
Mined	9,011	[3] 10,316	9,195	9,600	10,900	9,825
Value	$26,283	$34,099	$29,871	$32,495	[3] $39,231	$35,690
Imports for consumption	3,411	4,346	4,334	4,047	[3] 6,132	5,306
Calcined:						
Produced	7,592	8,608	7,801	8,122	9,268	8,591
Value	$71,375	$91,336	$83,455	$91,402	$111,740	$120,984
Products sold (value)	$259,458	$321,652	$301,095	$329,070	$388,335	$361,190
Gypsum and gypsum products:						
Imports for consumption (value)	$4,990	$8,546	$8,515	$7,864	[3] $13,196	$10,433
Exports (value)	$1,549	$1,216	$1,345	$2,465	$1,296	$1,293
World: Production	29,975	[3] 36,935	[3] 38,175	[3] 38,235	[3] 42,790	41,930

[1] Each mine, calcining plant, or combination mine and plant is counted as 1 establishment.
[2] Excludes byproduct gypsum.
[3] Revised figure.

DOMESTIC PRODUCTION

Crude.—Almost 9.9 million short tons of gypsum was produced from domestic mines in 1960, a decrease of 10 percent from the record established in the previous year. The production rate increased through the third quarter, when it was the greatest, and then declined in the fourth quarter. Over half of the crude gypsum mined in Iowa and Texas and over one-third of that mined in Michigan was calcined, whereas over half of the California output was sold for agricultural purposes. Of the 69 mines that operated during 1960, 53 were open pit and 16 were underground. Plants that had calcining equipment operated 38 of the mines and accounted for 86 percent of the crude gypsum output in 1960.

[1] Commodity specialist, Division of Minerals.
[2] Supervisory statistical assistant, Division of Minerals.

TABLE 2.—Crude gypsum mined in the United States, by States

(Thousand short tons and thousand dollars)

State	1959			1960		
	Active mines	Quantity	Value	Active mines	Quantity	Value
Arkansas	(1)	(1)	(1)	1	67	$208
California	14	1,686	$3,788	13	1,616	3,687
Colorado	5	106	385	4	82	296
Iowa	4	1,318	5,587	5	1,283	5,428
Michigan	5	1,721	6,595	4	1,463	5,609
Nevada	3	818	2,738	3	802	2,721
New Mexico				3	55	193
New York	5	919	4,663	5	755	3,928
South Dakota	1	19	78	1	22	89
Texas	6	1,351	4,770	7	1,131	3,960
Wyoming	1	9	30	1	13	46
Other States [2]	23	2,953	[3] 10,597	22	2,536	9,525
Total	67	10,900	[3] 39,231	69	9,825	35,690

[1] Included with "Other States."
[2] Includes the following States to avoid disclosing individual company confidential data: Arkansas (1959), Idaho (1959), Louisiana, Virginia, and Washington, 1 mine each; Indiana, Kansas, Montana, Ohio, and Utah, 2 mines each; Arizona (1959) 3 mines, (1960) 4 mines; and Oklahoma, 5 mines.
[3] Revised figure.

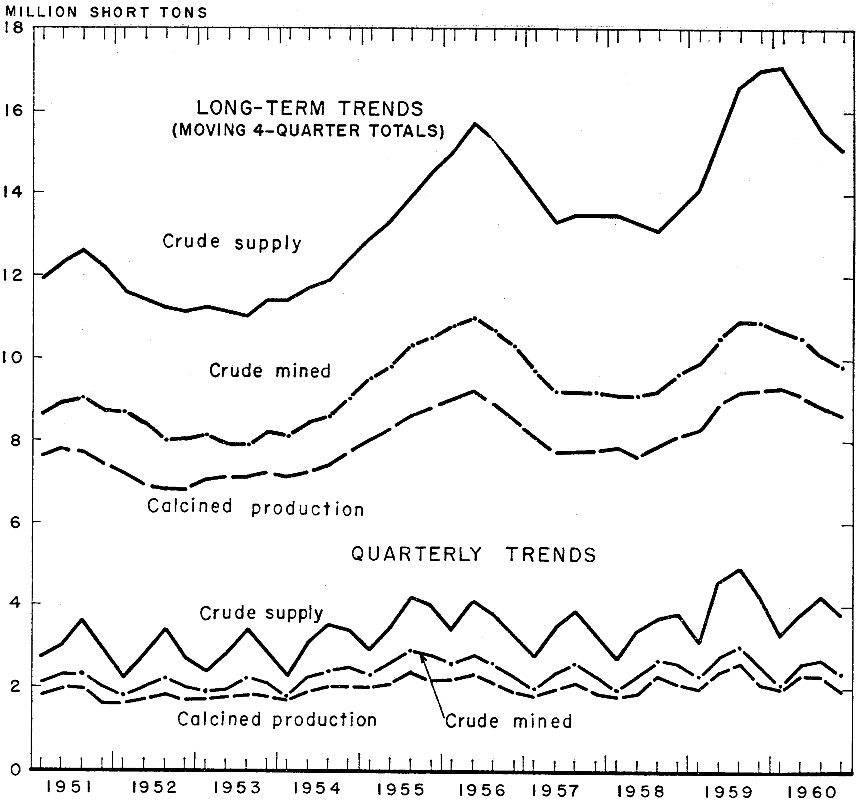

FIGURE 1.—Trends of new crude supply, domestic crude mined, and production of calcined gypsum, 1951–60, by quarters.

Calcined.—Calcined gypsum was produced from domestic and imported ores by 61 plants that had 277 kettles and other pieces of calcining equipment. The 8.6 million tons of calcined gypsum, valued at $121 million, produced in 1960 was 7 percent below the 1959 output. Oil, natural gas, and coal were used to supply the heat necessary to calcine gypsum.

TABLE 3.—Calcined gypsum produced in the United States, by States

(Thousand short tons and thousand dollars)

State	1959					1960				
	Active plants	Quantity	Value	Calcining equipment		Active plants	Quantity	Value	Calcining equipment	
				Kettles	Other [1]				Kettles	Other [1]
California	6	860	$8,197	18	10	6	838	$8,210	18	12
Iowa	4	861	10,592	20	4	4	793	11,517	20	4
Michigan	4	524	6,569	18	1	4	442	6,573	18	1
New York	7	1,349	16,698	24	6	7	1,186	16,979	24	6
Ohio	(2)	(2)	(2)	(2)	(2)	3	299	4,289	9	1
Texas	6	962	12,254	31	--------	6	789	12,445	31	--------
Other States [3]	33	4,712	57,430	103	36	31	4,244	60,971	97	36
Total	60	9,268	111,740	214	57	61	8,591	120,984	217	60

[1] Includes rotary and beehive kilns, grinding-calcining units, Holo-Flites, and Hydrocal cylinders.
[2] Figures withheld to avoid disclosing individual company confidential data; included with "Other States."
[3] Comprises States and number of plants as follows: Arizona, 1; Colorado (1959) 3, (1960) 2; Connecticut, 1; Florida, 1; Georgia, 2; Illinois, 1; Indiana, 3; Kansas, 2; Louisiana, 2; Maryland, 1; Massachusetts, 1; Montana, 1; Nevada, 2 New Hampshire, 1; New Jersey, 2; New Mexico (1960) 1; Ohio (1959) 2; Oklahoma, 1; Pennsylvania, 1; Utah, 2; Virginia, 2; and Washington, 1.

Mine and Products-Plant Development.—The $3 million plant of American Gypsum Co., 5 miles north of Albuquerque, N. Mex., went into production in December. Daily average production was 400,000 square feet of gypsum board products.

A new access slope and circular ventilating shaft was planned at the northeastern Kansas gypsum mine of Bestwall Gypsum Co. The mine will serve a new plant being built at Blue Rapids. Bestwall Gypsum Co. began constructing a $7.5 million building products plant at the Wilmington, Del., marine terminal in September. The plant, due to be completed in about a year, will produce 150 million square feet of gypsum wallboard, lath, and sheathing annually, as well as wall plasters, graded commercial rock, and agricultural gypsum. Design, equipment, and operation of the company's board and lath plant at Brunswick, Ga., were described.[3]

Big Horn Gypsum Co. was constructing a $3 million gypsum board plant at Cody, Wyo., to be ready for operation by January 1, 1961. The plant will have an annual production capacity of 100 million board feet of gypsum wallboard. This firm was reported in the 1959 chapter as the Big Horn Basin Gypsum Co.

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[3] Pit and Quarry, Bestwall Gypsum's Georgia Plant Has Many Firsts: Vol. 53, No. 4, October 1960, pp. 80–83, 90.
Rock Products, Bestwall Surges Into Deep South: Vol. 63, No. 11, November 1960, pp. 67–72.

An article described the mining methods and unique mobile mill of H. M. Holloway, Inc.[4] The 70-foot self-propelled mill processes gypsum at a rate of 300 tons per hour.

New Mexico's first gypsum plant was dedicated on June 9 by Kaiser Gypsum Co. The new board plant is located at Rosario, 42 miles north of Albuquerque, near three pueblos of the Santo Domingo and Coachete Indians. Mine and plant operations were described in an article.[5]

A major expansion of the National Gypsum Co. plant at Rotan, Tex., was completed. The expanded plant was expected to have sufficient capacity to produce gypsum wallboard, lath, plaster, and other building products for about 75,000 homes annually. Seven years of exploration, development, and construction were climaxed on June 8 by National Gypsum Co. with ceremonies marking completion of its new $25-million Great Lakes production network. The Lorain, Ohio, gypsum products plant was the final link in the extensive system. Natural Gypsum Co. began construction of a new $6 million gypsum products plant at Port Tampa, Fla. The plant will be fully automated, similar to the company's new plants at Lorain, Ohio, and Waukegan, Ill. Ore will be supplied by ships from the firm's deposits in Nova Scotia. Meanwhile, the Florida market was supplied from the recently expanded plant at Savannah, Ga. National Gypsum Co. also acquired Union Gypsum Co., in Phoenix, Ariz.

United States Gypsum Co. announced plans to build a new gypsum plant at Baltimore, Md., with completion scheduled for early 1962.

Universal Atlas Cement modernized extensively its facilities at Clarence Center, N.Y.[6]

The new chemical gypsum plant of Barrett Division, Allied Chemical Corp., to be built at Claymont, Del., will be able to make enough gypsum board annually for 32,000 homes.[7] Sludge from Allied Chemical's adjacent General Chemical Division phosphoric acid plant will be the raw material. Scheduled for operation in September 1961, the plant will have an initial capacity of 25 million pounds of gypsum per year.

CONSUMPTION AND USES

Outlays for new construction in the United States amounted to $55.1 billion, a decline of $1 billion, or nearly 2 percent from the record value of $56.2 billion established in 1959.[8] Private construction spending was down 3 percent to $38.9 billion, whereas outlays for public construction at $16.2 billion were virtually unchanged from 1959. The physical volume of construction activity—measured in constant dollars—dropped 4 percent in 1960, twice as much as in current dollars. The drop in physical volume was due in part to the rise in construction costs between 1959 and 1960. Residential

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[4] Pit and Quarry, Holloway Gypsum Grows With Area Agriculture: Vol. 53, No. 1, July 1960, pp. 104–106.

[5] Rock Products, Desert Unfolds Its Gypsum Lode: Vol. 64, No. 2, February 1961, pp. 92–96.

[6] Jordan, Robert B., Modernization of a Gypsum Operation: Min. Cong. Jour., vol. 46, No. 5, May 1960, pp. 34–37.

[7] Chemical and Engineering News, Synthetic Gypsum on the Way: Vol. 38, No. 35, Aug. 29, 1960, p. 21.

[8] Construction Review, vol. 7, No. 4, April 1961, p. 6.

construction, as in 1959, was the prime mover of total new construction activity. Spending for residential construction, which declined $2.5 billion in 1960, more than offset the $1.5 billion rise in all other types.

Gypsum building products consumption, particularly the high-value prefabricated materials, closely followed the pattern established by residential construction.

TABLE 4.—Gypsum products (made from domestic, imported, and byproduct crude gypsum) sold or used in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1959		1960	
	Quantity	Value	Quantity	Value
Uncalcined:				
Portland-cement retarder	2,757	$11,868	2,543	$11,246
Agricultural gypsum	1,188	3,672	1,126	3,706
Other uses [1]	44	569	47	534
Total	3,989	16,109	3,716	15,486
Calcined:				
Industrial:				
Plate-glass and terra-cotta plasters	68	982	62	895
Pottery plasters	50	1,062	49	1,057
Orthopedic and dental plasters	11	416	12	452
Industrial molding, art, and casting plasters	100	2,119	82	1,527
Other industrial uses [2]	82	2,508	79	2,431
Total	311	7,087	284	6,362
Building:				
Plasters:				
Base-coat	1,403	23,962	1,197	20,524
Sanded	634	15,335	584	14,205
To mixing plants	3	51	2	33
Gaging and molding	141	2,747	128	2,610
Prepared finishes	13	1,123	12	1,029
Roof-deck	415	6,941	407	6,774
Other [3]	25	2,585	23	2,371
Keene's cement	48	1,184	40	1,028
Total	2,682	53,928	2,393	48,574
Prefabricated products [4]	[5] 7,664	311,211	[5] 7,120	290,768
Total building	---------	365,139	---------	339,342
Grand total, value	---------	388,335	---------	361,190

[1] Includes uncalcined gypsum for use as filler and rock dust, in brewer's fixe, in color manufacture, and for unspecified uses.
[2] Includes dead-burned filler, granite polishing, and miscellaneous uses.
[3] Includes joint filler, patching, painter's, insulating, and unclassified building plasters.
[4] Excludes tile.
[5] Includes weight of paper, metal, or other materials.

STOCKS

Producers reported that stocks of crude gypsum on hand December 31, 1960, totaled 3.4 million short tons compared with 2.5 million tons at the end of 1959.

PRICES

According to reports from producers, the average value of crude gypsum mined in the United States was $3.63 per ton, compared with $3.60 in 1959. The reported values were not sales prices but rather values assigned arbitrarily by producers as a calculated or book cost

TABLE 5.—Prefabricated products sold or used in the United States, by products

Product	1959			1960		
	Thousand square feet	Thousand short tons [1]	Value (thousands)	Thousand square feet	Thousand short tons [1]	Value (thousands)
Lath:						
⅜-inch [2]	2,305,118	1,732	$60,320	1,867,710	1,410	$49,054
½-inch	40,999	42	1,281	42,510	43	1,332
Total	2,346,117	1,774	61,601	1,910,220	1,453	50,386
Wallboard:						
¼-inch	152,821	88	4,649	150,220	86	4,596
⅜-inch	2,195,283	1,677	77,748	2,055,077	1,578	73,189
½-inch	3,505,112	3,554	143,603	3,390,650	3,441	139,408
⅝-inch	225,047	294	12,625	236,791	310	13,203
Other [3]	1,099	2	72	1,855	3	116
Total	6,079,362	5,615	238,697	5,834,593	5,418	230,512
Sheathing	209,834	219	8,529	185,326	195	7,529
Laminated board	[4] 2,950	3	168	[4] 4,652	4	284
Formboard	50,540	53	2,216	47,651	50	2,057
Grand total [5]	8,688,803	7,664	311,211	7,982,442	7,120	290,768

[1] Includes weight of paper, metal, or other materials.
[2] Includes a small amount of ¼-inch lath.
[3] Includes 5/16-inch, ¾-inch, and 1-inch wallboard.
[4] Area of component board and not of finished product.
[5] Excludes tile, for which figures are withheld to avoid disclosing individual company confidential data.

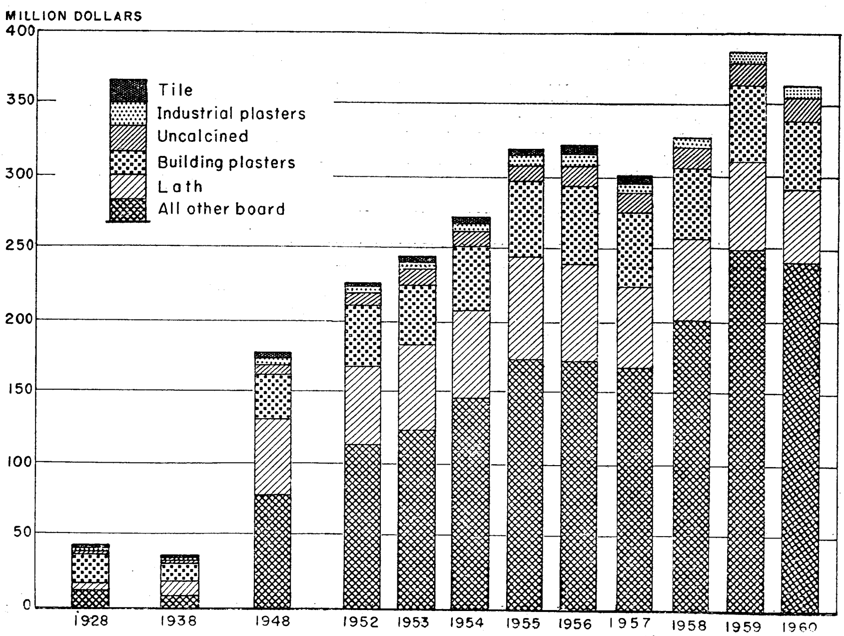

FIGURE 2.—Value of gypsum products sold or used in 1928, 1938, 1948, and 1952–60, by uses.

of mining the crude gypsum. This was particularly true of integrated or affiliated organizations where costs varied considerably among producers.

Portland cement retarder was $4.42 per ton, whereas the average value of agricultural gypsum was $3.29 per ton. Industrial plasters decreased 2 percent in average value. Building plasters and prefabricated gypsum products increased 1 percent in average values.

FOREIGN TRADE[9]

Imports of crude gypsum decreased 13 percent from 6.1 million tons in 1959 to 5.3 million tons in 1960. Canada provided 28 percent of the total U.S. supply.

TABLE 6.—U.S. imports for consumption of gypsum and gypsum products[1]

Year	Crude (including anhydrite)		Ground or calcined		Alabaster manufactures,[2] value (thousands)	Other manufactures, n.e.s., value thousands)	Total value (thousands)
	Short tons	Value (thousands)	Short tons	Value (thousands)			
1951-55 (average)	3,410,868	[3] $4,449	848	[3] $30	[3] $205	[3] $306	[3] $4,990
1956	4,346,135	[3] 7,814	1,146	39	[3] 416	[3] 277	[3] 8,546
1957	4,334,467	[3] 7,571	870	[3] 33	[3] 577	[3] 334	[3] 8,515
1958	4,046,999	6,864	787	33	612	355	7,864
1959	[4] 6,131,625	[4] 11,862	1,025	46	946	342	[4] 13,196
1960	5,305,816	8,997	1,159	48	963	425	10,433

[1] In addition, Keene's cement was imported as follows: 1951-55 (average), 4 short tons ($381); 1956-60, none.
[2] Includes imports of jet manufactures, which are believed to be negligible.
[3] Data known to be not comparable with other years.
[4] Revised figure.

Source: Bureau of the Census.

TABLE 7.—U.S. imports for consumption of crude gypsum (including anhydrite), by countries

(Thousand short tons and thousand dollars)

Country	1959		1960	
	Quantity	Value	Quantity	Value
North America:				
Canada	[1] 4,861	[1] $9,992	4,171	$7,044
Dominican Republic	113	308	332	883
Jamaica	437	915	231	549
Mexico	721	647	572	521
Total	[1] 6,132	[1] 11,862	5,306	8,997
Europe [2]	([3])	([4])	([3])	([4])
Grand total	[1] 6,132	[1] 11,862	5,306	8,997

[1] Revised figure.
[2] 1959: Italy; 1960: United Kingdom.
[3] Less than 1,000 tons.
[4] Less than $1,000.

Source: Bureau of the Census.

[9] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 8.—U.S. exports of gypsum and gypsum products

Year	Crude, crushed, or calcined		Plasterboard, wallboard, and tile		Other manufactures, n.e.c.[1] value (thousands)	Total value (thousands)
	Short tons (thousands)	Value (thousands)	Square feet (thousands)	Value (thousands)		
1951-55 (average)	23	$664	24,110	$745	$140	$1,549
1956	21	711	7,027	364	141	1,216
1957	24	763	8,867	520	62	1,345
1958	29	921	(1)	(1)	1,544	2,465
1959	14	641	(1)	(1)	655	1,296
1960	17	687	(1)	(1)	606	1,293

[1] Effective Jan. 1, 1958, plasterboard, wallboard, and tile not separately classified, included in "gypsum manufactures, n.e.c."

Source: Bureau of the Census.

WORLD REVIEW

NORTH AMERICA

Canada.—During 1959 producers of crude gypsum shipped 5,878,600 short tons valued at Can$8,393,700, compared with 3,964,100 tons valued at Can$5,139,159 in 1958.[10] The Commonwealth's two largest producing Provinces, Nova Scotia and Ontario, shipped 5,036,400 tons and 412,100 tons, respectively, in 1959. Remainder of the total shipments came from Manitoba (200,100 tons), New Brunswick (98,300 tons), British Columbia (94,000 tons), and Newfoundland (37,700 tons). Crude gypsum was mined by 6 producers at 12 sites; 4 of them manufactured gypsum products at 13 plants.[11] The six operators exported 82 percent of their output to markets along the eastern seaboard of the United States. Imports of crude gypsum were 117,800 tons, principally from Mexico. Most of the 19,700 tons of finished gypsum products imported into Canada in 1959 came from the United States.

To meet the increasing demand for building materials, caused by the rapid growth in housing and industrial development in the Province of Alberta, Gypsum, Lime & Alabastine Ltd. added a board plant and increased grinding and calcining capacity, rock storage, and warehousing and shipping facilities in Calgary.[12]

Columbia Gypsum Co. of Canada announced intention to seek a U.S. market. In March 1960, the company made public a balance sheet which included an investment in the Greenacres Gypsum Co., Inc., of Spokane. Estimated reserves of gypsum at the company's mine near Windemere, British Columbia, were between 10 and 20 million tons. Markets for this gypsum would be sought in the Spokane, Wash., area.[13]

[10] Dominion Bureau of Statistics, The Gypsum Industry 1959: Ottawa, Canada, December 1960, 12 pp.
[11] Canada Department of Mines and Technical Surveys, Gypsum and Anhydrite 1959: Ottawa, Canada, April 1960, 9 pp. (preliminary).
[12] Oszter, Zoltan F., New Plant Facilities for Gypsum, Lime & Alabastine Limited, Calgary, Alberta: Canadian Min. and Met. Bull., vol. 53, No. 575, March 1960, pp. 186–192.
[13] Northern Miner (Toronto), Columbia Gypsum to Seek U.S. Market: Vol. 46, No. 2, Apr. 7, 1960, p. 23.

TABLE 9.—World production of gypsum by countries [1] [2]

(Thousand short tons)

Country [1]	1951-55 (average)	1956	1957	1958	1959	1960
North America:						
Canada [3]	4,009	4,900	4,707	3,977	5,983	5,215
Cuba	[4] 33	24	[4] 45	[4] 45	[4] 45	([5])
Dominican Republic	30	84	80	84	175	[4] 176
Guatemala	----------	----------	7	17	[4] 17	[4] 17
Jamaica	88	140	212	645	525	248
Mexico	([6])	546	900	821	913	871
Trinidad	----------	1	3	3	5	7
United States	9,011	10,316	9,195	9,600	10,900	9,825
Total [4]	13,717	16,011	15,149	15,192	18,563	16,359
South America:						
Argentina	158	193	169	118	[4] 121	[4] 121
Brazil	69	175	121	143	202	[4] 220
Chile [4]	90	77	66	55	44	40
Colombia	12	55	[4] 66	66	77	77
Peru	[4] 57	70	70	69	61	90
Venezuela	1	----------	----------	----------	[4] 1	6
Total [4]	387	570	492	451	506	554
Europe:						
Austria [3]	309	500	579	597	621	730
Czechoslovakia	111	192	233	[4] 233	[4] 233	[4] 233
France (salable) [3]	3,092	3,933	4,028	4,079	4,134	[4] 4,134
Germany:						
East [7]	203	242	255	249	[4] 248	[4] 248
West [7]	906	1,046	982	958	1,058	1,332
Greece	19	6	6	24	33	[4] 39
Ireland	109	132	131	116	141	164
Italy	758	966	1,053	1,366	[4] 1,320	[4] 1,320
Luxembourg	7	6	8	[4] 9	[4] 9	[4] 9
Poland	218	390	[4] 390	[4] 390	[4] 390	[4] 440
Portugal	49	61	71	48	60	[4] 60
Spain	1,413	1,301	1,538	2,104	2,357	[4] 2,360
Switzerland	158	266	259	99	[4] 110	[4] 110
U.S.S.R.[8]	2,638	3,329	[4] 3,860	[4] 3,860	[4] 3,860	[4] 3,860
United Kingdom [3]	2,919	3,734	3,751	3,641	3,794	4,016
Yugoslavia	57	109	93	84	102	117
Total [1] [4]	13,055	16,300	17,325	17,945	18,560	19,265
Asia:						
Burma	[9] 2	----------	----------	----------	2	1
Ceylon	1	1	1	([10])	([10])	----------
China [4]	155	330	390	440	550	660
Cyprus [4]	165	140	160	155	165	165
India	561	956	1,033	876	945	1,099
Iran [11]	[4] 282	[4] 550	[4] 550	413	[4] 550	[4] 550
Iraq [4]	275	385	440	440	440	440
Israel [4]	32	55	56	44	66	66
Japan	298	417	527	528	596	832
Pakistan	31	41	72	74	109	105
Philippines	([10])	----------	----------	2	2	10
Taiwan	6	14	7	11	11	12
Thailand	([10])	----------	2	10	9	16
Turkey	[4] 19	[4] 32	[4] 42	50	[4] 57	67
United Arab Republic (Syria Region) [13]	4	2	[4] 2	[4] 3	[4] 7	15
Total [4]	1,831	2,923	3,282	3,046	3,509	4,038
Africa:						
Algeria	92	84	[4] 84	[4] 112	189	[4] 187
Angola	7	22	8	5	15	[4] 14
Congo, Republic of the (formerly Belgian)	7	9	12	[4] 11	----------	----------
Kenya	1	2	5	12	15	19
Morocco: Southern zone	14	28	[4] 28	[4] 28	[4] 28	[4] 28
Sudan	5	[4] 2	[4] 2	[4] 2	[4] 2	----------
Tanganyika	3	11	11	10	8	5
Tunisia	30	15	[4] 17	[4] 17	[4] 17	[4] 17
Union of South Africa	163	209	180	256	224	216
United Arab Republic (Egypt Region)	215	225	1,042	584	577	[4] 584
Total	537	607	1,389	1,037	1,075	[4] 1,070

See footnotes at end of table.

TABLE 9.—World production of gypsum, by countries—Continued

Country [1]	1951-55 (average)	1956	1957	1958	1959	1960
Oceania:						
Australia	438	524	536	565	579	[4] 643
New Caledonia	9					
Total	447	524	536	565	579	[4] 643
World total (estimate) [1 2]	29,975	36,935	38,175	38,235	42,790	41,930

[1] Gypsum is produced in Bulgaria and Rumania, but production data are not available; estimates for these countries are included in the totals. Production in Ecuador, Finland, and Korea is negligible.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Includes anhydrite.
[4] Estimate.
[5] Data not available; no estimate included in total.
[6] Data not available; estimate by senior author of chapter included in total.
[7] Crude production estimates based on calcined figures.
[8] Crude production for use in the construction industries only. In addition, substantial tonnages of gypsum are used in agriculture.
[9] Average for 1954-55.
[10] Less than 500 tons.
[11] Year ended March 20 of year following that stated.
[12] Some pure, some 60 percent gypsum and 20 percent limestone.

Compiled by Helen L. Hunt, Division of Foreign Activities.

TABLE 10.—Canada: Output of gypsum products

Product	1958		1959	
	Quantity	Value [1] (thousands)	Quantity	Value [1] (thousands)
Wallboard ... thousand square feet	375,004	Can$14,898	399,528	Can$15,854
Lath ... do	395,449	12,001	367,015	11,310
Hard wall plasters ... thousand short tons	231	5,109	229	5,070
Other plasters ... do	74	1,892	72	1,897
All other products [2]		1,819		1,330
Total		35,719		35,461

[1] Selling value at works.
[2] Includes tile and blocks, etc.

Source: Canada Department of Mines and Technical Surveys, Ottawa.

The Ontario Minister of Mines issued an exploratory license to the Moosonee Gypsum Exploration Co., Ltd., giving exclusive rights for 3 years to explore and develop deposits of gypsum, anhydrite, and calcium sulfate in an area about 384 square miles in the James Bay lowlands, in the district of Cochrane, Ontario. During the 3-year period, the company is bound to spend a minimum of $65,000 on drilling and other exploratory work and pay an annual fee of $2,000. If commercial deposits are located, the company has the option to lease a maximum of 10,000 acres in a single block. A plant must be constructed within 2 years after granting of the lease and production must begin within 3 years.[14]

An industrial first was claimed by Western Gypsum Products, Ltd., at its new plant, on stream in April, at Vancouver, British Columbia,

[14] Rock Products, Gypsum Exploration Rights Granted for Ontario Area: Vol. 63, No. 10, October 1960, p. 62.

with installation of a company-developed, gas-fired calcining kettle equipped with automatic timing and heat-control devices. The $2.5 million plant had several other features including a $75,000 electrostatic precipitator for dust collection and a completely automatic six-deck dryer. The dryer could produce enough gypsum board in 1 day to build 50 houses. A quarry near Lake Windermere in British Columbia supplied gypsum for the Vancouver plant.[15]

Flintkote Co. and the Newfoundland Government reached an agreement which paved the way for Flintkote to become the Province's biggest gypsum producer. The company was given immediate access to 40 square miles of gypsum properties at Flat Bay under an initial 99-year lease. The property reportedly contained at least 200 million long tons of gypsum. In addition, the company had 12 years to exercise rights to lease an area involving up to 3,000 square miles of undeveloped gypsum properties. Flintkote would pay the government a royalty of 5¢ per long ton of gypsum mined. Further, the agreement provided that Flintkote would acquire the assets of Atlantic Gypsum Co., Corner Brook, Newfoundland, for $1 million.[16]

Canadian Gypsum Co., Ltd., a subsidiary of U.S. Gypsum Co., put on stream a multimillion-dollar addition to its plant at Hagersville, Ontario. The plant was built directly over the gypsum mine 100 feet below; the new construction was adjacent to existing facilities. The expansion more than doubled the previous capacity.[17]

Dominican Republic.—Sal y Yeso Dominicanos C por A brought into full-scale production a large gypsum deposit near Las Salinas, 20 miles from the port of Barahona on the southwestern coast. The development had two phases: (1) A 400-ton-per-hour crushing and rail-car loading system at Las Salinas and (2) a stockpiling and ship-loading system at Barahona.[18]

Mexico.—The U.S. Gypsum Co. started construction at La Borreguita, S.L.P., of a crushing plant and a small village of about 25 single-dwelling units. The gypsum deposits are exposed on the surface or under shallow overburden. Crushed gypsum ore was transported by rail to the Port of Tampico for stockpiling and transshipment to U.S. Gypsum plants at New Orleans, La., and Galena Park, Tex.[19]

SOUTH AMERICA

Uruguay.—Trade with the Soviet bloc during 1959 included imports from Poland of 21,826 short tons of crude gypsum valued at $188,970.[20]

EUROPE

Germany, East.—The Chemiefaser-Kombinat, Coswig plant, using gypsum as a raw material, produced 80,000 tons of sulfuric acid in 1960 and announced a goal of 375,000 tons for 1963.

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15 Rock Products, Western Gypsum Products Opens Vancouver Plant: Vol. 63, No. 6, June 1960, p. 68.

16 Northern Miner (Toronto), Flintkote Gets Deal With Newfoundland on Gypsum Acreage: Vol. 46, No. 16, July 14, 1960, p. 13.

17 Pit and Quarry, vol. 52, No. 2, August 1960, p. 23.

18 Rock Products, Dominican Gypsrm Leaps Into World Spotlight: Vol. 63, No. 11, November 1960, pp. 76–80.

19 Pit and Quarry, U.S. Gypsum Begins Construction of Mexican Crushing Operation: Vol. 52, No. 12, June 1960, p. 32.

20 U.S. Embassy, Montevideo, Uruguay, State Department Dispatch 907: Mar. 30, 1960, p. 7, encl. 2.

Spain.—Interest in uses of gypsum products resulted in plans for two new projects assisted by German technical knowledge and capital: One was to develop gypsum deposits near the coast of Malaga and build a plant at Malaga to produce special gypsum and building materials and the second at Aranjuez, was to produce special gypsum for orthopedic, dental, and other uses.[21]

ASIA

Cyprus.—Exports in 1959 included 59,700 tons of gypsum rock and 1,723 tons of calcined gypsum.

India.—Rajasthan continued to be the major producing State in 1959, accounting for 95 percent of the total output. Bikaner Gypsum, Ltd., Bikaner, Rajasthan, the largest producer in India, supplied gypsum to the principal consumer, Sindri Fertilisers & Chemicals, Ltd., a State-owned plant in Bihar. The requirements of Fertilisers & Chemicals, Travencore, Ltd., Kerala, were met by the gypsum mines in the Tiruchirapalli district of Madras. In 1959 the price of special grade Rajasthan gypsum (90 to 95 percent $CaSO_4$) averaged $4.76 per ton and that of cement grade gypsum (80 to 85 percent $CaSO_4$) $2.38 per ton.

Imports of gypsum in 1959 decreased to 1,233 tons valued at US$4,620 from 5,508 tons valued at US$51,030 in 1958. Exports in 1959, all to East Pakistan, totaled 847 tons valued at US$17,220.[22]

Reserves of gypsum in Bombay, Madras, Rajasthan, Jammu, and Kashmir were reported to be 163 million tons.

Iran.—The Mesgarabad mine, 10 kilometers east of Tehran, produced gypsum which was hauled over gravel roads to the kilns in the city where it was fired into lime. During the development of the Mesgarabad mine, a cave with beautiful crystals of gypsum was encountered.[23]

Israel.—Of the 66,000 tons produced in 1959, 43,000 tons was used in the cement industry. Exports of gypsum in 1959 consisted of 551 tons, all to the Federation of Rhodesia and Nyasaland.

Lime and Stone Construction Co., Ltd., in the Wadi Ramon area, which began operating a calcining plant near the quarry in late 1959, processed 550 tons of raw gypsum a month for the manufacture of gypsum slabs and panels. The rated monthly productive capacity was reported to be 1,650 tons.[24]

Pakistan.—Large deposits of limestone and gypsum occur along the flanks of the Indus Valley in West Pakistan. The mined products were used mainly in the cement industry, and some gypsum was used in making fertilizer in a plant at Doudkhel, near Kalabagh.[25]

Thailand.—Thai Gypsum Co., started in 1957, was reported to have saved the Thai Government the equivalent of about US$500,000 a year in foreign exchange. The company planned to build a factory to produce construction materials with financial assistance from the

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[21] World Mining, German Firms Participate in Spanish Gypsum Products: Vol. 13, No. 10, September 1960, p. 69.

[22] Bureau of Mines, Mineral Trade Notes: Vol. 51, No. 6, December 1960, p. 32.

[23] Fayaz, Hashem, Mesgarabad Mine, Iran: Rocks and Minerals, vol. 35, Nos. 7–8, July–August 1960, pp. 333–335.

Czayo, Silvia E., Gypsum Cave in Iran: Rocks and Minerals, vol. 35, Nos. 7–8, July–August 1960, pp. 331–332.

[24] Bureau of Mines, Mineral Trade Notes: Vol. 51, No. 3, September 1960, p. 22.

[25] Mining Journal (London), vol. 254, No. 6500, Mar. 18, 1960, p. 325.

Development Loan Fund. The project had the approval of the Thai Board of Investment, and the company was granted the privilege of importing machinery and equipment duty free.[26]

AFRICA

Tanganyika.—The gypsum deposits at Mkomasi in the Lushoto district were nearing depletion and exports were reduced. Development of the better grade deposits in the Kilwa district was considered, but transport costs and communication difficulties were a problem. Adequate supplies of gypsum were available by sea from the Near East.[27]

OCEANIA

Australia.—Test drilling was begun on the dry bed of Lake Gairdner, which is actually a salt pan. The surface of the lake contains gypsum and salt.[28]

Large quantities of gypsum from the Dundas deposit near Lake Dundas were exported to Japan.[29]

The Australian Commonwealth Scientific and Industrial Research Organization developed a new method for irrigating heavy clay soils. Crude gypsum was added to the irrigation water in proportions as low as ½ pound to 100 gallons. The mixture of gypsum in water was pumped into a set of hydraulic cyclones which separated the undissolved gypsum from the solution and returned it to the sump. The gypsum particles continued to circulate through the system until they dissolved; the gypsum solution was removed continuously and pumped to the desired location. The solution was reported to prevent soil breakdown and the formation of hard surface crusts. Further, it allowed the water to infiltrate, air to enter, and seedlings to emerge from the soil.[30]

TECHNOLOGY

A continuous gypsum calcining process was reported to increase thermal efficiency to 78 percent, a significant contrast to the 30-percent efficiency of the conventional kettle process. Gypsum rock was dried and ground to 95 percent minus 100-mesh in a conventional preparation system. The ground gypsum was fed to a 4-section continuous calciner. Dehydration started in section 1 at 220° F. and continued in sections 2 and 3 under isothermal conditions. Hemihydrate was produced in section 4. The quality of the hemihydrate did not depend on gypsum rock quality because automatic controls adjusted the temperature in the calciner to compensate for changes in the feed. The type of hemihydrate produced can be regulated by control of dump temperature and agitator speed.[31]

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[26] Bureau of Mines, Mineral Trade Notes: Vol. 51, No. 2, August 1960, pp. 29–30.
[27] Mining Magazine (London), Tanganyika Mining Industry 1959: Vol. 103, No. 3, March 1960, p. 161.
[28] Mining and Chemical Engineering Review (Melbourne), vol. 52, No. 12, Sept. 15, 1960, p. 10.
[29] Mining and Chemical Engineering Review (Melbourne), vol. 53, No. 2, Nov. 15, 1960, p. 11.
[30] South African Mining and Engineering Journal (Johannesburg), Irrigation Technique With Gypsum: Vol. 71, No. 3502, pt. 1, Mar. 18, 1960, p. 669.
Mining and Chemical Engineering Review (Melbourne), Another Use for Cyclones: Vol. 52, No. 6, Mar. 15, 1960, p. 75.
[31] Chemical Engineering, Calciner Streamlines Gypsum Process: Vol. 67, No. 26, Dec. 26, 1960, p. 41.

Sulfur dioxide and lime were produced experimentally from gypsum under controlled conditions. Calcium sulfate was heated in an atmosphere of nitrogen, carbon dioxide, and sulfur dioxide and then reduced with carbon monoxide at elevated temperatures to produce sulfur dioxide and lime. The effects of variation in temperature and gas compositions were studied.[32]

A new salt plant produced high-purity salt directly from low-grade rock salt containing anhydride, making use of the inverse temperature solubility of $CaSO_4$.[33]

Results of differential thermal analysis and thermogravimetric analysis studies on gypsum from several different sources were reported.[34]

A modification of the ASTM Method for the Determination of the Normal Consistency of Plasters (C26–56) was suggested, using a conical plunger instead of a cylindrical plunger.

The suggested method was reported to be an improvement over other testing methods.[35]

The determination of the solubility of gypsum and its calcined products by conductivity measurements was described. A definite relation was indicated between solubility and the proportions of gypsum, hemihydrate, and anhydrite.[36]

A portable apparatus for determining the adhesion of gypsum plaster to various bases was described.[37]

The properties of cement were said to depend on whether the clinker and raw gypsum were ground separately or together. The strength of the cement increased as the content of gypsum increased; the maximum content of SO_3 appeared to be about 2 percent but varied with the type of gypsum. The behavior of different raw gypsums was reported to vary because of differences in particle structure. The suitability of various gypsums for cement manufacture was based on microscopic examination of the constitution of the crystals and of the intermediate lamellae at the particle boundaries.[38]

The addition of gypsum appeared to be a means of preventing winter damage to farms and highways. Soils containing gypsum showed virtually no expansion when placed in a freezer while untreated soils expanded more than 10 times their original size. However, more gypsum was needed to prevent expansion than is in the ordinary gypsum-containing fertilizers.[39]

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[32] Wheelock, T. D., and Boylan, D. R., Reductive Decomposition of Gypsum by Carbon Monoxide: Ind. and Eng. Chem., vol 52, No. 3, March 1960, pp. 215, 218.

[33] Chemical Engineering, New Process Automates Salt Refining: Vol. 67, No. 22, Oct. 31, 1960, pp. 49–50.

[34] Sudhir, Sen [Differential Thermal Analysis and Thermogravimetric Analysis Studies on Gypsum]: Central Glass & Ceramics Res. Inst. Bull. (India), vol. 5, No. 3, 1958, pp. 93–103; Jour. Am. Ceram. Soc., Ceram. Abs., vol. 43, No. 3, March 1960, p. 53.

[35] Kuntze, R. A., An Improved Method for the Determination of the Normal Consistency of Gypsum Plasters: ASTM Bull. 246, May 1960, pp. 35–37.

[36] Guha, S. K., and Sudhir, Sen [Application of Solubility Measurements in the Evaluation of Plaster of Paris]: Central Glass & Ceramics Res. Inst. Bull. (India), vol. 6, No. 2, 1959, M55–60; Jour. Am. Ceram. Soc., Ceram. Abs., vol. 43, No. 5, May 1960, p. 106.

[37] O'Kelly, B. M., Portable Adhesion Testing Device: ASTM Bull. 250, December 1960, pp. 32–33.

[38] Bartosch, E. [The Suitability of Raw Gypsum for Cement Manufacture]: Zement-Kalk-Gips, vol. 12, No. 8, 1959, pp. 362–369. Building Sci. Abs. (London), vol. 33, No. 3, March 1960, p. 67.

[39] Rock Products, Gypsum-Treated Soils Do Not Expand: Vol. 63, No. 7, July 1960, p. 10.

Iodine

By Henry E. Stipp[1] and Victoria M. Roman[2]

UNITED STATES production of crude iodine decreased significantly in 1960, but domestic consumption of iodine increased. The use of iodine in producing high-purity silicon, preparing motor fuel, and in recovering mineral sulfides was reported.

DOMESTIC PRODUCTION

Production of crude iodine decreased 30 percent in quantity and 32 percent in value compared with 1959. The principal iodine compound produced was potassium iodide; however, many other inorganic and organic compounds were made. Although much crude iodine was imported, U.S. plants produced a large part of domestic requirements. Iodine was extracted from oil-well brines by The Dow Chemical Co., with plants at Seal Beach, Venice, and Inglewood, Calif. Refined iodine and iodine compounds were produced in 50 plants from domestic and imported crude iodine.

Recovery and distribution of radioactive iodine isotopes increased.

CONSUMPTION AND USES

U.S. consumption of iodine and iodine compounds increased 12 percent compared with 1959. The addition of 13 companies to the 1960 canvass accounted for a 6-percent increase in the consumption reported. Most crude iodine was resublimed to greater purity or converted to iodine compounds for consumption. Iodine and iodine compounds were used in medicine as germicides, antiseptics, sanitizers, deodorants, drugs, laboratory reagents, aids in X-ray diagnosis, and nutrition and therapeutic agents. Iodine was used industrially in the production of photographic films and emulsions, analytical reagents and instruments, electronic devices, dyes, catalysts, and chemical synthesizing agents, and in the development of mineral separation and metallurgical refining processes and rubber and plastic treatments. In agriculture, iodine was used chiefly in stock feed supplements, anti-inflammatory agents, germicides, and antiseptics.

Radioactive iodine was used for physical therapy and examinations, process control, tracer studies, and general research.

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[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.

TABLE 1.—Crude iodine consumed in the United States

Product	1959			1960		
	Number of plants [1]	Crude iodine consumed		Number of plants	Crude iodine consumed	
		Thousand pounds	Percent of total		Thousand pounds	Percent of total
Resublimed iodine	4	[1] 102	[1] 6	4	132	7
Potassium iodide	11	[1] 893	51	10	897	46
Sodium iodide	5	[1] 70	4	4	(2)	(2)
Other inorganic compounds	14	[1] 271	[1] 16	16	495	26
Organic compounds	23	402	[1] 23	34	420	21
Total	[3] 37	[1] 1,738	100	[3] 50	1,944	100

[1] Revised figure.
[2] Included with "Other inorganic compounds" to avoid disclosing individual company confidential data.
[3] Nonadditive total because some plants produce more than one product.

PRICES

The following prices were quoted for iodine and iodine compounds by the Oil, Paint and Drug Reporter:

	Per pound
Crude iodine, kegs:	
January to September	$0.95
September through December	$0.95–1.10
Resublimed iodine, U.S.P.:	
January to November	2.00–2.02
November through December	2.20–2.22
Ammonium iodide, N.F., drums, bottles	4.26
Calcium iodide, jars:	
January to November	4.52
November through December	4.27
Potassium iodide, U.S.P., crystals, granular, powdered, fiber drums:	
January to November	1.40
November through December	1.55
Sodium iodide, U.S.P., 300-pound drums:	
January to November	1.98
November through December	2.13

FOREIGN TRADE [3]

U.S. imports of crude iodine increased 29 percent in quantity and 32 percent in value compared with 1959. Shipments from Japan more than doubled. Resublimed iodine imported from West Germany totaled 110 pounds valued at US$107.

The 251,000 pounds of iodine, iodide, and iodates exported from the United States went to 31 countries. Largest shipments were sent to Canada, the United Kingdom, India, and Brazil. Thirty-eight thousand pounds of iodine, valued at US$37,000, was reexported to Canada and Mexico.

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 2.—U.S. imports for consumption of crude iodine, by countries

(Thousand pounds and thousand dollars)

Country	1951-55 (average)		1956		1957		1958		1959		1960	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Chile	661	$959	1,002	$1,226	2,149	$2,049	1,401	$1,180	1,243	$892	1,420	$1,011
France	(1)	(2)										
Japan	295	408	703	954	536	720	160	149	223	191	474	414
Total	956	1,367	1,705	2,180	2,685	2,769	1,561	1,329	1,466	1,083	1,894	1,425

[1] Less than 1,000 pounds.
[2] Less than $1,000.

Source: Bureau of the Census.

TABLE 3.—U.S. exports of iodine, iodide, and iodates

(Thousand pounds and thousand dollars)

Year	Quantity	Value	Year	Quantity	Value
1951-55 (average)	260	$435	1958 [1]	199	$314
1956	505	750	1959 [1]	175	249
1957	233	335	1960 [1]	251	353

[1] Data not strictly comparable with earlier years.

Source: Bureau of the Census.

TABLE 4.—U.S. reexports of iodine, iodide, and iodates

(Thousand pounds and thousand dollars)

Year	Quantity	Value	Year	Quantity	Value
1951-55 (average)	96	$148	1958 [1]	30	$30
1956	96	131	1959 [1]	35	34
1957	70	79	1960 [1]	38	37

[1] Data not strictly comparable with earlier years.

Source: Bureau of the Census.

WORLD REVIEW

Chile.—Iodine production in 1959 totaled 1,376 short tons compared with 1,454 tons in 1958. Exports in 1959 totaled 1,469 tons valued at $2.8 million. The new iodine plants at Pedro de Valdivia and at Coya Sur were put into production and were expected to produce about 1,984 tons of iodine during 1960.[4]

Indonesia.—Production of iodine in 1959 totaled 780 pounds.[5] Comparable figures were: 1958, 589 pounds (revised) and 1957, 1,417 to 1,630 pounds (revised).[6] Iodine production figures for 1957 and 1958,

[4] U.S. Embassy, Santiago, Chile, State Department Dispatch 571: Feb. 9, 1960, p. 3.
[5] U.S. Embassy, Djakarta, Indonesia, State Department Dispatch 740: Mar. 28, 1961, encl. 1, p. 1.
[6] U.S. Embassy, Djakarta, Indonesia, State Department Dispatch 95: July 31, 1959, p. 1.

published in previous Minerals Yearbook chapters, were incorrect owing to errors in methods of reporting to the Bureau of Mines.

Japan.—Elemental iodine production totaled 853 short tons in 1959 compared with 800 tons in 1958.[7]

TECHNOLOGY

High-purity silicon was prepared by reacting silicon and iodine to form silicon tetraiodide, which was recrystallized, distilled, and decomposed to silicon and iodine.[8] Silicon and iodine were reacted in a fluidized bed which gave constant reactivity. This procedure gave a better separation of silicon from its impurities. Silicon tetraiodide was condensed in the recrystallizer, n-heptane was added, and the slurry was warmed and cooled. The n-heptane, which contained impurities, was decanted, and the operation was repeated with yields of up to 80 percent. The silicon tetraiodide was distilled into three fractions containing less volatile impurities, more volatile impurities, and purified silicon tetraiodide. The purified silicon tetraiodide was introduced to the vaporizer where a low pressure atmosphere and a heated silicon rod dissociated it to silicon diiodide which then dissociated to solid silicon and iodine gas.

The electrolytic processing of potassium iodide to potassium iodate was reported to be attractive for small-scale production because it is clean, efficient (94 to 96 percent yield), and gives only iodate.[9] Basic data for the design of a plant to prepare 150 pounds per day was obtained from a handbook[10] and a few laboratory experiments. Graphite anodes were substituted for platinum and yielded lower cost, decreased polarization, and longer life. Nickel was used as a cathode material. Four cells were operated at 500 amperes and about 2.0 to 2.5 volts per cell. Current density was about 20 amperes per square foot. The cells were operated by electrolyzing a batch of potassium iodide at 50° C. until desired concentration was reached. Iodate solution was sent to crystallizers, and fresh feed was added.

A process was patented for recovering iodine from a brine by adsorping iodide ions on a quaternary ammonium anion exchange resin, eluting the iodide ions from the resin, and converting them to iodine.[11] The iodide ions were washed from the resin with an acidic solution containing an alkali metal chloride or bromide salt and sulfur dioxide.

Iodine was reported to have flotation properties for mineral sulfides.[12] Iodine was fixed on the surfaces of mineral pulp particles

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[7] U.S. Embassy, Tokyo, Japan, State Department Dispatch 1353: May 11, 1960, encl. 1, p. 3.

[8] Herrick, Carlyle S., and Krieble, James G., High-Purity Silicon From an Iodide Process Pilot Plant: Jour. Electrochem. Soc., vol. 107, No. 2, February 1960, pp. 111–117.

[9] Chemical Week, Bypassing the By-Product Route to Iodates: Vol. 86, No. 2, Jan. 9, 1960, pp. 49–50.

Chemical Engineering Progress, Electrolytic Production of Potassium Iodate: Vol. 56, No. 5, May 1960, pp. 83–84.

[10] Foerster, Friedrich, Elektrochemie Wässeriger Lösungen: J. A. Barth, Leipzig, 1923, 900 pp.

[11] Shaw, Kernal Glenn (assigned to The Dow Chemical Co., Midland, Mich.), Process for Recovering Iodides From Aqueous Solutions By Ion Exchange and Conversion of the Iodides to Iodine: U.S. Patent 2,945,746 July 19, 1960.

[12] Plaksin, I. N., and Shafeyev, P. Sh. [Influence of Iodine on the Floatability of Mineral Sulfides]: Trans. Akademiya Nauk U.S.S.R. Doklady, vol. 127, No. 2, 1959, pp. 384–385; U.S. Dept. of Commerce, Tech. Trans., Chem. Eng., vol. 3, No. 10, May 25, 1960, p. 651.

and reacted with xanthate, oxidizing it to dixanthogen. In this manner small additions of iodine intensified the floatability of sulfide minerals.

In a study of the reaction of iodine crystals subjected to a pressure of about 700,000 atmospheres, the crystals changed from insulators to conductors of electricity.[13]

A process was patented for producing a motor fuel of improved octane number.[14] A naphtha, containing iodine aromatizable compounds, was subjected to a process that converted hydrocarbons to iodine-resistant hydrocarbons of high octane number and iodine-aromatizable hydrocarbons of low octane number. Part of this naphtha was contacted with iodine at 300° C. for 0.01 second to 5 minutes. A naphtha of increased octane number was recovered from the reaction product.

Dialdehyde starch was produced on a pilot-plant scale by reacting corn starch with periodic acid.[15] The iodic acid that formed from the reaction was converted to periodic acid in an electrolytic cell and reused in the first stage of the process.

The effect of additions of iodine on the electrical and thermal properties of selenium was reported.[16] Iodine impurity increased the electrical conductivity of selenium and decreased the activation energy of holes in the selenium. Additions of iodine increased the differential thermo-emf and increased the concentration and mobility of the charge carriers. At 60° to 80° C. iodine additions accelerated the crystallization of selenium. The effect of iodine on the crystallization of selenium weakens with increased temperature and disappears at 190° C.

A compilation of radiochemical information and procedures on iodine and other halogen elements was published by the National Academy of Sciences-National Research Council.[17] The publication will be useful to radiochemists and other persons who use radiochemical elements.

Radioactive iodine 131 was used to determine relative roughness factors for gold, brass, and aluminum surfaces.[18] A roughness factor of 1 was assigned to gold foil, and all factors were related to this. Brass had the highest roughness factor of any metal tested.

Radioactive iodine 131 was produced commercially by a private U.S. firm.[19] The production process differed from that used by the Atomic Energy Commission. Tellurium 130 was irradiated in a high flux reactor. Bombardment of Te^{130} with neutrons yielded Te^{131}

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13 Chemistry, New Materials Through Pressure: Vol. 33, No. 8, April 1960, p. 24.

14 Mullineaux, Richard D., and Raley, John H. (assigned to Shell Development Co., New York, N.Y.), Production of Motor Fuels: U.S. Patent 2,921,013, Jan. 12, 1960.

15 Industrial and Engineering Chemistry, Two-Stage Process for Dialdehyde Starch Using Electrolytic Regeneration of Periodic Acid: Vol. 52, No. 3, March 1960, pp. 201–206.

16 Aliyev, M. I. [The Effect of Iodine on the Electrical and Thermal Properties of Selenium]: Trans. Akademiya Nauk Azerbaydzhanskoy U.S.S.R. Baku, Inst. Fiz. i Matemat., Trudy, Seriya Fizicheskaya, vol. 9, 1958, pp. 27–39; U.S. Dept. of Commerce, Tech. Trans., Phys. Chem., vol. 4, No. 5, Sept. 14, 1960, pp. 257–258.

17 Kleinbery, Jacob, and Cowan, G. A., The Radiochemistry of Fluorine, Chlorine, Bromine, and Iodine: Univ. of California, Los Alamos Sci. Lab., Los Alamos, N. Mex., January 1960; Office of Tech. Services, U.S. Dept. of Commerce, Washington, D.C.

18 Testerman, M. K., Report on Surface and Interface Phenomena of Matter: Wright Air Development Center Tech., Rept. 59–659, December 1959, 48 pp.; U.S. Government, Res. Repts., Off. Tech. Services, U.S. Department of Commerce, vol. 34, No. 4, Oct. 14, 1960, p. 479.

19 Chemical and Engineering News, Abbott Makes Its Own Radioisotopes: Vol. 38, No. 36, Sept. 5, 1960, p. 31.

which decayed to I^{131}. Iodine 131 was extracted from the bombarded material by oxidizing it with an unknown medium to soluble tellurous and telluric ions. The material was put into solution, and the volatile iodine was distilled.

A device was produced for analyzing the ozone in the air by measuring electrochemical reactions of potassium iodide in potassium bromide and ozone.[20]

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[20] Chemical and Engineering News, Portable Ozone Analyzer: Vol. 38, No. 38, Sept. 19, 1960, p. 81.

Iron Ore

By R. W. Holliday[1] and Helen E. Lewis[2]

THE UNITED STATES produced 18 percent of the world's iron ore in 1960, compared with 40 percent in 1951 and 34 percent over the past 2 decades. The decrease in 1960 was due both to expanded foreign production and lower domestic output. Output in the United States in 1960 was 5 million tons below the average annual domestic production of the past 20 years.

The six nations of the European Coal and Steel Community produced a record 93 million tons of iron ore in 1960, and the output of Western Europe was well above that of either the United States or the U.S.S.R. Productive capacity in other areas of the world, especially in Canada, increased substantially during the year.

In the United States several large iron ore deposits were being developed. However, a number of the older underground mines closed. Imports were only slightly below the record total of 1959, and the outlook was for future increases both in tons produced and as a percentage of total supply.

The ratio of crude ore to usable ore continued to climb. Although domestic production of usable ore in 1960 was some 29 million tons below the peak year, 1953, crude ore output was only about 1.7 million tons lower than in 1953.

Production in the Western States comprised only 9 percent of the Nation's total production, but increased exploration and development, large low-grade iron deposits, and rapid increase in population and industrial activity gave assurance of continued expansion in this region.

Consumption of iron ore in the United States declined in each successive quarter of the year. This factor, combined with the large tonnage of imports, resulted in the largest stocks in history at yearend. The stocks at mines, docks, and consumers' plants on December 31 were nearly equal to the year's domestic production.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

TABLE 1.—Salient iron ore statistics

(Thousand long tons and thousand dollars)

	1951-55 (average)	1956	1957	1958	1959	1960
United States:						
Iron ore (usable;[1] less than 5 percent Mn):						
Production [2]	102,710	97,877	106,148	67,709	60,276	88,777
Shipments [3]	102,320	96,945	104,157	66,288	59,164	82,957
Value [3]	$657,228	$750,354	$865,703	$569,154	$514,067	$723,496
Average value at mines per ton	$6.42	$7.47	$8.31	$8.59	$8.69	$8.72
Imports for consumption	14,048	30,411	33,651	27,544	[4] 35,617	34,585
Value	$107,216	$250,490	$285,051	$231,617	[4] $312,447	$321,693
Exports	4,273	5,508	5,002	3,573	2,967	5,236
Value	$32,520	$48,805	$47,543	$34,898	$33,831	$57,575
Consumption	111,372	125,171	129,375	91,900	93,662	108,050
Stocks Dec. 31:						
At mines	5,638	5,465	6,776	7,033	[4] 7,358	12,406
At consuming plants	43,365	47,292	53,175	53,599	53,038	61,845
At Lake Erie docks	6,338	4,558	5,160	5,577	7,575	6,839
World: Production [4]	316,944	388,281	426,483	398,609	431,709	507,089

[1] Direct shipping ore, washed ore concentrates, agglomerates, and byproduct pyrites cinder and agglomerates.
[2] Includes byproduct ore.
[3] Excludes byproduct ore.
[4] Revised figure.

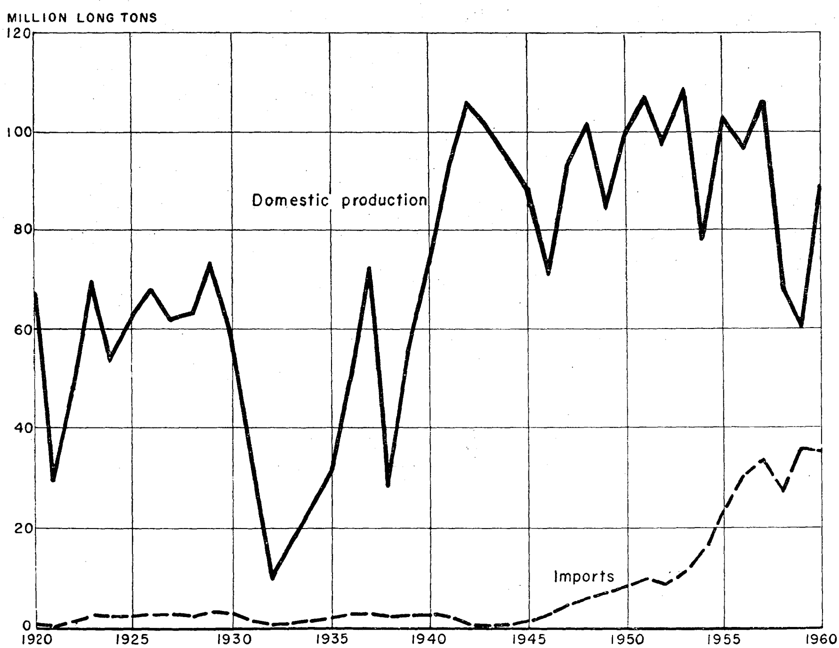

FIGURE 1.—Production of iron ore in the United States and iron ore imports for consumption, 1920–60.

EMPLOYMENT

Employment data for 1960 were not available. Preliminary information indicated that the average number of men employed in iron mines during the first half of 1960 was slightly greater than during the first half of 1959. Second-half employment for the 2 years was not comparable because of the steel strike extending from July 15 to November 7, 1959.

Table 2 gives employment and productivity data for 1959 by districts, and table 3 gives revised employment and productivity data for the years 1952–58. This latter table includes employment at beneficiating plants previously omitted.

TABLE 2.—Employment at iron ore mines and beneficiating plants, quantity and tenor of ore produced and average output per man in 1959, by districts and States

District and State	Employment[1]					Production[2]									
	Average number of men employed	Time employed				Crude ore (thousand long tons)	Usable ore			Average per man (long tons)					
		Average number of days	Total man-shifts (thousands)	Man-hours			Thousand long tons	Iron contained		Crude ore		Usable ore			
				Average per shift	Total (thousands)			Thousand long tons	Natural (percent)	Per shift	Per hour	Per shift	Per hour	Iron contained	
														Per shift	Per hour
Lake Superior:															
Minnesota	13,399	187	2,505	8.00	20,050	65,360	36,278	19,565	53.93	26.09	3.26	14.48	1.81	7.81	0.98
Michigan	5,415	171	927	8.00	7,419	8,623	7,129	3,791	53.18	9.30	1.16	7.69	.96	4.09	.51
Wisconsin	944	142	134	8.02	1,075	944	944	503	53.28	7.04	.88	7.04	.88	3.75	.47
Total	19,758	180	3,566	8.00	28,544	74,927	44,351	23,859	53.80	21.01	2.62	12.44	1.55	6.69	.84
Southeastern States:															
Alabama and Georgia	2,891	172	497	8.32	4,135	8,194	4,350	1,692	38.90	16.49	1.98	8.75	1.05	3.40	.41
Northeastern States:															
New Jersey and Pennsylvania	2,170	196	425	8.07	3,428	2,946	1,502	926	61.65	6.93	.86	3.53	.44	2.18	.27
New York	1,358	197	267	8.01	2,138	6,078	2,167	1,357	62.62	22.76	2.84	8.12	1.01	5.08	.63
Total	3,528	196	692	8.04	5,566	9,024	3,669	2,283	62.22	13.04	1.62	5.30	.66	3.30	.41

Western States:																
California, New Mexico, and Texas	792	256	195	8.07	1,573	6,439	3,135	1,717	54.77	33.02	4.09	16.08	1.99	8.81	1.09
Washington, Idaho, and Montana	21	190	4	8.00	32	55	55	30	54.55	13.75	1.72	13.75	1.72	7.50	.94
Nevada, Utah, Wyoming, and Colorado	964	180	175	8.00	1,400	4,209	3,952	2,018	51.06	24.05	3.01	22.58	2.82	11.53	1.44
Total	1,777	213	374	8.03	3,005	10,703	7,142	3,765	52.72	28.62	3.56	19.10	2.38	10.07	1.25
Undistributed [3]	414	171	71	7.96	565	582	374	175	46.79	8.20	1.03	5.27	.66	2.46	.31
Grand total	28,368	183	5,200	8.04	41,815	103,430	59,886	31,774	53.06	19.89	2.47	11.52	1.43	6.11	.76

[1] No production reported for Arizona and Alaska; therefore, employment data have been excluded from all totals.
[2] Includes manganese bearing ore from the Lake Superior district.
[3] Includes North Carolina, Tennessee, and Missouri to avoid disclosing individual company confidential data.

TABLE 3.—Employment at iron ore mines and beneficiating plants, quantity and tenor of ore produced and average output per man

Year	Employment					Production [1]									
	Average number of men employed	Time employed				Crude ore (thousand long tons)	Useable ore			Average per man (long tons)					
		Average number of days	Total man-shifts (thousands)	Man-hours			Thousand long tons	Iron contained		Crude ore		Usable ore			
				Average per shift	Total (thousands)			Thousand long tons	Natural (percent)	Per shift	Per hour	Per shift	Per hour	Iron contained	
														Per shift	Per hour
1952: [2]															
Mines	31,802	248	7,880	8.03	63,308	129,261	98,157	49,154	50.08	16.40	2.04	11.21	1.39	5.61	0.69
Mills	3,914	222	869	8.09	7,037	----------									
Total	35,716	245	8,749	8.04	70,345	129,261	98,157	49,154	50.08	--------	--------	--------	--------	--------	--------
1953: [2]															
Mines	30,862	270	8,335	8.02	66,840	157,870	118,390	59,490	50.25	18.94	2.36	12.57	1.56	6.31	.78
Mills	4,439	244	1,083	8.05	8,722	----------									
Total	35,301	267	9,418	8.02	75,562	157,870	118,390	59,490	50.25	--------	--------	--------	--------	--------	--------
1954: [2]															
Mines	27,840	220	6,132	8.02	49,177	109,861	77,752	39,409	50.69	17.91	2.23	10.99	1.37	5.57	.69
Mills	4,153	226	939	8.07	7,574	----------									
Total	31,993	221	7,071	8.03	56,751	109,861	77,752	39,409	50.69	--------	--------	--------	--------	--------	--------
1955: [3]															
Mines	24,954	245	6,105	8.02	48,941	143,293	102,294	52,270	51.10	23.30	2.90	14.30	1.78	7.31	.91
Mills	4,055	258	1,044	8.03	8,383	----------									
Total	29,009	246	7,149	8.02	57,324	143,293	102,294	52,270	51.10	--------	--------	--------	--------	--------	--------
1956: [3]															
Mines	26,817	234	6,281	8.02	50,376	147,088	97,313	49,851	51.24	23.41	2.92	12.95	1.61	6.63	.82
Mills	5,114	241	1,231	8.07	9,937	----------									
Total	31,931	235	7,512	8.03	60,313	147,088	97,313	49,851	51.24	--------	--------	--------	--------	--------	--------

1957:[2]															
Mines	25,669	252	6,480	8.02	51,958	162,198	106,066	54,292	51.19	25.03	3.12	13.51	1.68	6.91	.86
Mills	5,218	262	1,367	8.05	11,004										
Total	30,887	254	7,847	8.02	62,962	162,198	106,066	54,292	51.19						
1958:[3]															
Mines[3]	21,382	206	4,411	8.02	35,374	110,642	67,372	35,676	52.95	25.08	3.12	11.51	1.43	6.09	.76
Mills	5,857	246	1,441	8.01	11,536										
Total	27,239	215	5,852	8.02	46,910	110,642	67,372	35,676	52.95						

[1] Includes manganese-bearing ore in the Lake Superior district.

[2] Man-hour data are not available for the following States: 1952, Virginia and Puerto Rico; 1953, Montana and South Dakota; 1954, Arkansas, Montana, South Dakota, and Virginia. However, production data are included for all States.

[3] Man-hour data are not available for the following States: 1955, Montana, Oregon, South Dakota, Tennessee and Washington; 1956, Idaho, Mississippi, Oregon, South Dakota; 1957, South Dakota. Production data have been excluded for all States.

DOMESTIC PRODUCTION

The Lake Superior district supplied most of the 29-million-ton increase in domestic iron ore output (compared with 1959), more than 80 percent of the Nation's total. Expansion of the Humboldt Mining Co. pellet plant west of Ishpeming, Mich., to an annual capacity of 650,000 tons was completed. Plans to expand mining and processing facilities at the nearby Republic mine from 700,000 to 1.6 million tons of pellets were announced. The Reserve Mining Co. in Minnesota announced a program to expand pellet production from 5.5 million tons per year to more than 9 million tons. A number of underground mines in Michigan's Upper Peninsula closed. Producers of traditionally acceptable domestic ores found increasing difficulty in competing with the producers of higher-grade pellets and imported ores available in 1960.

Efforts to secure passage of a Minnesota State constitutional amendment that would guarantee continuation of the present tax formula on taconite were unsuccessful.

The U.S. Tariff Commission released a report[8] concluding that iron ore imports did not cause or threaten serious injury to domestic iron ore producers.

Mine production of crude ore (prior to concentration) exceeded that of 1959 by 51 percent and fell only 4 percent short of production in 1957, the year of highest crude ore output. About 24 percent of crude ore shipments from mines went directly to consuming plants and the remaining 76 percent went to beneficiating plants. The grade of crude ore ranged widely, from about 30 percent iron for the taconite-jaspilite-type ores to more than 60 percent for some of the direct-shipping ores.

Although 246 mines reported production in 1960, only 139 mines produced more than 100,000 tons and these accounted for more than 98 percent of the Nation's total. In Minnesota 25 mines and in Michigan 3 mines produced 1 million or more tons of crude ore in 1960; and in 7 other States 7 additional mines also produced a million tons.

Usable ore production increased 47 percent, compared with 1959, but fell 29 million tons short of the peak production in 1953. The average iron content, however, was 53.65 percent, compared with 50.44 percent in 1953. Usable ore shown in tables 7 and 8 includes direct-shipping ore, concentrates, and that portion of the agglomerate produced at mine and beneficiation plant sites; agglomerate produced at consuming plants was excluded because some of the direct-shipping ores, some concentrate, some imported ores, and other materials such as flue dust were consumed and the relative proportions are not known. The ratio of crude ore to usable ore was 1.8:1 compared with 1.7:1 in 1959, 1.6:1 in 1958, 1.5:1 in 1957 and 1956, and 1.2:1 in 1948 reflecting not only the depletion of higher grade ores but also the increased production from taconite-type ores.

[8] U.S. Tariff Commission: Iron Ore, December 1960, 52 pp.

TABLE 4.—Crude iron ore mined in the United States, by districts and varieties

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

District and State	1959					1960				
	Number of mines	Hematite	Brown ore	Magnetite	Total	Number of mines	Hematite	Brown ore	Magnetite	Total
Lake Superior:										
Michigan	27	8,623	---	---	8,623	27	14,017	---	---	14,017
Minnesota	95	40,238	---	24,276	64,514	107	69,880	856	38,845	109,581
Wisconsin	4	944	---	---	944	2	1,484	---	---	1,484
Total	126	49,805	---	24,276	74,081	136	85,381	856	38,845	125,082
Southeastern States:										
Alabama	[1] 31	3,203	4,243	---	7,446	[1] 28	3,317	3,851	---	7,168
Georgia	9	---	748	---	748	9	---	457	---	457
North Carolina	1	---	---	(2)	(2)	1	---	---	2	2
Tennessee	3	(2)	(2)	---	(2)	(3)	(2)	(3)	---	(2)
Total	44	3,203	4,991	(2)	8,194	41	3,317	4,308	2	7,627
Northeastern States:										
New Jersey } Pennsylvania }	5	---	---	2,946	2,946	4	---	---	2,845	2,845
New York	5	---	---	6,078	6,078	5	---	---	8,283	8,283
Total	10	---	---	9,024	9,024	9	---	---	11,128	11,128
Western States:										
California	2	(2)	---	(2)	(2)	3	(2)	---	(3)	(2)
Colorado	3	---	11	---	11	4	---	11	---	11
Idaho	1	---	---	1	1	3	3	---	6	9
Missouri	12	530	(3)	---	530	20	(3)	863	---	863
Montana	3	50	---	(3)	50	2	---	---	54	54
Nevada	11	(3)	---	962	962	13	(3)	---	1,014	1,014
New Mexico	2	---	---	(2)	(2)	1	---	---	1	1
South Dakota	---	---	---	---	---	1	(2)	---	---	(2)
Texas	4	---	(2)	---	(2)	4	(2)	(3)	---	(2)
Utah	11	2,765	(3)	(3)	2,765	7	3,369	---	(3)	3,369
Washington	1	4	---	---	4	---	---	---	---	---
Wyoming	3	471	---	---	471	2	(2)	---	(3)	(2)
Total	53	3,820	11	963	4,794	60	3,372	874	1,075	5,321
Undistributed	---	3,182	3,215	94	6,491	---	5,736	---	---	5,736
Grand total	233	60,010	8,217	34,357	102,584	246	97,806	6,038	51,050	154,894

[1] Excludes an undetermined number of small pits. Output of these pits included with tonnage given.
[2] Included with "Undistributed" to avoid disclosing individual company confidential data.
[3] Varieties of ore not shown separately are combined with other varieties in the same State.

TABLE 5.—Crude iron ore mined in the United States, by States and mining methods

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

State	1959			1960		
	Open pit	Underground	Total	Open pit	Underground	Total[1]
Alabama	4,384	3,062	7,446	4,014	3,154	7,168
California	(2)	----------	(2)	(2)	----------	(2)
Colorado	11	----------	11	11	----------	11
Georgia	748	----------	748	457	----------	457
Idaho	1	----------	1	9	----------	9
Michigan	1,806	6,817	8,623	3,952	10,065	14,017
Minnesota	63,188	1,326	64,514	107,416	2,166	109,581
Missouri	530	(3)	530	863	(3)	863
Montana	50	----------	50	54	----------	54
Nevada	962	(3)	962	1,014	(3)	1,014
New Jersey, Pennsylvania	(4)	2,946	2,946	----------	2,845	2,845
New York	6,078	(3)	6,078	8,283	(3)	8,283
New Mexico	(2)	----------	(2)	1	----------	1
North Carolina	(2)	(3)	(2)	----------	2	2
South Dakota	----------	----------	----------	(2)	----------	(2)
Tennessee	(2)	----------	(2)	(2)	----------	(2)
Texas	(2)	----------	(2)	(2)	----------	(2)
Utah	2,765	----------	2,765	3,369	----------	3,369
Washington	4	----------	4	----------	----------	----------
Wisconsin	61	883	944	----------	1,484	1,484
Wyoming	----------	471	471	(2)	(3)	(2)
Undistributed	6,491	----------	6,491	5,736	----------	5,736
Total	87,079	15,505	102,584	135,179	19,716	154,894

1 In some instances data do not add to totals shown because figures have been rounded.
2 Included with "Undistributed" to avoid disclosing individual company confidential data.
3 Included with "open pit."
4 Included with "underground."

TABLE 6.—Crude iron ore shipped from mines in the United States, by States and disposition

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

State	1959			1960		
	Direct to consumers	To beneficiation plants	Total [1]	Direct to consumers	To beneficiation plants	Total [1]
Alabama	2,088	5,351	7,440	2,097	5,061	7,158
California	(2)	(2)	(2)	(2)	(2)	(2)
Colorado	10	----------	10	11	----------	11
Georgia	(3)	748	748	(3)	457	457
Idaho	6	----------	6	9	----------	9
Michigan	5,867	2,466	8,333	7,503	5,967	13,469
Minnesota	16,195	48,024	64,219	21,542	88,060	109,602
Missouri	----------	530	530	----------	863	863
Montana	50	----------	50	55	----------	55
Nevada	960	(4)	960	(3)	1,011	1,011
New Jersey Pennsylvania	(3)	2,947	2,947	----------	2,523	2,523
New York	(3)	6,077	6,077	----------	8,283	8,283
New Mexico	(5)	----------	(5)	1	----------	
North Carolina	(5)	----------	(5)	(5)	----------	(5)
South Dakota	----------	----------	----------	(2)	----------	(2)
Tennessee	(2)	(2)	(2)	(2)	(2)	(2)
Texas	----------	(2)	(2)	(2)	(2)	(2)
Utah	2,842	----------	2,842	3,334	----------	3,334
Washington	4	----------	4	----------	----------	
Wisconsin	701	----------	701	1,502	----------	1,502
Wyoming	471	----------	471	(2)	(2)	(2)
Undistributed	111	6,465	6,576	529	5,177	5,708
Total	29,305	72,608	101,914	36,583	117,402	153,986

1 In some instances data do not add to totals shown because figures have been rounded.
2 Included with "Undistributed" to avoid disclosing individual company confidential data.
3 Included with ore shipped to beneficiation plants.
4 Included with direct shipping ore.
5 Less than 1,000 tons.

TABLE 7.—Usable iron ore produced in the United States, by districts and varieties

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

District and State	1959				1960			
	Hematite	Brown ore	Magnetite	Total [1]	Hematite	Brown ore	Magnetite	Total
Lake Superior:								
Michigan	7,129			7,129	12,866			12,866
Minnesota	27,411		8,465	35,877	43,687	473	13,282	57,442
Wisconsin	944			944	1,484			1,484
Total	35,484		8,465	43,950	58,037	473	13,282	71,792
Southeastern States:								
Alabama	3,098	1,062		4,160	3,207	1,029		4,235
Georgia		190		190		128		128
North Carolina			(2)	(2)			2	2
Tennessee	(2)	(2)		(2)	(2)	(3)		(2)
Total	3,098	1,252		4,350	3,207	1,157	2	4,365
Northeastern States:								
New Jersey } Pennsylvania }			1,502	1,502			1,246	1,246
New York			2,167	2,167			2,879	2,879
Total			3,669	3,669			4,125	4,125
Western States:								
California	(2)		(2)	(2)	(2)		(3)	(2)
Colorado		11		11		11		11
Idaho			1	1	3		6	9
Missouri	174	175		349	404	(3)		404
Montana	37		13	50			54	54
Nevada	(2)		673	673	(3)		729	729
New Mexico			(2)	(2)			1	1
South Dakota					(2)			(2)
Texas		(2)		(2)	(2)	(3)		(2)
Utah	2,765	(3)	(3)	2,765	3,369		(3)	3,369
Washington	4			4				
Wyoming	503		(3)	503	(2)		(3)	(2)
Total	3,483	186	687	4,356	3,776	11	790	4,577
Undistributed	2,171	943	46	3,160	3,127			3,127
Total all districts	44,236	2,381	12,867	59,485	68,147	1,641	18,199	87,986
Byproduct ore [4]				791				791
Grand total [1]	44,236	2,381	12,867	60,276	68,147	1,641	18,199	88,777

[1] In some instances data do not add to totals shown because figures have been rounded.
[2] Included with "Undistributed" to avoid disclosing individual company confidential data.
[3] Combined with other varieties in the same State.
[4] Cinder and sinter obtained from treating pyrites. Ore was treated in Delaware, Colorado, Tennessee, Pennsylvania, Virginia, and Arizona.

TABLE 8.—Iron ore produced in the United States, by States and types of product

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

State	1959				1960			
	Direct-shipping ore	Agglomerates [1]	Concentrates	Iron content (natural percent)	Direct-shipping ore	Agglomerates [1]	Concentrates	Iron content (natural percent)
Alabama	3,098	(2)	1,062	38.57	2,108	(2)	2,128	39.13
California	(3)	----------	(3)	(3)	(3)	----------	(3)	(3)
Colorado	11	----------	----------	49.29	11	----------	----------	54.55
Georgia	(2)	----------	190	45.94	(2)	----------	128	43.75
Idaho	1	----------	----------	60.56	9	----------	----------	55.56
Michigan	5,562	429	1,138	53.17	9,076	905	2,885	53.79
Minnesota	16,276	8,528	11,073	54.11	21,589	13,436	22,417	54.22
Missouri	----------	----------	349	46.70	----------	----------	404	50.90
Montana	50	----------	----------	57.95	54	----------	----------	55.56
Nevada	673	----------	(2)	59.14	729	----------	(2)	58.98
New Jersey, Pennsylvania	(2)	582	920	61.67	----------	(2)	1,246	61.88
New York	(2)	(2)	2,167	62.60	----------	2,043	837	61.86
New Mexico	(3)	----------	----------	(3)	1	----------	----------	64.97
North Carolina	(3)	----------	----------	(3)	2	----------	----------	(3)
South Dakota	----------	----------	----------	----------	(3)	----------	----------	(3)
Tennessee	(3)	----------	(3)	(3)	(3)	----------	(3)	(3)
Texas	(3)	(2)	(3)	(3)	(3)	(2)	(3)	(3)
Utah	2,765	----------	(4)	50.15	3,369	----------	----------	50.70
Washington	4	----------	----------	----------	----------	----------	----------	----------
Wisconsin	944	----------	----------	53.32	1,484	----------	----------	53.57
Wyoming	503	----------	(2)	45.42	(3)	----------	(3)	(3)
Undistributed	88	----------	3,072	54.69	529	----------	2,598	50.76
Total	29,975	9,539	19,971	53.16	38,961	16,384	32,643	53.53
Byproduct ore [5]	----------	791	----------	67.03	----------	791	----------	66.58
Grand total	29,975	10,330	19,971	53.34	38,961	17,175	32,643	53.65

[1] Exclusive of agglomerates produced at consuming plants.
[2] Types of ore not shown separately are combined with other types in the same States.
[3] Included with "Undistributed" to avoid disclosing individual company confidential data.
[4] Less than 1,000 tons.
[5] Cinder and sinter obtained from treating pyrites.

TABLE 9.—Shipments of iron ore in the United States in 1960, by States and uses

(Thousand long tons and thousand dollars; exclusive of ore containing 5 percent or more manganese)

State	Iron and steel			Cement	Paint	Miscellaneous	Total	
	Direct-shipping ore	Agglomerates [1]	Concentrates				Quantity [2]	Value
Alabama	2,097	(3)	1,970				4,068	$23,511
California	(4)		(4)	(3)		(3)	(4)	(4)
Colorado					11		11	80
Georgia	(3)		128				128	613
Idaho	9			(3)			9	(4)
Michigan	7,503	737	2,552		(3)	(3)	10,792	95,791
Minnesota	21,542	11,489	21,693	(3)	(3)	(3)	54,723	470,874
Missouri			365				365	3,760
Montana	55			(3)			55	293
Nevada	(3)	734				(3)	734	3,648
New Jersey	(3)		1,276		(3)	(3)	1,276	23,907
Pennsylvania		(3)				(3)		
New Mexico						1	1	27
New York		2,043	441	(3)		(3)	2,484	32,377
North Carolina	(5)						(5)	(4)
South Dakota	(4)			(3)			(4)	(4)
Tennessee	(4)		(4)				(4)	(4)
Texas		(3)	(4)	(3)			(4)	(4)
Utah	3,334			(3)			3,334	23,862
Virginia						(3)	(4)	(4)
Wisconsin	1,502						1,502	(4)
Wyoming	(4)		(4)			(3)	(4)	(4)
Undistributed	496		2,978				3,475	44,753
Total	36,538	15,003	31,403		11	1	82,957	723,496
Byproduct ore [6]							821	10,605
Grand total	36,538	15,003	31,403		11	1	83,778	734,101

[1] Exclusive of agglomerates produced at agglomerating plants.
[2] In some instances data do not add to totals shown because figures have been rounded.
[3] Combined with other uses in the same State.
[4] Included with "Undistributed" to avoid disclosing individual company confidential data.
[5] Less than 1,000 tons.
[6] Cinder and sinter obtained from treating pyrites; treated in Delaware, Tennessee, Colorado, Pennsylvania, Virginia, and Arizona.

Values of iron ore shipments shown in table 9 are those reported by producers; they exclude transportation costs but include cost of mining, concentrating, and agglomerating. Shipments are classified by use according to information supplied by the producers.

Most of the agglomerate produced at mines or benefication plant sites was in the form of pellets. The agglomerate produced at mines (17 million tons) is classed as usable ore. Agglomerate produced at consuming plants (37 million tons) was mostly in the form of sinter and is excluded from usable ore because the ore used to produce it is listed elsewhere, as either direct-shipping ore, concentrate, or imports.

TABLE 10.—Iron ore produced in the Lake Superior district, by ranges

(Thousand long tons and exclusive after 1905 of ore containing 5 percent or more manganese)

Year	Marquette	Menominee	Gogebic	Vermilion	Mesabi	Cuyuna	Total
1854–1955	283,429	249,496	294,376	92,281	2,036,153	56,600	3,012,335
1956	5,869	4,349	4,377	1,285	59,346	2,242	77,468
1957	6,557	4,250	4,437	(1)	65,886	[2] 2,400	83,530
1958	4,111	2,896	2,549	(1)	40,860	[2] 1,360	[3] 51,777
1959	2,851	2,677	2,546	(1)	34,556	[2] 1,321	[3] 43,950
1960	6,619	4,079	3,653	[2] 1,834	54,442	1,166	[3] 71,792
Total	309,436	267,747	311,938	95,400	2,291,243	65,089	[3] 3,340,852

[1] Included with Mesabi range to avoid disclosing individual confidential company data.
[2] Includes production from the Spring Valley district, not in the true Lake Superior district.
[3] In some instances data do not add to totals shown because figures have been rounded.

TABLE 11.—Average analyses of total tonnages (bill-of-lading weights) of all grades of iron ore from all ranges of Lake Superior district

Year	Long tons	Content (natural), percent				
		Iron	Phosphorus	Silica	Manganese	Moisture
1951–55 (average)	82,240,898	50.49	0.097	10.09	0.74	10.87
1956	76,407,170	51.34	.090	9.78	.67	10.39
1957	83,264,900	52.14	.089	9.39	.65	9.83
1958	52,243,820	53.78	.086	8.76	.53	8.49
1959	44,402,848	53.81	.085	8.93	.61	[1] 8.29
1960	67,438,764	53.84	.083	8.90	.63	8.26

[1] Revised figure.

Source: American Iron Ore Association.

TABLE 12.—Beneficiated iron ore shipped from mines in the United States

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

Year	Beneficiated	Total	Proportion of beneficiated to total (percent)
1951–55 (average)	31,504	102,320	30.8
1956	38,260	96,945	39.4
1957	42,027	104,157	40.3
1958	31,968	66,288	48.2
1959	30,363	59,164	51.3
1960	46,012	82,952	55.5

CONSUMPTION AND USES

Although more iron ore was consumed in 1960 than in 1959, consumption was far short of expectations based on the belief that settlement of the steel strike in late 1959 would be followed by a great surge in demand for steel. Consumption declined in each succeeding quarter of 1960.

The 108 million tons of iron ore consumed represented an increase of 15 percent from 1959, but was 2 percent less than average of the 10 preceding years. Iron ore consumed in agglomerating plants, shown in table 13, includes consumption at all such plants whether at mine, beneficiation plant, or consuming plant site. Blast furnaces and agglomerating plants consumed 93 percent of the total; steel furnaces consumed 6 percent; and all other uses consumed 1 percent. Agglomerate from foreign countries, shown in table 14, footnote 1, was not reported by type.

TABLE 13.—Consumption of iron ore in the United States in 1960, by States and uses

(Long tons and exclusive of ore containing 5 percent or more manganese)

State	Metallurgical uses			Miscellaneous uses				Total
	Iron blast furnaces	Steel furnaces	Agglomerating plants	Ferroalloy furnaces	Cement	Paint	Other	
Alabama					27,272			
Kentucky	5,292,232	366,225	4,721,978		(1)			10,452,032
Tennessee					2,666			
Texas					41,659			
California					108,721		(1)	
Colorado	2,991,821	437,286	2,789,704			(1)	(1)	6,334,478
Utah					6,946			
Delaware								
Maryland	3,229,902	757,519	4,983,366		(1)			8,970,787
West Virginia					(1)			
Illinois	8,502,296	1,277,252	9,223,629		(1)			19,003,177
Indiana								
Michigan	3,427,292	363,541	18,274,081			(1)	(1)	22,064,914
Minnesota						(1)	(1)	
New York				(1)	13,748		(1)	
Ohio	22,551,262	3,399,254	14,468,654	(1)	14,821			40,486,985
Pennsylvania				(1)	39,246		(1)	
Undistributed [2]				220,675	106,119	47,524	363,304	737,622
Total	45,994,805	6,601,077	54,461,412	220,675	361,198	47,524	363,304	108,049,995

[1] Included with "Undistributed."

[2] Includes States indicated by footnote 1 plus the following: For cement, Arizona, Arkansas, Florida, Georgia, Hawaii, Idaho, Iowa, Kansas, Louisiana, Missouri, Montana, Nebraska, Oklahoma, Oregon, South Carolina, South Dakota, and Washington; for paint, New Jersey; and for other uses, Nevada, New Jersey, New Mexico, Virginia, and Wyoming.

TABLE 14.—Production and consumption of agglomerates in the United States in 1960, by States

(Thousand long tons)

State	Agglomerate produced	Agglomerate consumed [1]	
		In blast furnaces	In steel furnaces
Alabama, Kentucky, Tennessee, Texas	2,139	3,452	(2)
California, Colorado, Utah	2,986	2,993	----------
Delaware, Maryland, West Virginia	5,325	5,575	----------
Illinois, Indiana	9,663	12,077	397
Michigan, Minnesota	17,981	4,150	(2)
New York, Ohio, Pennsylvania	16,249	22,669	425
Total	54,343	50,916	832

[1] Includes 1,733,000 long tons of agglomerate produced in foreign countries.
[2] Included in total.

TABLE 15.—Agglomerate produced and consumed in blast and steel furnaces in the United States in 1960, by types

(Long tons)

Type	Agglomerate produced	Agglomerate consumed	
		In blast furnaces	In steel furnaces
Sinter [1]	40,037,796	40,542,815	108,880
Pellets	13,659,016	8,039,582	44,127
Nodules	432,583	43,383	281,213
Briquets	----------	39,675	31,272
Other	213,489	877,743	5,498
Foreign	----------	1,372,187	360,451
Total	54,342,884	50,915,385	831,441

[1] Includes self-fluxing sinter.

STOCKS

Although domestic shipments were curtailed as the shipping season progressed, imports of 34 million tons and the yearlong downward trend in consumption combined to enlarge stockpiles of ore. Yearend stocks of usable iron ore at mines, docks, and consuming plants comprised a record total of 81 million tons.

TABLE 16.—Stocks of usable iron ore at mines, Dec. 31, by States

(Thousand long tons)

State	1959 [1]	1960
Michigan Minnesota Wisconsin	5,520	10,296
Alabama North Carolina	88	258
New York New Jersey Pennsylvania	718	1,092
California Colorado Texas Nevada	563	221
Missouri		38
Montana	2	
Utah	467	501
Total	7,358	12,406

[1] Revised figures.

PRICES

The average value of domestic usable ore per long ton f.o.b mines excluding byproduct ore, was $8.72, compared with $8.69 in 1959 and $8.59 in 1958. These data were taken from producers' statements and probably approximated the commercial selling price less the cost of mine-to-market transportation.

Lake Erie base prices per long ton for Lake Superior iron ores remained at the 1957–59 level: Mesabi non-Bessemer, $11.45; Mesabi Bessemer, $11.60; Old Range non-Bessemer, $11.70; and Old Range Bessemer $11.85. These prices were for ores containing 51.5 percent iron natural, delivered at rail of vessel at lower lake ports, and were used as a basis for negotiating premiums or penalties to be applied for variations in the analyses and physical structure.

E&MJ Metal and Mineral Markets quoted Brazilian ore, 68.5 percent iron, premium for low phosphorous, at $11.25 per long ton, f.o.b. shipping point, and $11.25 for smaller sellers; prices for Eastern ores, foundry and basic, and Swedish ores were nominal.

TABLE 17.—Average value of iron ore at mines in the United States, in 1960

(Per long ton)

State	Direct-shipping ore			Iron ore concentrates			Iron ore agglomerates
	Hematite	Brown ore	Magnetite	Hematite	Brown ore	Magnetite	
Alabama	$5.71			$5.60	$6.19		$5.60
Michigan	8.48			9.30			11.47
Minnesota	7.70			8.11	(1)		11.24
Utah	7.16		(2)				
Other States	9.08	$4.48	$6.58	9.65	9.03	$12.67	14.47
Total	7.74	4.48	6.58	8.32	7.45	12.67	11.64

1 Included with hematite concentrate.
2 Included with direct-shipping hematite.

TRANSPORTATION

Development of new competing sources of iron ore during the last decade made the cost of transportation an item of major economic importance. Many consumers formerly linked to a single supplier or district were able in 1960 to choose between various ores and various transportation routes.

Nearly all ore produced in the Lake Superior district was transported over the long-established rail-lake-rail system. An example of freight charges over this route follows: Mesabi to Duluth ($1.28), handling ($0.19), lake freight (2.00), unloading ($0.28), rail of vessel to car ($0.22), lake to Pittsburgh ($2.73), total cost per long ton ($6.70). All-rail rates from the Mesabi range to Pittsburgh were quoted at $10.23 per long ton.

Ocean rates over much greater distances were at least competitive with lake rates. For example, the rate from Liberia to the United States, about 4,200 miles, was quoted [4] at $4.50 and from Seven Islands on the Gulf of St. Lawrence to Philadelphia, about 1,315 miles, at $0.90. These do not include rail or docking costs either in the country of origin or in the country of destination. Rail rates from ports in the Maryland and Philadelphia customs districts to the Pittsburgh area were identical at $3.92 per ton.

Seven customs districts received 93 percent of the total U.S. imports; Philadelphia (11,273,365 tons), Maryland (10,704,923 tons), Ohio (3,554,370 tons), Mobile (2,406,511 tons), Michigan (1,913,504 tons), Chicago (1,275, 454 tons), and Buffalo (1,190,410 tons).

Lake carriers were limited by port and dock dimensions to a capacity of about 25,000 tons, whereas ocean carriers ranged to 50,000 tons and above. As of December 31, 1960, the U.S. Great Lakes ore fleet comprised 232 vessels with a combined trip-capacity of 2,934,460 long tons.

Lake Superior ports opened on March 29 and closed November 26 in 1960.

4 Wilbur, John S., Competitive Position of Lake Superior Ores: Skillings' Min. Rev., vol. 47, No. 43, Jan. 23, 1960, pp. 1, 4, 5, 7.

RESERVES

A Geological Survey compilation[5] of domestic iron resources, in 1957, indicated that 5.5 billion tons of direct shipping ore and concentrate could probably be obtained from domestic deposits by known methods. Potential ore, mostly in low-grade iron formations in the Lake Superior region, was estimated as capable of yielding an additional 25 billion tons of concentrate. These resource estimates, still valid in 1960, were presented only to show their probable order of magnitude. No attempt was made to evaluate price fluctuations or other economic factors.

Of the 5.5 billion tons of direct-shipping ore and ore amenable to concentration by present methods, about 73.4 percent was in the Lake Superior district, 11 percent in the Southeastern, 9 percent in the Western, and 5 percent in the Northeastern districts.

Iron ore reserves of Michigan and Minnesota, given in tables 18 and 19, are recalculated each year as deposits are explored and mined and represent only taxable and State-owned reserves, excluding taconite and jaspilite reserves.

TABLE 18.—Iron ore reserves in Michigan, Jan. 1

(Thousand long tons)

Range	1952–56 (average)	1957	1958	1959	1960	1961
Gogebic	31,275	26,209	25,187	23,547	19,341	17,911
Marquette	65,759	64,464	64,027	58,719	55,575	54,001
Menominee	60,564	63,536	60,877	58,535	53,554	52,167
Total	157,598	154,209	150,091	140,801	128,470	124,079

Source: Michigan Department of Conservation.

TABLE 19.—Unmined iron ore reserves in Minnesota, May 1

(Thousand long tons)

	1951–55 (average)	1956	1957	1958	1959	1960
Mesabi	840,061	739,971	697,267	618,606	564,253	520,269
Vermilion	12,082	10,449	9,641	9,044	8,307	8,887
Cuyuna	49,327	54,518	52,337	44,416	42,701	36,944
Total Lake Superior district (taxable)	901,470	804,938	759,245	672,066	615,261	566,100
Fillmore County	666	926	1,125	2,088	2,638	2,930
Morrison County	[1] 29					
Aitkin County	[2] 860	825	825	825	825	825
Mower County	[1] 118	118	118	173	152	68
Olmstead County				28	28	141
State ore (not taxable)	1,096	2,352	2,629	1,134	9,263	9,076
Total Minnesota	904,239	809,159	763,942	676,314	628,167	579,140

[1] Average for 2 years.
[2] Average for 4 years.

Source: Minnesota Department of Taxation.

[5] U.S. Department of the Interior, Geological Survey Estimates United States Iron Ore Resources: Inf. Service Release, July 15, 1957, 6 pp.

FOREIGN TRADE[6]

U.S. imports in 1960 were slightly below the record quantity imported in 1959, although foreign productive capacity continued to expand. The 5.2 million tons exported went to Canada and Japan except for a few thousand tons to other countries.

WORLD REVIEW

World trade data for 1960 were not complete, but preliminary information indicated some increase in volume compared with 1959. During 1959, the latest year for which complete statistics were available, the United States was by far the world's largest iron ore importer. Measured in long tons, France was the largest exporter, but in terms of contained iron the largest exporters in 1959 were Venezuela, Sweden, Canada, and France, in that order.

Widespread exploration and development continued as individual nations or private interests sought to improve their vending or purchasing situations.

NORTH AMERICA

Canada.—Shipments of iron ore from Canadian mines totaled 19.0 million tons in 1960 compared with 21.8 million in 1959. However, productive capacity increased considerably as major mines reached the operating stage.

British Columbia.—A new formula for computing royalties to the Provincial government and relaxation of the "50% reserve" rule became effective late in 1960. Under the latter rule, half of the ore belonged to the Government and had to be left in the ground. Expanded production, principally for export to Japan, was expected to result from these changes.

Consolidated Mining & Smelting Co. of Canada Ltd. began constructing a plant for electric furnace production of pig iron at a rate of 36,000 tons per year. Some 30 million tons of pyrrhotite tailings, accumulated from concentration of the firm's Sullivan mine lead-zinc ores, will provide the feed.

Newfoundland-Quebec.—Quebec Cartier Mining Co., a subsidiary of United States Steel Corp., completed its 193-mile railway from Port Cartier on the Gulf of St. Lawrence to Gagnon, Quebec, on December 10, 1960. First shipments of concentrate from the 8-million-ton annual capacity plant were scheduled for February 1961. First production was to be from the Lac Jeanine deposit, although the mineralized area (Mount Reed-Mount Wright) extends for more than 70 miles.

Iron Ore Company of Canada was developing a new mine and building a beneficiating plant in the Carol Lake-Wabush Lake district, Labrador, with initial production scheduled for 1962. Annual production of 7 million tons of concentrate was planned.

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[6] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 20.—U.S. imports for consumption of iron ore,[1] by countries

(Thousand long tons and thousand dollars)

Country	1951–55 (average)		1956		1957		1958		1959		1960	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
North America:												
Canada	3,848	$30,403	13,723	$117,666	12,537	$111,777	8,289	$77,329	[2] 13,458	[2] $128,940	10,597	$104,727
Costa Rica	1	1	----	----	----	----	----	----	----	----	----	----
Cuba	73	682	93	910	33	346	----	----	4	40	3	30
Dominican Republic	58	677	163	2,043	149	2,025	21	298	50	552	----	----
Mexico	168	581	133	447	236	744	221	739	106	356	150	513
Panama	----	----	(3)	3	----	----	14	164	----	----	----	----
Total	4,148	32,344	14,112	121,069	12,955	114,892	8,545	78,530	[2] 13,618	[2] 129,888	10,750	105,270
South America:												
Brazil	823	9,696	1,223	15,416	1,431	20,275	832	12,004	1,200	13,613	1,461	15,518
Chile	1,938	8,485	1,564	10,813	2,741	20,641	3,257	25,876	[2] 3,590	[2] 27,815	3,942	30,684
Peru	867	7,049	1,840	16,405	2,373	20,859	1,674	16,785	[2] 2,236	[2] 21,358	2,762	26,866
Surinam	----	----	----	----	----	----	----	----	2	23	----	----
Venezuela	3,361	23,401	9,254	61,929	12,291	87,733	12,180	87,976	[2] 13,542	[2] 104,347	14,556	132,856
Total	6,989	48,631	13,881	104,563	18,836	149,508	17,943	142,641	[2] 20,570	[2] 167,156	22,721	205,924
Europe:												
Norway	----	----	----	----	----	----	----	----	15	147	----	----
Spain	18	152	----	----	----	----	(3)	6	(3)	6	(3)	7
Sweden	1,899	19,041	999	11,914	677	9,575	113	1,640	136	1,737	94	1,543
United Kingdom	(3)	33	1	39	(3)	35	1	54	19	195	(3)	29
Other Europe	(3)	(4)	(3)	4	(3)	4	(3)	5	1	15	1	13
Total	1,917	19,226	1,000	11,957	677	9,614	114	1,705	171	2,100	95	1,592
Asia:												
Iran	2	126	4	266	----	----	2	167	3	187	2	133
Portuguese Asia	----	----	----	----	----	----	----	----	----	----	57	367
Philippines	----	----	23	381	----	----	54	1,131	71	1,491	1	22
Total	2	126	27	647	----	----	56	1,298	74	1,678	60	522

Africa:												
Algeria	116	859	11	86								
British West Africa	219	1,241	162	1,053	170	1,253	49	351	62	481	46	315
Liberia	617	4,566	1,218	11,115	1,013	9,784	837	7,092	[2] 1,105	[2] 10,981	907	8,034
Other Africa	40	223							17	163	6	36
Total	992	6,889	1,391	12,254	1,183	11,037	886	7,443	[2] 1,184	[2] 11,625	959	8,385
Grand total	14,048	107,216	30,411	250,490	33,651	285,051	27,544	231,617	[2] 35,617	[2] 312,447	34,585	321,693

[1] In addition, pyrites cinder (byproduct iron ore) were imported as follows: 1951–55 (average), 7,331 long tons ($31,263); 1956, 1,430 tons ($5,972); 1957, 567 tons ($2,222); 1958, 2,721 tons ($9,212) all from Canada; 1959, Canada 6,741 tons ($22,988), Italy 3,416 tons ($24,812); 1960, 5,884 tons ($19,679) all from Canada.
[2] Revised figure.
[3] Less than 1,000 tons.
[4] Less than $1,000.

Source: Bureau of the Census.

TABLE 21.—U.S. exports of iron ore, by countries

(Thousand long tons and thousand dollars)

Destination	1951–55 (average)		1956		1957		1958		1959		1960	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Canada	3,606	$26,017	4,529	$39,272	3,958	$36,871	3,077	$29,701	2,453	$28,189	4,391	$48,665
Japan	667	6,481	974	9,313	1,041	10,532	493	5,044	507	5,247	839	8,622
Mexico	(1)	1	3	41	1	8	(1)	4	(1)	2	-------	-------
Philippines	(1)	8	-------	-------	-------	-------	(1)	2	(1)	3	-------	-------
Union of South Africa	(1)	9	2	143	2	125	3	140	3	127	4	174
Other countries	(2)	4	(2)	36	(2)	7	(2)	7	4	263	2	114
Total	4,273	32,520	5,508	48,805	5,002	47,543	3,573	34,898	2,967	33,831	5,236	57,575

[1] Less than 1,000 tons.
[2] Includes countries receiving less than 1,000 tons each.

Source: Bureau of the Census.

TABLE 22.—World production of iron ore, iron ore concentrates, and iron ore agglomerates by countries [1]

(Thousand long tons)

Country	1951–55 (average)	1956	1957	1958	1959	1960
North America:						
Canada	7,162	19,954	19,886	14,042	21,864	19,067
Cuba	91	135	177	16	---------	---------
Dominican Republic	[2] 79	111	124	17	12	---------
Guatemala	[3] 2	[3] 3	4	5	[3] 4	[3] 4
Mexico	545	801	[3] 935	[3] 955	[3] 875	924
United States [4]	102,710	97,877	106,148	67,709	60,276	88,777
Total	110,589	118,881	127,274	82,744	83,031	108,772
South America:						
Argentina	65	64	66	65	108	[3] 108
Brazil	3,079	4,011	4,898	5,103	8,701	5,173
Chile	2,403	2,624	2,652	3,605	3,843	4,665
Colombia	[5] 214	388	584	543	399	645
Peru	[6] 1,625	2,604	3,522	3,532	3,519	6,875
Venezuela	3,818	10,930	15,054	15,240	17,018	19,182
Total	11,204	20,621	26,776	28,088	33,588	36,648
Europe:						
Albania	---------	(7)	(7)	88	[3] 155	[3] 160
Austria	2,626	3,207	3,441	3,356	3,329	3,486
Belgium	98	142	136	121	140	159
Bulgaria	96	232	267	340	370	[3] 395
Czechoslovakia	2,031	2,499	2,766	2,755	2,921	3,071
Finland [8]	[6] 110	203	207	212	224	281
France	41,847	51,872	56,873	58,499	59,956	65,854
Germany:						
East	1,132	1,729	1,455	1,482	1,574	[3] 1,575
West	14,107	16,661	18,031	17,704	17,778	18,571
Greece	112	323	424	275	221	[3] 295
Hungary	347	344	327	365	432	508
Italy	953	1,648	1,556	1,272	1,217	1,225
Luxembourg	6,521	7,474	7,719	6,533	6,406	6,867
Norway	913	1,526	1,567	1,617	1,558	1,614
Poland	1,303	1,774	1,757	1,931	1,982	2,148
Portugal	109	233	281	228	238	283
Rumania	597	683	634	731	1,047	1,437
Spain	2,945	4,410	5,155	4,954	4,536	5,382
Sweden	16,140	18,648	19,609	18,023	17,999	20,975
Switzerland	104	129	114	[3] 75	[3] 60	[3] 125
U.S.S.R. [9]	57,747	76,846	82,963	87,414	92,900	105,310
United Kingdom	15,712	16,245	16,902	14,613	14,872	17,056
Yugoslavia	898	1,698	1,846	1,965	2,062	2,165
Total [9]	166,448	208,526	224,030	224,553	231,977	258,942

TABLE 22.—World production of iron ore, iron ore concentrates, and iron ore agglomerates by counties [1]—Continued

Country	1951-55 (average)	1956	1957	1958	1959	1960
Asia:						
Burma	4	4	4	6	4	16
China [3] [10]	5,500	8,900	14,800	29,500	44,300	54,100
Hong Kong	123	123	94	105	120	115
India	4,084	4,898	5,074	6,033	7,810	10,514
Iran [11]	11	10	[3] 10	138	59	----------
Japan [12]	1,427	1,882	2,204	2,056	2,508	2,801
Korea:						
North	(7)	(7)	(7)	1,527	2,650	2,950
Republic of	30	62	182	257	278	386
Lebanon	[2] 32	41	41	23	3	[3] 3
Malaya	1,129	2,445	2,972	2,795	3,761	5,641
Philippines	1,211	1,417	1,325	1,082	1,211	1,121
Portuguese India	1,075	2,505	2,901	2,889	3,025	4,615
Thailand (Siam)	5	6	9	15	6	11
Turkey	504	915	1,146	936	859	723
Total [9]	15,460	24,198	31,752	47,362	66,594	82,996
Africa:						
Algeria	3,116	2,587	2,746	2,298	1,897	3,387
Angola	----------	----------	104	282	343	649
Guinea, Republic of	[6] 538	834	1,074	405	337	716
Liberia	1,086	2,108	1,935	2,264	2,647	3,003
Morocco:						
Northern zone	949	1,356	} 1,839	1,514	1,245	1,552
Southern zone	464	482				
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia	2	----------	----------	----------	----------	----------
Southern Rhodesia	65	114	133	142	128	156
Sierra Leone	1,145	1,311	1,324	1,300	1,426	1,447
Sudan	----------	----------	----------	----------	----------	3
Tunisia	996	1,151	1,162	1,086	966	1,017
Union of South Africa	1,780	2,031	2,047	2,177	2,845	3,023
United Arab Republic (Egypt Region)	----------	129	250	175	242	[3] 245
Total	10,141	12,103	12,614	11,643	12,076	15,198
Oceania:						
Australia	3,102	3,924	3,806	3,926	4,149	4,250
Fiji	----------	----------	1	3	12	11
New Caledonia	----------	28	230	290	282	272
Total	3,102	3,952	4,037	4,219	4,443	4,533
World total (estimate) [1] [7]	316,944	388,281	426,483	398,609	431,709	507,089

1 Table incorporates some revisions.
2 Average for 1952–55.
3 Estimate.
4 Includes byproduct ore.
5 Average for 1954–55.
6 Average for 1953–55.
7 Data not available for Albania and North Korea; estimate included in the total for North Korea.
8 Iron concentrates and pellets.
9 U.S.S.R. in Asia included with U.S.S.R. in Europe.
10 Roughly equivalent of 50 percent iron.
11 Year ending March 21 of year following that stated.
12 Includes iron sand production as follows: 1951–55 (average), 434,862 tons; 1956, 897,788 tons; 1957, 1,067,088 tons; 1958, 898,913 tons; 1959, 1,335,646 tons; and 1960, 1,533,927 tons.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

TABLE 23.—World trade of iron ore, iron ore concentrates, iron ore agglomerate in 1959

(Thousand long tons)

Exports by countries of origin	Fe (percent) [1]	Production	Exports	Exports by countries of destination																	
				North America		Europe													Asia	Oceania	
				Canada	United States	Austria	Belgium-Luxembourg	Czechoslovakia	France	Germany, East	Germany, West	Hungary	Italy	Netherlands	Poland	Rumania	Saar	United Kingdom	Japan	Australia	Other countries
North America:																					
Canada	55	21,864	18,552		13,394		82				1,137		41	423				2,822	653		
Cuba	62		4		[2] 4																
Dominican Republic	66	12	50		50																
Mexico	60	[1] 875	114		114						(3)										
United States	49	60,276	2,967	2,453															507		7
South America:																					
Brazil	70	8,701	3,895	84	1,269			456	50		736	13	28	210	291			557	193		8
Chile	64	3,843	4,193	43	3,397		20				216								68		449
Peru	62	3,519	3,267		2,271						[2] 719			(3)					141		136
Venezuela	60	17,018	17,104		13,864		50		20		1,214		536					1,387	33		
Europe:																					
Austria	32	3,329	49		(3)			49			(3)		(3)								
Belgium-Luxembourg	28	6,546	122						120												2
Finland	36	224	274					18	4	3	71				129			49			
France	33	59,956	27,502				14,489				4,762			15			7,805	431			(3)
Germany, West	27	17,778	290			268	3		4				1	1			11				2
Greece	49	221	159			107					39			13							
Italy	29	1,217	2						(3)		2										
Norway	65	1,558	925								605				119			169			32
Portugal	50	238	189								98							91			(3)
Spain	50	4,536	1,769			11	11	5	84		983		47	105	28			433			62
Sweden	60	17,999	15,224		150	34	3,173	155	325	10	6,865	12	262	313	590			3,216			119
Switzerland	40	[1] 60	49								49										(3)
U.S.S.R	55	92,900	13,234			241		4,563		1,933		1,586			4,121	790					
United Kingdom	30	14,872																			
Yugoslavia	45	2,062	18									18									
Other Europe		8,481	(4)																		

Asia:																					
China	50	44,300	[5, 6] 213	-	-	-	-	(6)	-	-	-	-	-	-	[2] 213	-	-	-	-	-	-
Hong Kong	56	120	124	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	124	-	-
India	53	7,810	2,471	-	-	-	-	473	1	45	27	-	89	1	57	22	-	(3)	1,662	-	94
Korea, North	50	2,650	198	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	198	-	(3)
Malaya	55	3,761	3,748	-	-	-	-	-	-	-	21	-	-	-	-	-	-	-	3,700	-	27
Philippines	54	1,211	1,178	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,178	-	-
Portuguese India	55	3,025	3,677	-	39	-	8	61	24	-	1,077	-	406	122	-	-	-	32	1,907	-	1
Turkey	60	859	131	-	-	-	-	-	-	-	8	-	110	13	-	-	-	-	-	-	-
Other Asia	-	2,858	(5)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Africa:																					
Algeria	52	1,897	1,991	-	-	6	35	-	118	-	47	-	189	107	-	-	-	1,489	-	-	-
Angola	65	343	332	-	17	(3)	5	38	19	-	250	-	-	3	-	-	-	-	-	-	(3)
Guinea, Republic of	53	337	347	-	-	-	-	-	-	-	-	-	-	-	[1] 97	-	-	250	-	-	-
Liberia	68	2,647	2,665	127	1,088	-	-	-	-	-	[2] 734	-	31	324	-	-	-	349	-	-	12
Morocco	60	1,245	695	-	5	-	7	10	157	-	[2] 88	-	-	-	-	-	-	350	-	-	78
Sierra Leone	60	1,426	1,503	-	62	10	-	-	-	-	353	-	(3)	359	-	-	-	719	-	-	-
Tunisia	53	966	818	-	-	-	-	25	69	-	19	-	138	32	-	-	-	535	-	-	-
Union of South Africa	62	2,845	166	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	162	-	-
Oceania:																					
Australia	63	4,149	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
New Caledonia	55	282	277	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	262	15
Other countries	-	893	(5)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	431,709	130,486	2,707	35,724	677	17,883	5,853	995	1,991	20,120	1,629	1,878	2,045	5,645	812	7,816	12,879	10,526	262	1,044

[1] Estimate.
[2] Imports.
[3] Less than 500 tons.
[4] Data not available.
[5] Incomplete data.
[6] Trade agreements between China and Czechoslovakia indicate shipments of iron ore from China, but quantity is unknown.

Compiled by Corra A. Barry, Division of Foreign Activities.

Ontario.—Dredging of Steep Rock Lake, started on March 4, 1955, was completed in September 1960 with removal of 162 million cubic yards of overburden. Caland Ore Co., Ltd., Canadian subsidiary of Inland Steel Co., planned eventual annual production of 3 million tons from the property.

The International Nickel Company of Canada, Ltd., announced plans to expand its iron ore recovery plant. Capacity in 1963 will be 900,000 tons of pellets containing 68 percent iron.

Marmoraton Mining Co., Ltd., Canadian subsidiary of Bethlehem Steel Corp., returned to full production in November after a 6-week closure due to a decline in demand.

Mexico.—Successful operation since March 1958 of the 200-ton-per-day Hojalata y Lamina S.A. (HyL) direct-reduction plant at Monterrey led to construction of an additional 500-ton-per-day plant at the same site. The new plant went into operation in November. Several descriptions of the process were published.[7]

SOUTH AMERICA

The iron ore industry of South America was reviewed in a paper[8] presented at the 21st Annual Mining Symposium sponsored by the University of Minnesota.

Argentina.—According to the Argentine press, an agreement was signed, pending final approval by executive decree, for exploration of the Sierra Grande iron ore deposits in Rio Negro province. Argentine, German, and U.S. firms were listed as participants.[9]

Brazil.—St. John Del Rey Mining Co. Ltd. announced it would sell its gold-mining property in Minas Gerais to a new Brazilian-controlled firm and concentrate efforts on developing the Aquas Claras iron ore deposit near Belo Horizonte. Exploration of the iron ore deposit was reported virtually complete, but plans for developing and transporting the ore were not announced.

Chile.—Productive capacity increased substantially in 1960, pointing to an export capability of 6 million tons or more in 1961. New automatic loading facilities at Chanarel, Huasco, and Caldera, development or expansion of operations at several deposits, large reserves of high-grade ore, and additional tonnage of potential ore contributed to a booming iron ore industry in 1960. The most active iron ore producing, purchasing, and exporting companies were Compañia Minera Santa Fe, Compañia Minera Santa Barbara, and Bethlehem Chile Iron Mines.

Companhia de Acero del Pacifico, S. A., began developing the large high-grade Algarrobo deposit in the province of Atacama. Annual production of 1 to 2 million tons was scheduled for 1961. It was expected that sufficient ore would be exported to the world market to

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[7] McAneny, Colin C., Iron, How Is Direct Reduction Doing Commercially?: Eng. Min. Jour., vol. 161, No. 12, December 1960, pp. 84, 85.
Muller, Gunther H., Sponge Iron in Mexico: Metal. Prog., vol. 77, No. 1, January 1960, pp. 111–115, 192, 193.
World Mining, New Sponge Iron Plant: Vol. 13, No. 1, January 1960, pp. 26–29.

[8] Reno, Horace T., and Anderson, Sumner, Iron Ore: Min. World, vol. 22, No. 6, May 1960, pp. 32–41.

[9] U.S. Embassy, Buenos Aires, Argentina, State Department Dispatch 722, Dec. 6, 1960, p. 5.

return the capital investment and that the remaining ore would be held in reserve to supply the firm's Huachipato steel mill.

Peru.—Marcona Mining Co., owned jointly by Cypress Mines Corp. and Utah Construction Co., announced a $21.9 million program for improved mining, beneficiation, and handling facilities. Production by Marcona, plus the first large-scale output from the Acarí property of Panamerican Commodities, S.A., resulted in a twofold increase in exports of iron ore.

Venezuela.—It was unofficially reported that Government development of the Cerro San Isidro deposit was being considered. The Government policy of withholding new petroleum concessions from private companies was extended to other mineral resources, including iron ore.

EUROPE

The European Coal and Steel Community produced a record 93 million long tons of iron ore, compared with 105 million produced in the U.S.S.R. and 89 million in the United States. Production in Sweden, the United Kingdom, and other European countries brought the total for Western Europe well above that of either the United States or the U.S.S.R.

The four largest pig-iron-producing countries in Western Europe (West Germany, France, United Kingdom, and Belgium) produced 69 million short tons, compared with 52 million tons in the U.S.S.R. and 67 million in the United States.

France.—Consumption of iron ore, virtually all from French mines, increased 5 percent in 1960 to 36.5 million tons. Pig iron production increased 4 percent to 12.5 million tons. Experimental use of fuel oil and natural gas in blast furnaces reduced the coke rate and increased production.

Germany, West.—Production of pig iron increased 19 percent to a record 25.7 million tons in 1960. The first shipment of iron ore from the recently discovered deposits between Salzgitter and Gifhorn in Lower Saxony was reported. Deposits in this area, estimated to contain 2 billion tons of ore averaging 28 percent iron, were described.[10]

Sweden.—Production and exports of iron ore were at record levels in 1960. About 45 percent of the exports, estimated at more than 19 million tons, went to West Germany; 20 percent went to Belgium, and 20 percent went to the United Kingdom. Of the total Swedish production in 1960, 12 million tons came from the Kiruna mine of Luossavaara Kiirunavaara, a. -b. (LKAB), and most of the remainder came from the Malmberget and Grängesberg properties. LKAB announced plans to build a new ore harbor at Lulea on the Baltic seaboard. It was estimated the new facility, scheduled for completion by 1964, would handle about 9 million tons per year.

United Kingdom.—The United Kingdom produced 17 million tons of iron ore and imported 17.5 million tons to support the 15.8-million-ton record pig iron production of 1960. Sweden was the largest ore supplier, but Canada, Algeria, Venezuela, and other countries sup-

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[10] Huttl, John B., Salzgitter Brown Iron Ores Basis for a Second Ruhr: Eng. Min. Jour., vol. 160, No. 11, November 1959, pp. 82–92.

plied substantial quantities. New mines in Liberia and in the Republic of Mauretania were among African sources expected to augment future supplies of iron ore to the United Kingdom.

U.S.S.R.—The Soviet Minister of Geology told a Moscow news conference that geologists found 30 billion tons of high-grade ore (200 billion tons of all grades) in the Kursk magnetic anomaly about 300 miles south of Moscow. Others had reported the existence of iron ore in this area, but tonnage estimates had not previously been given. Unofficial reports indicated that much of the ore lies beneath water-bearing sand beds that will make developing this new source more difficult.

ASIA

China.—The program to expand the iron and steel industry of China was reported[11] to be based on abundant raw material and human resources; existing plant plus foreign technical assistance for training and new construction; and the incentive of urgent need. More than 400 foreign geologists had been brought to China.

Although iron ore reserves may differ considerably from the estimated 10 to 12 billion tons, they are known to be substantial and widely distributed. Grade varies widely, and much of the blast furnace feed in 1960 was beneficiated. Feed charged to the larger blast furnaces was reported in the range of 50 to 65 percent iron.

India.—A draft of the Third Five Year Plan was released in 1960.[12]

Production of iron ore had increased every year since 1953 and reached 10.5 million tons in 1960. Under the Third Plan, production was to be increased to 32 million tons, with 20 million tons required for domestic use and 12 million tons for export. Inadequate facilities in some areas for transportation of iron ore and fuel and the need for agglomerating fine ores were among the many difficult problems to be solved.

Japan.—The Ministry of International Trade and Industry, late in 1960, revised its 10-year projection of Japan's crude steel requirements to 48 million tons per year by 1970, based on an annual growth rate of 9 percent. The steel industry estimated that 30 blast furnaces in addition to the present 34 would be needed to provide the corresponding 35-million-ton pig iron requirement. Construction of nine new furnaces was scheduled to begin in 1961. According to the new estimate, 58 million tons of iron ore would be needed in 1970, of which 48 million would be imported.

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[11] Wang, K. P., A Review of Mining and Metallurgy in Communist China: Symposium on Sciences in Communist China, Sponsored by the Am. Assoc. for the Advancement of Science, Dec. 26, 1960, pp. 25–31.
Chao, Edward C. T., Progress and Outlook of Geology in Communist China, 1960: Symposium on Sciences in Communist China. Sponsored by the Am. Assoc. for the Advancement of Science, Dec. 26, 1960, pp. 25–31.
Smith, Wm. L., Red China's Steel Industry Makes Giant Strides (three parts): Am. Metal Market, vol 67, No. 107, June 6, 1960, pp. 1, 12; No. 108, June 7, 1960, pp. 1, 2; No. 109, June 8, 1960, pp. 1, 6.

[12] U.S. Embassy, New Delhi, India, State Department Dispatch 188, Aug. 26, 1960, p. 44.

The Japanese iron ore import plan, by country of origin, for fiscal years 1960 and 1970 follows:[13]

	Thousand tons 1960	Thousand tons 1970
From existing sources:		
African countries	300	2,000
Brazil	300	500
Canada	1,130	1,000
Chile	270	2,000
Goa	2,850	7,500
Hong Kong	120	100
India	2,200	8,500
Korea, Republic of	300	200
Malaya	5,360	3,000
Peru	450	3,000
Philippines	1,470	1,000
United States	530	1,000
Total	15,280	29,800
From new sources:		
African countries	----	1,500
Australia	----	1,000
Brazil	----	500
Chile	----	1,000
China	----	1,000
India	----	2,000
Korea, North	----	1,000
Peru	----	1,000
U.S.S.R.	----	2,000
Venezuela	----	1,000
Other	----	3,180
Total	----	15,180
Grand total	15,280	44,980

Malaya.—Malaya was an important supplier to the Japanese steel industry and produced 4 million tons of iron ore in 1960, exceeding the former record high established in 1959. Plans for mining the Bukit Iban deposit called for first production in 1963 at an annual production rate of 1 million tons.

AFRICA

Angola.—The Council of Ministers in Lisbon approved a US$45,-448,000 contract between German, Danish, and Portuguese interests to finance purchases by the Angolan mining firm, Companhia Mineira do Lobito.[14]

Rail connections from the Cassinga and Cuima iron ore deposits and port facilities at Mocamedes were to be built for export of some 3,500 tons of iron ore per day.

[13] U.S. Embassy, Tokyo, Japan, State Department Dispatch 627, Dec. 12, 1960, pp. 3, 4.
[14] U.S. Consul, Luanda, Angola, State Department Dispatch 146, Dec. 21, 1960, 3 pp.

Gabon.—The Societé des Mines de Fer de Mekambo (SOMIFER) continued to explore the Mekambo iron deposits in northeast Gabon. Although proved reserves of high-grade ore exceeded 500 million tons, no decision on its exploitation was announced. This project, if implemented, would be one of the largest single investments in Africa, chiefly because of the high cost of transportation facilities.

Liberia.—Liberia Mining Co., at its Bomi Hills deposit, was the only important producer of iron ore in 1960. However, when new mines being developed begin producing, Liberia will become a major world source of iron ore.[15]

The Liberian-American-Swedish Minerals Co. (LAMCO) and Bethlehem Steel Corporation established a joint venture to exploit high-grade deposits in the Nimba Mountains, 165 miles inland from a port being constructed at Lower Buchanan. Production of 6 million tons annually was planned by 1963, with expansion later to 10 million tons.

National Iron Ore Co. (NIOC) obtained a US$6 million Export-Import Bank loan to aid in the US$22.3 million development of iron ore deposits in the Mano River district. Annual capacity of 4 million tons was expected by 1963.

German Liberian Mining Co. (DELIMCO) planned to develop the Bong Range iron deposit. Annual production was expected to reach a rate of 5 million tons in 1963.

Mauritania.—Societé Anonyme des Mines de Fer de Mauritanie (MIFERME) began to construct railroad and port facilities and to develop the Kedia D'Idjil deposit. The 444-mile railroad and port at Étienne were expected to be ready to handle the planned 4-million-ton annual output by 1964.

TECHNOLOGY

Over the last 2 decades, revolutionary changes occurred in the technology and pattern of iron ore supply. World productive capacity had been greatly expanded and decentralized. In 1960, consumers were not bound to traditional ore sources. Neither were they bound to traditional types or grades of ore. Transportation and beneficiation were major factors in the 1960 technology, and vast tonnages of high-grade ores were imported by the industrial nations from newly developed mines thousands of miles distant. Although much of the imported ore was high in quality, the worldwide trend was toward utilizing the larger low-grade deposits amenable to beneficiation.

Geological work conducted by the Iron Ore Co. of Canada in the important Knob Lake area of Quebec and Labrador was reviewed.[16] The review included information on geology, mineralogy, ore reserves, and origin of the deposits. Another paper [16] related the metamorphism of iron formations to their beneficiation amenability. The recrystal-

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[15] U.S. Embassy, Monrovia, Liberia, State Department Dispatch 141, Oct. 27, 1960, pp. 6–8.
Skillings' Mining Review, vol. 49, No. 16, July 16, 1960, pp. 1, 4–6.

[16] Stubbins, John B., Blais, Roger A., and Zojac, Stephen I., Origin of the Soft Iron Ores of the Knob Lake Range: Canadian Min. Met. Bull., vol. 54, No. 585, January 1961, pp. 43–58.

lization and coarsening of grain size, brought about by higher grade metamorphism, leads to easier crushing, grinding, and concentrating.[17] Use of the gravity method in exploring for iron ore, particularly taconites, was described.[18] The staff at Wabana Mines in Newfoundland described a method of diamond-drill exploring from a point on the vein.[19] The Federal Bureau of Mines published a report on a titaniferous iron deposit in Colorado.[20]

The trend in mining was to larger tonnage and less selective methods, and in the United States about 86 percent of the 1960 production came from open-pit mines. In many areas of the world, however, underground mining was important; in the United States a large, new underground mine at the Pea Ridge deposit in Missouri was being developed.

Modern, large-scale mining methods and equipment in Sweden's underground mines were described.[21] The use of diesel-driven haulage trucks, mechanical raise climbers, underground crushing, automatic hoisting, and long-hole drilling of raises, and underground use of ammonium nitrate explosives, were noted.

Through research on blasting patterns and explosives, the Iron Ore Co. of Canada was able to double breakage per foot of borehole. Spacing of the 40-foot-deep holes in hard, siliceous iron formation was increased from 15 by 15 feet to 21 by 23 feet.[22]

More than 76 percent of the crude ore shipped from mines in the United States in 1960 went to beneficiation plants, and, in addition, a substantial part of the ore shipped directly to consumers was agglomerated at the consuming plant. Blending, drying, sizing, concentrating, and agglomerating were widely practiced in the United States and foreign countries. Incorporation of flux and partial reduction of ore prior to use in the blast furnace were subjects of additional interest and study.

The decreasing importance of traditional, direct-shipping iron ores, the demand for higher grade blast furnace feeds, and trends and developments in beneficiation were reviewed.[23]

A paper on the energy input required for comminution of rock particles described apparatus, testing procedure, and the theory of crushing.[24]

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[17] Gross, G. A., Metamorphism of Iron Formations and Its Bearing on Their Beneficiation: Canadian Min. Met. Bull., vol. 54, No. 585, January 1961, pp. 30–37.

[18] Hinye, William J., Application of the Gravity Method to Iron Ore Exploration: Econ. Geol., vol. 55, No. 3, May 1960, pp. 465–484.

[19] Canadian Mining and Metallurgical Bulletin, Deflection Diamond Drilling at Wabana Mines: Vol. 53, No. 577, May 1960, pp. 309–314.

[20] Rose, Charles K., and Shannon, Spencer S., Jr., Cebolla Creek Titaniferous Iron Deposits, Gunnison County, Colo.: Bureau of Mines Rept. of Investigations 5679, 1960, 29 pp.

[21] Janelid, Ingvar, Mining Huge Ore Bodies in Sweden: Min. Cong. Jour., vol. 46, No. 12, December 1960, pp. 39–42, 59.

[22] Farnam, H. E., Jr., Blasting Slurries: Canadian Min. Met. Bull., vol. 53, No. 582, October 1960, pp. 818–823.

[23] Erickson, S. E., Trends in Iron Ore Benefication: Min. Cong. Jour., vol. 46, No. 4, April 1960, pp. 67–69, 72.
Davies, G. E., Recent Developments in Iron Ore Concentration: Mine and Quarry Eng. (London), vol. 26, No. 4, April 1960, pp. 158–163.

[24] Bergstrom, B. H., Sollenberger, C. L., and Mitchell, Will, Jr., Energy Aspects of Single Particle Crushing: Paper pres. at AIME, New York, N.Y., Feb. 14–18, 1960, 21 pp.

A number of reports dealt with techniques for concentrating iron ores with emphasis on flotation and reduction roasting methods applicable to the ores of the taconite-jaspilite type, which represented the largest iron ore resource in the United States.[25]

The beneficiation of Alabama and Texas iron ores was described.[26]

Agglomeration continued to gain importance as furnace operators specified better preparation of raw materials, and mine operators concentrated lower grade ores.[27] World production of sinter was estimated at an annual rate of 150 million tons. Pellets were favored where subsequent handling was involved, and some operators also considered pellets to have superior characteristics in the blast furnace. However, sinter was favored where agglomerating was done at the consuming-plant site.

Although direct-reduction processes made no appreciable gain in tons produced, interest in them persisted because of the rising proportion of fine ores resulting from concentration processes, relatively low capital expenditure, and the lack in some areas of fuel suitable for the blast furnace. A number of the more advanced direct-reduction processes were described in a special report.[28] Evidence in 1960 seemed to indicate a growing, though limited, use of these methods where special circumstances proved favorable or where their use as a supplement to the blast furnace might prove feasible, as in partial reduction of blast furnace feed or production of iron for powder metallurgy.

Blast furnace productivity had been increasing both in tons of metal per unit of time and tons per unit of fuel. The increase was due chiefly to improved feed materials but also to improved operating practice. Use of up to 100 percent self-fluxing sinter was reported in some foreign furnaces. Oxide pellets produced in the United States ranged between 60 and 65 percent iron, and some research groups suggested that partially reduced ores or pellets of 80 to 90

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[25] Smith, Richard R., Iron Ore Flotation in Michigan: Skillings' Min. Rev., vol. 50, No. 4, Jan. 28, 1961, pp. 1, 4–5.
Titkov, N. P., and Yegorkin, A. N., Development of Technology for the Beneficiation of Hematite Ores: Paper pres. at AIME, New York, N.Y., Feb. 14–18, 1960, 28 pp.
Cooke, S. R. B., Iwasaki, I., and Choi, H. S., Effect of Temperature on Soap Flotation of Iron Ore: Min. Eng., vol. 12, No. 5, May 1960, pp. 491–498.
Edwards, J. R. J., and Salamy, S. G., The Magnetic Reduction of Jaspilite in a Shaft Furnace: Paper pres. at AIME, New York, N.Y., Feb. 14–18, 1960, 13 pp.
Wade, H. H., and Schulz, N. F., Magnetic Roasting of Iron Ores in a Traveling Grate Roaster: Paper pres. at AIME, New York, N.Y., Feb. 14–18, 1960, 13 pp.
Dailey, W. H., Jr., and Bunge, F. H., The Reaction of Low-Grade Nonmagnetic Iron Ores to Magnetic Roasting in a Fixed Bed: Paper pres. at AIME, New York, N.Y., Feb. 14–18, 1960, 19 pp.

[26] Feld, I. L., Perry, R. E., and Lamont, W. E., Concentrating Argilaceous Surface Iron Ore of Tuscaloosa County, Ala., by Washing: Bureau of Mines Rept. of Investigations 5623, 1960, 15 pp.
Powell, H. E., and Dressel, W. M., Laboratory Beneficiation of East Texas Limonite-Siderite Iron Ores: Bureau of Mines Rept. of Investigations 5647, 1960, 14 pp.

[27] Merklin, K. E., and DeVaney, F. D., Production of Self-Fluxing Pellets in the Laboratory and Pilot Plant: Min. Eng., vol. 12, No. 3, March 1960, pp. 266–271.
Langston, B. G., and Stephens, F. M., Jr., Self-Agglomerating Fluidized-Bed Reduction: Jour. Metals, vol. 12, No. 4, April 1960, pp. 312–316.
Merklin, K. E., and Childs, M. H., Some Factors Influencing the Physical Qualities of Iron Ore Pellets: Paper pres. at AIME, New York, N.Y., Feb. 14–18, 1960, 15 pp.
Slater, R. A., Construction and Design Problems Involved in New Sintering Plant: Iron and Steel Eng., vol. 37, No. 12, December 1960, pp. 114–117.
Hamilton, D. E., and Houlton, R. L., Automation for Sinter Plants: Blast Furnace and Steel Plant, vol. 48, No. 6, June 1960, pp. 569–579.

[28] McAneny, Colin C., Special Report, Direct Reduction of Iron Ore: Eng. Min. Jour., vol. 161, No. 12, December 1960, pp. 83–99.

percent iron might ultimately prove to be the most economic blast furnace feed.

The Bureau of Mines experimental blast furnace was used to develop and demonstrate techniques for injecting solid, gaseous, and liquid fuels into the smelting zone, and two Bureau publications were issued.[29] The experimental furnace was also used for comparing various blast furnace burdens.[30]

Considerable blast furnace research by the Bureau was in cooperation with private industry and was instrumental in the wide acceptance by industry of new operating procedures, such as fuel injection and higher blast temperature.

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[29] Melcher, Norwood B., Morris, J. P., Ostrowski, E. J., and Woolf, P. L., Use of Natural Gas in an Experimental Blast Furnace: Bureau of Mines Rept. of Investigations 5621, 1960, 15 pp.
Ostrowski, E. J., Royer, M. B., and Ropelewski, L. J., Injecting Solid Fuels Into Smelting Zone of an Experimental Blast Furnace: Bureau of Mines Rept. of Investigations 5648, 1960, 14 pp.

[30] Melcher, Norwood B., and Royer, Miles B., Smelting Unfired Iron Ore Pellets in an Experimental Blast Furnace: Bureau of Mines Rept. of Investigations 5640, 1960, 9 pp.
Royer, Miles B., Melcher, Norwood B., and Philbrook, W. O., Smelting Taconite in the Bureau of Mines Experimental Blast Furnace: Bureau of Mines Rept. of Investigations 5724, 1961, 15 pp

Iron and Steel

By James C. O. Harris [1]

Contents

NATIONAL pig iron and steel output was below expectations in 1960, but was greater than in 1958 and 1959, and the sixth highest in history. The United States remained for the 71st consecutive year as the world leader in steel manufacture. Its production, representing more than one-fourth of world output, surpassed that of U.S.S.R., which ranked second as producer, by 30 million tons.

Domestic production of pig iron totaled 66.5 million tons, a 10-percent increase over 1959. Steel output by ingot producers was 99.3 million tons, up 6 percent. Steel castings made by noningot producers (1.2 million tons) dropped 13 percent, and shipments of gray and malleable-iron castings (12.4 million tons) decreased 6 percent.

During the first quarter of 1960, record tonnage of steel was produced, and customers replenished stocks that had been depleted by the 1959 steel strike. Then as demand for steel decreased, customers slowed their buying. Lower inventories at yearend placed the steel industry in a good position to increase operations during the first half of 1961.

Advances in technology included increased unit output of blast furnaces through improved preparation of raw materials, the use of natural gas, and higher hot-blast temperatures. Output of open hearth furnaces increased through the greater use of oxygen. Techniques included the addiition of oxygen through furnace-roof lances and the use of oxygen-fuel lances to speed the melting of scrap and refinery of pig iron. A new record of about 3.3 million tons of steel was produced in oxygen converters. Rapid progress was made in improving steels to meet growing demands for strength and lightness, corrosion resistance, and formability. The use of vinyl-coated steel increased.

Shipments of steel-mill products, including exports, totaled 71.1 million tons, compared with 69.4 million in 1959 and 59.9 million in 1958. All major consuming industries bought more steel except appliances, utensils, cutlery, and agriculture. Construction and maintenance showed the largest increase. The automotive industry continued to be the leading consumer, receiving 14.6 million tons or 21 percent of domestic shipments.

[1] Commodity specialist, Division of Minerals.

Imports of major iron and steel products totaled 3.5 million short tons and made 1960 the second highest year, compared with the 1959 peak of 4.6 million tons. Exports totaled 3.3 million and exceeded the 1959 low of 2 million tons.

No change in the price of steel had occurred in 2 years. Lower priced foreign steels, however, continued to penetrate domestic markets, although to a lesser degree than in 1959. According to the American Iron and Steel Institute (A.I.S.I.), the 1960 payroll of steel ingot producers set a new record, estimated at more than $3.9 billion, compared with a record of $3.8 billion in 1957. Data also showed that the number of wage and salaried employees declined less than 8 percent from 1957, contrasted with a 15-percent decrease in steel production.

Weekly hours per employee in the steel industry in 1960 averaged 37.8, compared with 39.3 in 1959. The average number of employees was 460,000 compared with 417,000 in 1959, and the average hourly wage was $3.06 compared with $3.08 in 1959. The 12th wage increase since World War II for steelworkers went into effect December 1, 1960.

TABLE 1.—Salient iron and steel statistics

(Thousand short tons)

	1951–55 (average)	1956	1957	1958	1959	1960
United States:						
Pig Iron:						
Production	68,247	75,030	78,404	57,155	60,210	66,501
Shipments	68,146	75,110	76,887	56,918	61,245	65,612
Imports for consumption	522	327	225	210	[1] 700	331
Exports	17	269	882	103	10	112
Steel:						
Production of ingots and castings (all grades):						
Carbon	93,577	104,888	103,803	78,591	84,539	90,864
Stainless	1,000	1,256	1,047	896	1,131	1,004
All other alloy	8,488	9,072	7,865	5,768	7,776	7,414
Total	103,065	115,216	112,715	85,255	93,446	99,282
Capacity, annual Jan. 1	116,105	128,363	133,459	140,743	147,634	148,571
Percent of capacity	88.8	89.8	84.5	60.6	63.3	66.8
Index (1951–55=100)	100.0	111.8	109.4	82.7	90.7	96.3
Imports of major iron and steel products [2]	1,441	1,479	1,295	1,820	[1] 4,615	3,544
Exports of major iron and steel products	3,738	4,749	5,917	3,225	[1] 1,973	3,298
Total shipments of steel mill products	74,991	83,251	79,895	59,914	69,377	71,149
World: Production:						
Pig iron [3]	181,000	[1] 221,900	233,200	216,700	[1] 247,000	285,000
Steel ingots and castings	253,700	312,650	[1] 322,550	[1] 298,700	[1] 336,400	381,200

[1] Revised figure.
[2] Data not comparable for all years.
[3] Includes ferroalloys.

PRODUCTION AND SHIPMENTS OF PIG IRON

U.S. production of pig iron, exclusive of ferroalloys, was 10 percent greater than 1959 but 3 percent below the 1951–55 average. Blast furnaces operated at above 95-percent capacity during the first quarter with a record monthly production of 7.8 million tons in January. The operating rate for the year was 69.7 percent of capacity. Pig iron production increased in 12 of the 17 States included in table 2. Pennsylvania, Ohio, Indiana, and Illinois led in production and supplied 25, 17, 13, and 8 percent, respectively, of the pig iron, compared with 25, 19, 11 and 9 percent in 1959.

Blast furnaces produced 28.8 million short tons of blast-furnace slag, or 867 pounds per ton of pig iron, compared with 895 pounds (revised) in 1959; 4.8 million tons of flue dust was recovered, or 145 pounds per ton of pig iron, compared with 166 pounds in 1959.

The number of blast furnaces in the United States decreased from 263 to 260; one furnace was dismantled at Martin's Ferry, Ohio, and another, at Duquesne, Pa.; the Everett furnace in Massachusetts was abandoned. Blast furnace capacity at the beginning of 1960 was 96.5 million tons. Blast furnace capacity as of January 1, 1961, was not collected by A.I.S.I. (See Production and Shipments of Steel). Despite the dismantling of the 3 blast furnaces, capacity increased during the year because of technological developments. United States Steel Corp. was constructing a large, modern blast furance at Duquesne, Pa., which would include all recent technological advances.

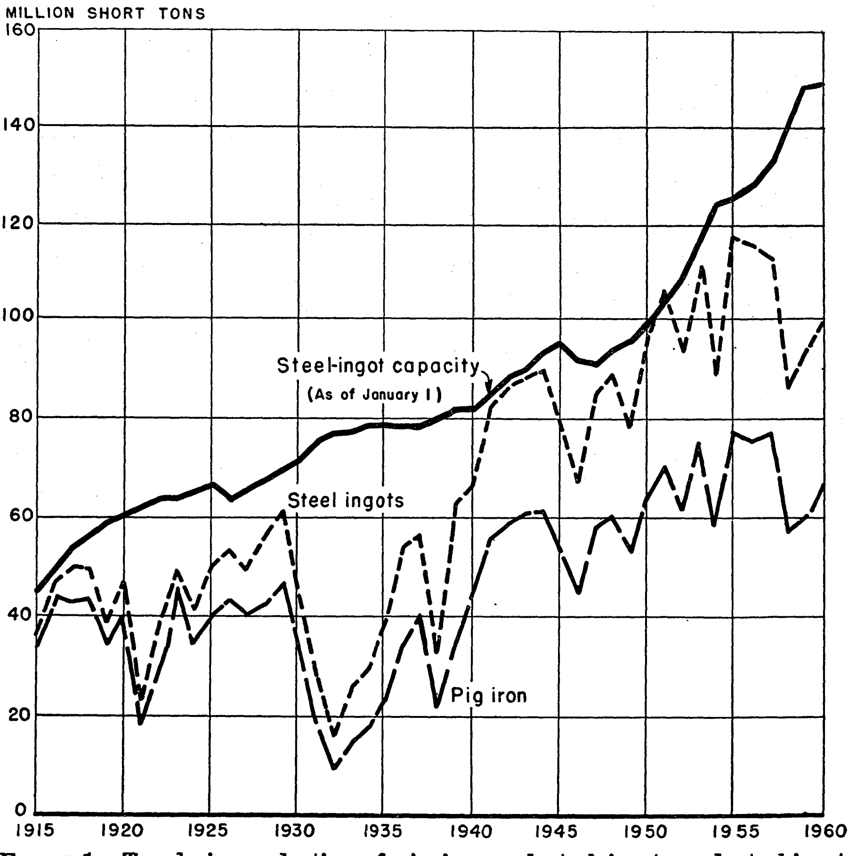

FIGURE 1.—Trends in production of pig iron and steel ingots and steel-ingot capacity in the United States, 1915–60.

Shipments of pig iron (including on-site transfers) were 7 percent above 1959. As over 90 percent of all pig iron made in the United States was used in the molten state for making steel ingots, castings, and iron castings, the values of pig iron shown in tables 2 and 4 are largely estimated and may differ from prices published in trade journals or other sources.

Metalliferous Materials Used.—The production of pig iron, excluding coke and fluxes, required 109.4 million tons of iron ore, manganiferous ores, and agglomerates; 3.9 million tons of scrap, compared with 3.3 million tons (revised) in 1959; 62,855 tons of flue dust; and 6.9 million tons of miscellaneous materials, compared with 6.5 million tons (revised) in 1959. The total of the foregoing is equivalent to 1.809 tons of material per ton of pig iron produced. The scrap charge consisted of 2,819,806 tons of home and purchased scrap, 863,111 tons of slag scrap, and 208,742 tons of offgrade pig iron. Consumption of miscellaneous materials included 3.5 million tons of mill cinder and scale, 3.3 million tons of open hearth and Bessemer slag, 60,053 tons of other metalliferous materials, and 196,936 tons of nonmetalliferous materials. Net totals shown in table 6 were computed by deducting 4.8 million tons of flue dust recovered and 708,132 tons of scrap produced at blast furnaces.

The agglomerate charge consisted of 45,407,953 tons of sinter, including 11,187,627 tons of self-flux sinter; 9,004,332 tons of pellets; 48,589 tons of nodules; 44,436 tons of briquets; and 2,519,921 tons of unclassified agglomerates; 1,536,849 tons came from foreign sources. Canada, Venezuela, Chile, and Peru were the leading suppliers of foreign iron and manganiferous ores used in blast furnaces. In addition to the foregoing, 16.3 million tons of foreign iron ore were used in agglomerate plants, and most of this was used in blast furnaces. According to AISI, 4.4 billion cubic feet of oxygen was used at blast-

TABLE 2.—Pig iron produced and shipped in the United States, by States

(Thousand short tons and thousand dollars)

State	Produced		Shipped from furnaces			
	1959	1960	1959		1960	
	Quantity		Quantity	Value	Quantity	Value
Alabama	3,658	3,545	3,634	$206,449	3,545	$200,366
Illinois	5,268	5,307	5,327	320,243	5,247	316,382
Indiana	6,630	8,404	6,636	390,329	8,424	496,750
Ohio	11,564	11,788	11,859	705,553	11,561	688,038
Pennsylvania	15,133	16,539	15,593	933,035	16,199	973,815
California, Colorado, Utah	3,067	3,735	3,120	188,703	3,700	221,002
Kentucky, Tennessee, Texas	1,463	1,670	1,446	79,213	1,619	93,718
Maryland, West Virginia	5,719	6,318	5,755	348,224	6,338	395,955
Michigan, Minnesota	4,049	4,985	4,109	232,302	4,921	265,094
New York, Massachusetts	3,659	4,210	3,766	229,875	4,058	254,608
Total	60,210	66,501	61,245	3,633,926	65,612	3,905,728

furnace plants, compared with 4.5 billion in 1959. According to data collected by the Bureau of Mines, 11 blast-furnace plants also consumed 3.9 billion cubic feet of natural gas and 282.4 million cubic feet of coke-oven gas by injection through tuyeres.

TABLE 3.—Foreign iron ore and manganiferous iron ore consumed in manufacturing pig iron in the United States, by sources of ore

(Short tons)

Source	1959	1960 [1]	Source	1959	1960 [1]
Brazil	59, 399	30, 692	Venezuela	4, 861, 766	5, 160, 601
Canada	5, 438, 401	5, 645, 373	Other Countries	63, 476	234, 113
Chile	1, 405, 884	1, 273, 570			
Peru	1, 132, 643	1, 888, 866	Total	12, 961, 569	14, 233, 215

[1] Excludes 16,269,354 tons used in making agglomerates.

TABLE 4.—Pig iron shipped from blast furnaces in the United States, by grades [1]

(Thousand short tons and thousand dollars)

Grade	1959			1960		
	Quantity	Value		Quantity	Value	
		Total	Average per ton		Total	Average per ton
Foundry	1, 854	$111, 438	$60. 10	1, 526	$91, 739	$60. 11
Basic	52, 735	3, 118, 433	59. 13	57, 806	3, 433, 263	59. 42
Bessemer	3, 137	186, 950	59. 60	3, 230	193, 456	59. 90
Low-phosphorus	395	24, 872	62. 98	338	20, 997	62. 17
Malleable	2, 828	174, 812	61. 82	2, 427	149, 426	61. 57
All other (not ferroalloys)	296	17, 421	58. 84	285	16, 847	59. 11
Total	61, 245	3, 633, 926	59. 33	65, 612	3, 905, 728	59. 53

[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

State	Jan. 1, 1960			Jan. 1, 1961		
	In blast	Out of blast	Total	In blast	Out of blast	Total
Alabama	16	6	22	11	11	22
California	2	2	4	3	1	4
Colorado	4		4	2	2	4
Illinois	21	1	22	9	13	22
Indiana	21	2	23	11	12	23
Kentucky	2	1	3	1	2	3
Maryland	9	1	10	4	6	10
Massachusetts		1	1			
Michigan	8	1	9	5	4	9
Minnesota	2	1	3	1	2	3
New York	15	2	17	8	9	17
Ohio	46	6	52	18	33	51
Pennsylvania	70	6	76	32	43	75
Tennessee	1	2	3	1	2	3
Texas	2		2	1	1	2
Utah	5		5	3	2	5
Virginia	1	1	2	1	1	2
West Virginia	4	1	5	3	2	5
Total	229	34	263	114	146	260

Source: American Iron and Steel Institute.

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TABLE 6.—Iron ore and other metallic materials, coke, and fluxes consumed and pig iron produced in the United States, by States

(Short tons)

Year and 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: Net ores and agglomerates [1]	Metalliferous materials consumed per ton of pig iron made: Net scrap [2]	Metalliferous materials consumed per ton of pig iron made: Miscellaneous [3]	Metalliferous materials consumed per ton of pig iron made: Total	Coke and fluxes consumed per ton of pig iron: Net coke	Coke and fluxes consumed per ton of pig iron: Fluxes
1959:																
Alabama	4,320,268	1,264,452	1,879,646	7,213,533	175,336	66,305	7,455,174	3,458,812	1,095,826	3,658,287	1.972	0.048	0.018	2.038	0.945	0.300
Illinois	5,486,398	183,499	3,310,947	8,489,753	287,081	580,149	9,356,983	4,169,395	1,407,970	5,267,526	1.612	.054	.110	1.776	.792	.267
Indiana	6,293,213	142,815	4,887,966	10,648,807	103,761	887,394	11,639,962	5,057,707	1,644,956	6,630,339	1.606	.016	.134	1.756	.763	.248
Ohio	7,678,017	2,867,409	7,653,380	17,352,067	746,090	1,442,566	19,540,723	9,097,557	3,330,416	11,563,896	1.501	.064	.125	1.690	.787	.288
Pennsylvania	9,673,731	4,162,644	10,094,926	22,703,314	866,582	2,046,853	25,616,749	11,936,579	4,194,137	15,133,520	1.500	.057	.135	1.692	.789	.277
California, Colorado, Utah	(4)	(4)	2,398,021	5,294,686	77,899	69,485	5,442,070	2,277,526	584,910	3,067,238	1.726	.025	.023	1.774	.743	.191
Kentucky, Tennessee, Texas	611,287	263,130	1,301,579	2,220,891	70,381	173,329	2,464,601	1,155,685	470,555	1,463,396	1.518	.048	.118	1.684	.790	.322
Maryland, West Virginia	(4)	(4)	5,335,565	8,701,300	154,195	602,378	9,457,873	4,165,544	1,076,041	5,718,573	1.522	.027	.105	1.654	.728	.188
Michigan, Minnesota	(4)	(4)	3,527,364	6,838,548	60,993	208,915	7,108,456	3,277,228	1,199,156	4,048,867	1.689	.015	.052	1.756	.809	.296
New York, Massachusetts	2,595,593	560,496	3,035,549	5,900,168	166,279	370,782	6,437,229	2,964,032	1,156,530	3,658,615	1.613	.045	.101	1.759	.810	.316
Total	43,826,061	12,961,569	43,424,943	95,363,067	2,708,597	6,448,156	104,519,820	47,560,065	[5] 16,160,497	60,210,257	1.584	.045	.107	1.736	.790	.268
1960:																
Alabama	4,937,610	181,317	2,169,705	7,025,942	117,744	84,154	7,227,840	3,376,924	1,102,905	3,544,862	1.982	.033	.024	2.039	.953	.311
Illinois	4,353,529	62,850	4,384,323	8,467,644	242,684	670,698	9,381,026	4,039,896	1,237,451	5,307,121	1.596	.046	.126	1.768	.761	.233
Indiana	4,811,611	323,408	9,141,807	13,760,797	175,231	1,031,745	14,967,773	5,684,307	1,311,714	8,403,794	1.637	.021	.123	1.781	.676	.156
Ohio	7,094,397	3,278,551	8,216,629	17,762,718	757,721	1,440,800	19,961,239	9,142,089	3,249,982	11,787,861	1.507	.064	.122	1.693	.776	.276
Pennsylvania	7,412,435	5,607,721	12,623,343	24,292,886	1,054,701	2,157,349	27,504,936	12,314,350	4,224,565	16,539,421	1.469	.064	.130	1.663	.745	.255
California, Colorado, Utah	(4)	(4)	3,352,484	6,591,835	92,295	76,832	6,760,962	2,695,196	623,555	3,734,739	1.765	.025	.021	1.810	.722	.167

Kentucky / Tennessee / Texas	436,333	386,032	1,696,204	2,479,299	143,022	219,990	2,842,311	1,248,495	436,366	1,670,360	1.484	.086	.132	1.702	.747	.261
Maryland / West Virginia	(4)	(4)	6,243,870	9,485,416	181,864	722,064	10,389,344	4,400,559	1,066,593	6,317,683	1.501	.029	.114	1.644	.697	.169
Michigan / Minnesota	(4)	(4)	4,647,801	8,183,625	186,625	245,901	8,616,151	3,698,981	1,367,341	4,985,388	1.587	.037	.049	1.728	.742	.274
New York / Massachusetts	2,098,026	305,496	4,549,065	6,650,608	231,640	228,404	7,110,652	3,274,181	1,312,346	4,209,993	1.580	.055	.054	1.689	.778	.312
Total	31,143,941	14,233,215	57,025,231	104,700,770	3,183,527	6,877,937	114,762,234	49,874,978	[6] 15,932,818	66,501,222	1.574	.048	.103	1.726	.750	.240

[1] Net ores and agglomerates=ores+agglomerates+flue dust used−flue dust recovered.
[2] Excludes home scrap produced at blast furnaces.
[3] Does not include recycled material.
[4] Included in total.
[5] Fluxes consisted of 11,846,103 tons of limestone and 4,314,394 tons of dolomite, excluding 1,975,121 tons of limestone and 1,197,652 tons of dolomite used in agglomerate production at or near steel plants and an unknown quantity used in making agglomerates at mines.
[6] The corresponding figures for 1960 (5) 11,500,714 tons of limestone, 4,431,252 tons of dolomite, 3,389,992 tons of limestone and 1,243,203 tons of dolomite—quantities used at mines are unknown.

PRODUCTION AND SHIPMENTS OF STEEL

Domestic steel production in 1960 was 99.3 million short tons or 66.8 percent of capacity with an AISI index of 101.9 (1957–59=100). The corresponding figures for 1959 were 93.4, 63.3, and 96.2, respectively. In the first half of the year production was high with a total of 60.8 million tons, equivalent to 82.0 percent of capacity. A record tonnage of 12.0 million tons was made in January. However, demand for steel lessened during the last half of the year, and only 38.5 million tons was produced. Steel casting production by independent foundries, not included in the production data, totaled 1,184,459 short tons, compared with 1,366,328 tons in 1959.

Of the total tonnage of steel produced, 87 percent was made in open hearth furnaces, 8.4 per cent in electric furnaces, 3.4 percent in oxygen converters, and 1.2 percent in Bessemer converters. Corresponding figures for 1959 were 87.4, 9.1, 2.0, and 1.5, respectively. Pennsylvania led in steel production, and Ohio, Indiana, and Illinois ranked second, third, and fourth, supplying 24, 17, 14, and 8 percent, respectively, compared with 25, 19, 12, and 9 percent in 1959.

The AISI announced in December that it would stop issuing weekly and monthly figures of steel operating rate as a percent of capacity, starting in 1961. Also, yearend steelmaking capacity figures were not published. The primary reason given for discontinuing these figures was that rapid technological developments had made it possible to greatly increase output of existing facilities. It had been demonstrated that the output of a blast furnace could be increased considerably by using natural gas, high hot-blast temperatures, and improved charge. Similarly, steel furnace output could be increased by using more hot metal, by using oxygen, and by installing all-basic roofs, which permit faster firing rates.

At the beginning of 1960, the steel industry budgeted about $1.6 billion for capital expenditures and considerable progress was made in modernizing and adding new equipment. However when business slowed down, some projects were postponed, and a few were canceled. Expansions include conversion of open hearths to use oxygen roof lances, new oxygen converters, consumable electrode vacuum-arc furnaces, vacuum degassing, vacuum deoxidation units, open hearth enlargements with all-basic roofs, and new rolling mills and revamping of old mills. New electric furnaces were built in El Paso, Tex., and Etiwanda, Calif.

Shipments of steel products (table 10) increased 1.8 million tons. Although shipments in most categories increased, those to the oil and gas industry for construction and drilling and to distributors who service this industry decreased 1.0 million tons. Shipments for export increased 1.1 million tons.

Alloy Steel.[2]—Domestic alloy-steel production was 8,417,762 short tons—8,355,655 tons of ingots and 62,107 tons of castings—a decline of 5.5 percent from 1959. Alloy steel supplied 8.5 percent of the steel output, compared with 9.5 percent in 1959.

Stainless-steel ingot production (12.7 percent of the total alloy-steel output) was 1,000,683 tons, 11.3 percent below 1959 but 12.1 percent above 1958. The production of austenitic stainless steel AISI 300 (nickel-bearing) and 200 series (manganese-nickel-bearing), representing 64.4 percent of stainless-steel production, was 10.0 percent below 1959; output of ferritic and martensitic, straight chromium types, AISI 400 series, decreased 13.8 percent. Production of AISI 200 series (26,804 tons) decreased 4.8 percent. The output of type 501, 502, and other high-chromium, heat-resisting steels, included in the stainless-steel-production figure, decreased 8 percent.

Output of carbon-steel ingots and castings was 90.9 million short tons, compared with 84.5 million tons in 1959.

Production of all grades of alloy-steel ingots, other than stainless, decreased 4.8 percent. Production of chromium steels (1.2 million short tons) decreased 19 percent; nickel-chromium-molybdenum steels (1.2 million tons) decreased 10 percent; and high-strength steels (940,000 tons) increased 21 percent. Chromium-molybdenum steel output (840,000 tons) was virtually the same as the preceding year.

The percentages of alloy steel produced in the basic open hearth, acid open hearth, and electric furnaces were 61, 1, and 38 percent, respectively, compared with 58, 1, and 41 percent in 1959.

Metalliferous and Other Materials Used in Steelmaking.—Pig iron and scrap consumed in steelmaking furnaces totaled 111.2 million short tons; the percentage of each was 54 and 46, respectively, compared with 52 and 48 percent in 1959. Consumption of foreign iron ore reached a record high of 6.3 million short tons. The principal sources of iron ore were Chile, Brazil, Liberia, Peru, and Venezuela. According to AISI, other materials used in steelmaking, excluding independent foundries, included 5.4 million tons of limestone, 1.4 million tons of lime, 209,609 tons of fluorspar, and 463,303 tons of other fluxes. Oxygen consumption at steel plants, exclusive of blast furnaces, reached a record 43.9 billion cubic feet, used as follows: Steelmaking, 29.2 billion cubic feet; conditioning, 9.8 billion; scrap preparation, 1.5 billion; other burning and welding, 1.3 billion; and all other, 2.1 billion cubic feet.

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[2] The Bureau of Mines uses the American Iron and Steel Institute specifications for alloy steels, which include stainless and any other steel containing one or more of the following elements in the designated percentages: Manganese in excess of 1.65 percent, silicon in excess of 0.60 percent, and copper in excess of 0.60 percent. It also includes steel, containing the following elements in any quantity specified or known to have been added to obtain a desired alloying effect: Aluminum, boron, chromium, cobalt, columbium, molybdenum, nickel, titanium, tungsten, vanadium, zirconium, and other alloying elements.

Stainless steel includes all grades of steel that contain 10 percent or more of chromium with or without other alloys or a minimum combined content of 18 percent of chromium and other alloys. Valve or bearing steels, high-temperature alloys, or electrical grades with analyses meeting the definition for stainless steels are included. All tool-steel grades are excluded.

Heat-resisting steel includes all steel containing 4 percent or more but less than 10 percent of chromium (excluding tool-steel grades).

TABLE 7.—Steel capacity, production, and percentage of operations in the United States [1]

(Thousand short tons)

Year	Annual capacity, Jan. 1	Production						
		Open hearth		Bes-semer	Oxygen converter	Electric [2]	Total	Percent of capacity
		Basic	Acid					
1951-55 (average)	116,105	91,837	598	3,628	(3)	7,003	103,065	88.8
1956	128,363	102,168	673	3,228	506	8,641	115,216	89.8
1957	133,459	101,028	630	2,475	612	7,971	112,715	84.5
1958	140,743	75,502	378	1,396	1,323	6,656	85,255	60.6
1959	147,634	81,225	444	1,380	1,864	8,533	93,446	63.3
1960	148,571	85,964	404	1,189	3,346	8,379	99,282	66.8

[1] Includes only that steel for castings produced in foundries operated by companies manufacturing steel ingots. Omits about 2 percent of total steel production.
[2] Includes a very small quantity of crucible steel.
[3] Data not available.
Source: American Iron and Steel Institute.

TABLE 8.—Production of steel by States and processes [1]

(Thousand short tons)

Year and State	Open hearth	Bessemer	Basic oxygen process	Electric	Total
1955	105,359	3,320	307	8,050	117,036
1956	102,841	3,228	506	8,641	115,216
1957	101,658	2,475	611	7,971	112,715
1958	75,880	1,396	1,323	6,656	85,255
1959	81,669	1,380	1,864	8,533	93,446
New York	5,011			114	5,125
Pennsylvania	21,157	(2)	(2)	[3] 1,507	23,781
Rhode Island, Connecticut, New Jersey, Delaware, and Maryland	7,020			143	7,163
Virginia, West Virginia, Georgia, and Florida	(2)			(2)	3,202
Kentucky	(2)			(2)	1,398
Alabama, Tennessee, and Mississippi	(2)			(2)	3,572
Ohio	14,693	(2)		(2)	17,225
Indiana	(2)			(2)	13,836
Illinois	6,501		(2)	(2)	8,229
Michigan	(2)		(2)	482	6,534
Minnesota, Missouri, Oklahoma, and Texas	2,144			889	3,034
Arizona, Colorado, Utah, Washington, and Oregon	(2)			(2)	3,543
California	1,539		(2)	(2)	2,639
Total 1960	86,368	1,189	3,346	8,379	99,282

[1] Includes only that steel for castings produced in foundries operated by companies manufacturing steel ingots. Omits about 2 percent of total steel production.
[2] Figure withheld to avoid disclosing individual company confidential data.
[3] Includes production of crucible steel.
Source: American Iron and Steel Institute.

TABLE 9.—Steel electrically manufactured in the United States [1]

(Thousand short tons)

Year	Ingots	Castings	Total [2]	Year	Ingots	Castings	Total [2]
1951-55 (average)	6,932	71	7,003	1958	7,929	51	7,980
1956	9,090	57	9,147	1959	8,477	56	8,533
1957	8,514	68	8,582	1960	8,313	66	8,379

[1] Includes only that steel for castings produced in foundries operated by companies manufacturing steel ingots. See table 7.
[2] Includes a very small quantity of crucible steel, and for 1955-58, oxygen converter steel.
Source: American Iron and Steel Institute.

TABLE 10.—Shipments of steel products by market classifications, all grades including carbon, alloy, and stainless

(Thousand short tons)

Market classification	1959		1960	
	Shipments	Percent of total	Shipments	Percent of total
Steel for converting and processing [1]	3,133	4.5	2,928	4.1
Forgings	957	1.4	841	1.2
Bolts, nuts, rivets, and screws	1,071	1.6	1,072	1.5
Warehouses and distributors:				
Oil and gas industry	1,890	2.7	1,125	1.6
All other	11,159	16.1	11,355	15.9
Total	13,049	18.8	12,480	17.5
Construction, including maintenance:				
Rail transportation	40	.1	51	.1
Oil and gas	2,262	3.3	2,166	3.0
All other	6,212	8.9	7,447	10.5
Total	8,514	12.3	9,664	13.6
Contractors' products	3,573	5.2	3,602	5.1
Automotive:				
Passenger cars, trucks, parts, etc	13,792	19.9	14,194	19.9
Forgings	422	.6	416	.6
Total	14,214	20.5	14,610	20.5
Rail transportation:				
Railroad rails, trackwork, and equipment	763	1.1	723	1.0
Freight cars, passenger cars, and locomotives	1,572	2.3	1,763	2.5
Street railways and rapid-transit systems	22		39	
Total	2,357	3.4	2,525	3.5
Shipbuilding and marine equipment	642	.9	622	.9
Aircraft	71	.1	78	.1
Oil and gas drilling	541	.8	404	.6
Mining, quarrying, and lumbering	235	.3	288	.4
Agriculture:				
Agricultural machinery	964	1.4	765	1.1
All other agricultural	301	.4	238	.3
Total	1,265	1.8	1,003	1.4
Machinery, industrial equipment, and tools	4,158	6.0	3,958	5.6
Electrical machinery and equipment	2,052	3.0	2,078	2.9
Appliances, utensils, and cutlery	1,829	2.6	1,760	2.5
Other domestic and commercial equipment	1,833	2.6	1,959	2.8
Containers:				
Cans and closures	5,010	7.2	4,976	7.0
Barrels, drums, and shipping pails	773	1.1	842	1.2
All other containers	535	.7	611	.8
Total	6,318	9.1	6,429	9.0
Ordnance and other military	127	.2	165	.2
Shipments of nonreporting companies	2,029	2.9	2,120	3.0
Total domestic	67,968	98.0	68,586	96.4
Export (companies reporting to AISI only)	1,409	2.0	2,563	3.6
Total shipments	69,377	100.0	71,149	100.0

[1] Net total after deducting shipments to reporting companies for conversion or resale.

Source: American Iron and Steel Institute.

TABLE 11.—Alloy-steel ingots and castings manufactured in the United States, by processes [1]

(Thousand short tons)

Process	1951–55 (average)	1956	1957	1958	1959	1960
Open hearth:						
Basic	6,651	6,289	5,746	[2] 3,926	5,144	5,109
Acid	192	201	170	[2] 85	89	89
Electric [3]	3,245	3,838	2,996	2,653	3,674	3,220
Total	9,488	10,328	8,912	6,664	8,907	8,418

[1] Includes only that steel for castings produced in foundries operated by companies manufacturing steel ingots. See table 7.
[2] Revised figure.
[3] Includes a very small quantity of crucible steel, and for 1955–58, oxygen converter steel.

Source: American Iron and Steel Institute.

CONSUMPTION OF PIG IRON

Although all States used some pig iron, 86 percent of the States canvassed (table 14) was consumed in steelmaking centers in the East, North Central, Middle Atlantic, and South Atlantic States. Pennsylvania (the leading consumer) used 24 percent of the total; Ohio, 17 percent; and Indiana, 13 percent; corresponding figures for 1959 were 25, 19, and 12 percent respectively.

TABLE 12.—Metalliferous materials consumed in steel furnaces in the United States

(Thousand short tons)

Year	Iron ore		Sinter [1]	Pig iron	Ferro-alloys [2]	Iron and steel scrap
	Domestic	Foreign				
1951–55 (average)	3,487	3,272	1,605	60,139	1,494	55,248
1956	3,398	4,741	1,517	66,438	1,630	62,276
1957	2,837	5,592	[3] 1,934	68,768	1,530	56,765
1958	2,092	4,742	[4] 1,261	51,299	1,115	43,024
1959	1,690	5,238	[5] 961	54,699	1,380	49,794
1960	1,570	6,251	[6] 931	60,092	1,395	51,140

[1] Includes consumption of pig iron and scrap by ingot producers and iron and steel foundaries.
[2] Includes ferromanganese, spiegeleisen, silicomanganese, manganese briquets, manganese metal, ferrosilicon, and ferrochromium alloys.
[3] Includes other agglomerates (nodules, pellets, etc.) and 106,602 tons of foreign origin.
[4] Includes 601,509 tons of sinter, 238,040 tons of pellets, 281,390 tons of nodules, and 139,824 tons of other agglomerates. (325,268 tons of foreign origin.)
[5] Includes 271,736 tons of sinter, 215,109 tons of pellets, 255,448 tons of nodules, 32,039 tons of briquets, and 87,017 tons of other agglomerates. (314,507 tons of foreign origin.)
[6] Includes 121,946 tons of sinter, 49,422 tons of pellets, 314,958 tons of nodules, 35,025 tons of briquets, and 409,863 tons of other agglomerates. (403,705 tons of foreign origin.)

TABLE 13.—Consumption of pig iron in the United States, by type of furnace

(Thousand short tons)

Type of furnace or equipment	1959		1960	
	Quantity	Percent of total	Quantity	Percent of total
Open hearth	51,250	83.0	55,270	83.0
Bessemer	1,483	2.4	1,303	2.0
Oxygen converter	1,574	2.6	2,937	4.4
Electric	[1] 391	.6	[1] 372	.5
Cupola	4,412	7.1	3,822	5.7
Air	251	.4	210	.3
Direct castings	2,411	3.9	2,712	4.1
Total	61,773	100.0	66,626	100.0

[1] Includes a small quantity of pig iron consumed in crucible furnaces.

TABLE 14.—Consumption of pig iron in the United States, by districts and States

(Short tons)

District and State	1959	1960
New England:		
Connecticut	34,047	33,756
Maine	4,195	4,929
New Hampshire		
Massachusetts	77,114	73,313
Rhode Island	45,792	48,380
Vermont	8,329	7,345
Total	169,477	167,723
Middle Atlantic:		
New Jersey	149,673	147,537
New York	2,988,093	3,382,392
Pennsylvania	15,489,188	16,295,129
Total	18,626,954	19,825,058
East North Central:		
Illinois	5,141,524	5,244,885
Indiana	7,296,402	8,883,812
Michigan	4,138,861	5,034,654
Ohio	11,574,983	11,503,557
Wisconsin	255,452	195,801
Total	28,407,222	30,862,709
West North Central:		
Iowa	93,718	69,287
Kansas	5,251	5,332
Nebraska		
Minnesota	432,814	431,151
Missouri	73,518	44,649
Total	605,301	550,419
South Atlantic:		
Delaware	3,554,242	4,392,072
Maryland		
Florida	13,850	13,048
Georgia		
South Atlantic—Con.		
North Carolina	24,732	26,417
South Carolina	17,846	17,986
Virginia		
West Virginia	2,449,489	2,129,461
Total	6,060,159	6,578,984
East South Central:		
Alabama	3,125,492	3,144,319
Kentucky		
Mississippi	771,705	905,603
Tennessee		
Total	3,897,197	4,049,922
West South Central:		
Arkansas		
Louisiana	7,222	8,183
Oklahoma		
Texas	768,110	723,894
Total	775,332	732,077
Mountain:		
Arizona	142	88
Nevada, Colorado, Idaho, Montana, and Utah	1,847,229	2,202,759
Total	1,847,441	2,202,847
Pacific Coast:		
California	1,379,104	1,649,991
Oregon	5,004	3,327
Washington		3,279
Total	1,384,108	1,656,597
Total United States	61,773,191	66,626,336

PRICES

Pig iron and steel prices remained virtually constant during 1960. The weighted average annual price of pig iron, as published by Iron Age, was $59.28 per short ton. The Iron Age composite price of finished steel for 1960 was 6.196 cents per pound, the same as in 1959.

TABLE 15.—Average value of pig iron at blast furnaces in the United States, by States

(Per short ton)

State	1951–55 (average)	1956	1957	1958	1959	1960
Alabama	$46.14	$50.23	$53.94	$55.14	$56.81	$56.52
California, Colorado, Utah	51.15	50.67	57.44	57.53	60.47	59.73
Illinois	49.16	54.52	58.04	61.32	60.12	60.30
Indiana	49.07	53.09	58.33	58.41	58.82	58.90
New York	50.02	54.54	63.09	64.48	61.01	62.54
Ohio	48.24	52.42	55.88	57.93	59.50	57.79
Pennsylvania	49.74	55.01	59.25	62.45	59.84	60.12
Other States [1]	49.24	54.19	60.37	60.53	58.38	58.06
Average	49.09	53.58	58.43	59.60	59.33	59.53

[1] Comprises Kentucky, Maryland, Massachusetts, Michigan, Minnesota, Tennessee, Texas, and West Virginia.

TABLE 16.—Average prices of chief grades of pig iron [1]

(Per short ton)

Month	Foundry pig iron at Birmingham furnaces	Foundry pig iron at Valley furnaces	Bessemer pig iron at Valley furnaces	Basic pig iron at Valley furnaces
	1959–60	1959–60	1959–60	1959–60
January-December	$55.80	$59.38	$59.82	$58.93

[1] Prices did not change during 1959 and 1960.

Source: Metal Statistics.

TABLE 17.—Free-on-board value of steel-mill products in the United States, in cents per pound

Product	1959			
	Carbon	Alloy	Stainless	Average
Ingots	4.432	9.135	27.629	5.688
Semifinished shapes and forms	5.912	10.410	40.388	6.724
Plates	6.333	12.606	61.850	7.114
Sheets and strips	7.146	14.341	46.678	8.261
Tin-mill products	9.176			9.176
Structural shapes and piling	6.406	8.079		6.424
Bars	7.752	13.836	63.526	9.406
Rails and railway-track material	7.779			7.779
Pipes and tubes	10.766	19.642	163.464	12.118
Wire and wire products	12.870	37.497	82.895	13.549
Other rolled and drawn products	9.460	43.810	69.493	8.432
Average total steel	7.894	14.223	54.387	8.857

This table represents the weighted average value based on the quantity of each type of steel shipped therefore, it reflects shifts in the distribution of the 3 classes of steel.

Source: Computed from figures supplied by the U.S. Department of Commerce, Bureau of the Census.

FOREIGN TRADE [8]

Lower priced foreign steels continued to penetrate domestic markets, although to a lesser degree than in 1959.

Imports.—Imports for the year were the second highest on record, totaling 3.5 million short tons, compared with 4.6 million tons in 1959, the previous record year. The European Coal and Steel Community and Japan were the leading suppliers of foreign steel to the United States with 2.2 and 0.6 million short tons, respectively. Imported steel furnished 52.8 percent of the domestic barbed wire market, 43.1 percent of nails and staples, 27.3 percent of wire rods, 21.3 percent woven wire fence, and 19 percent of concrete reinforcement bars. Imports of pig iron were 330,847 tons, compared with 699,593 tons in 1959.

Exports.—Exports of iron and steel products totaled 3.3 million short tons, compared with 2 million in 1959. Exports of pig iron were 111,773 tons, compared with 10,444 tons in 1959.

TABLE 18.—U.S. imports for consumption of pig iron, by countries
(Short tons)

Country	1951–55 (average)	1956	1957	1958	1959	1960
North America: Canada	255,623	303,121	221,166	182,128	437,095	281,593
South America:						
Brazil	6,787	19,621	-	2	-	-
Chile	11,964	-	-	-	-	-
Total	18,751	19,621	-	2	-	-
Europe:						
Austria	18,740	-	-	-	-	-
Belgium-Luxembourg	3,930	-	-	-	-	4,408
Finland	34	-	-	-	10,253	-
France	7,533	-	-	-	-	-
Germany [1]	76,568	-	34	13,933	[2][3] 71,805	386
Netherlands	27,909	112	-	1,125	[3] 4,427	1,575
Norway	5,624	339	-	334	168	-
Portugal	-	-	-	-	4,395	-
Spain	15,728	-	-	7,867	78,499	21,551
Sweden	21,244	1,852	3,135	1,615	1,071	1,445
U.S.S.R.	-	-	-	-	1,550	1,298
Other Europe	816	-	-	-	51	-
Total	178,126	2,303	3,169	24,874	[3] 172,219	30,663
Asia:						
India	13,101	336	-	-	56	6,742
Japan	-	-	-	-	10,674	-
Turkey	7,442	-	-	-	-	-
Total	20,543	336	-	-	10,730	6,742
Africa:						
Rhodesia and Nyasaland, Federation of [4]	1,758	-	-	-	4,863	392
Union of South Africa	5,430	128	-	-	70,519	7,543
Total	7,188	128	-	-	75,382	7,935
Oceania: Australia	41,932	1,191	1,052	2,739	4,167	3,914
Grand total: Short tons	522,163	326,700	225,387	209,743	[3] 699,593	330,847
Value	$24,572,596	$17,842,357	$13,527,813	$12,026,015	[3] $35,493,259	$18,351,333

[1] Effective 1952 classified as West Germany.
[2] Includes 110 tons from East Germany.
[3] Revised figure.
[4] Classified as Southern Rhodesia through June 30, 1954; 1,562 short tons January through June 1954.
Source: Bureau of the Census.

[8] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 19.—U.S. imports for consumption of major iron and steel products

Products	1959		1960	
	Short tons	Value	Short tons	Value
Iron products:				
Bar iron, iron slabs, blooms, or other forms	81	$30,222	73	$21,942
Pipes and fittings:				
Cast-iron pipe and fittings	16,330	1,842,424	18,390	2,112,097
Malleable cast-iron pipe fittings	6,461	2,490,604	7,518	2,917,896
Castings and forgings	17,334	3,600,240	15,202	3,617,809
Total	40,206	7,963,490	41,183	8,669,744
Steel products:				
Steel bars:				
Concrete reinforcement bars	851,950	68,697,236	515,522	47,353,942
Solid and hollow, n.e.s	215,536	22,714,724	133,511	19,168,100
Hollow and hollow drill steel	1,697	578,891	1,848	651,189
Wire rods, nail rods, and flat rods up to 6 inches in width	[1] 448,628	[1] 45,218,485	408,201	46,763,683
Boiler and other plate iron and steel, n.e.s	[1] 382,314	[1] 40,389,675	301,885	34,970,619
Steel ingots, blooms, and slabs; billets, solid and hollow	91,771	9,025,204	67,762	8,780,659
Die blocks or blanks, shafting, etc	1,263	361,395	2,195	652,737
Circular saw plates	41	51,670	51	52,437
Sheets of iron or steel, common or black and boiler or other plate iron or steel	[1] 179,167	[1] 27,965,171	274,335	42,508,732
Sheets and plates and steel, n.s.p.f	26,083	3,232,925	12,977	3,194,914
Tinplate, terneplate, and taggers' tin	66,989	12,949,433	19,726	3,846.437
Structural iron and steel	[1] 871,483	[1] 90,480,482	607,161	73,445,439
Rails for railways	8,194	735,878	7,831	656,430
Rail braces, bars, fishplates, or splice bars and tie plates	650	61,201	875	109,936
Steel pipes and tubes	553,139	87,982,850	480,044	77,641,974
Wire:				
Barbed	78,287	10,251,360	52,964	7,849,830
Round wire, n.e.s	[1] 236,505	[1] 37,237,324	206,564	35,764,109
Telegraph, telephone, etc., except copper, covered with cotten jute, etc	2,875	1.082,778	3,013	783,701
Flat wire and iron and steel strips	80,579	16,267,399	63,389	15,657,325
Rope and strand	41,855	[1] 14,258,835	35,974	11,981,995
Galvanized fencing wire and wire fencing	79,040	11,373,461	51,881	7,920,155
Iron and steel used in card clothing	(2)	533,817	(2)	518,122
Hoop and band iron and steel, for baling	29,094	3,933,149	22,592	3,086,315
Hoop, band and strips, or scroll iron or steel, n.s.p.f	10,828	1,759,375	15,003	2,821,964
Nails	315,102	48,822,612	239,577	39,041,521
Steel castings and forgings	1,675	287,790	3,945	679,156
Total	4,574,745	556,253,120	3,528,826	485,901,421
Advanced manufactures:				
Bolts, nuts, and rivets	53,869	15,772,886	48,303	15,460,819
Chains and parts	6,998	4,465,750	9,022	5,111,540
Hardware, builders'		831,742		1,712,324
Hinges and hinge blanks		1,721,929		1,848,399
Screws (wholly or chiefly of iron or steel)		[1] 2,017,786		2,033,059
Tools		[1] 17,120,055		18,555,594
Other		289,586		546,200
Total		[1] 42,219,734		45,267,935
Grand total		[1] 606,436,344		539,839,100

[1] Revised figure.
[2] Weight not recorded.

Source: Bureau of the Census.

TABLE 20.—U.S. exports of major iron and steel products

Products	1959		1960	
	Short tons	Value	Short tons	Value
Semimanufactures:				
Steel ingots, blooms, billets, slabs, and sheet bars	14,719	$2,261,733	74,524	$7,664,271
Iron and steel bars and rods:				
Carbon-steel bars, hot-rolled, and iron bars	39,399	7,091,515	43,832	8,223,429
Concrete reinforcement bars	13,775	2,057,893	15,467	2,235,889
Other steel bars	13,917	5,551,294	25,542	9,710,031
Wire rods	4,189	464,651	10,238	1,326,981
Iron and steel plates, sheets, skelp, and strips:				
Plates, including boiler plate, not fabricated	65,585	13,649,810	91,434	20,473,441
Skelp iron and steel	15,742	1,915,143	44,370	5,338,650
Iron and steel sheets, galvanized	[1] 40,615	[1] 8,851,511	46,341	9,957,398
Steel sheets, black, ungalvanized	437,028	91,478,276	1,324,388	248,310,646
Strip, hoop, band, and scroll iron and steel:				
Cold-rolled	17,778	8,592,523	40,447	19,262,047
Hot-rolled	21,892	6,674,977	27,685	8,355,908
Tinplate and terneplate	368,355	62,954,269	565,536	101,356,117
Tinplate circles, cobbles, strip, and scroll shear butts	16,892	1,774,146	22,949	2,679,757
Total	[1] 1,069,886	[1] 213,317,741	2,332,753	444,894,565
Manufactures—steel-mill products:				
Structural iron and steel:				
Water, oil, gas, and other storage tanks (unlined), complete and knockdown material	30,206	11,745,510	18,367	7,576,258
Structural shapes:				
Not fabricated	225,958	29,594,976	334,292	39,473,511
Fabricated	57,704	18,426,091	76,068	18,977,810
Plates, sheets, fabricated, punched, or shaped	30,372	6,949,496	9,505	3,110,125
Metal lath	1,362	501,742	1,176	450,996
Frames, sashes, and sheet piling	14,918	2,832,062	11,615	2,398,121
Railway-track material:				
Rails for railways	[1] 61,318	[1] 7,373,146	108,768	14,290,683
Rail joints, splice bars, fishplates, and tie plates	20,429	3,958,268	24,100	5,088,184
Switches, frogs, and crossings	1,665	806,435	3,132	1,507,246
Railroad spikes	1,006	231,196	941	224,524
Railroad bolts, nuts, washers, and nut locks	416	227,215	571	348,467
Tubular products:				
Boiler tubes	6,298	3,932,547	9,783	6,355,181
Casing and line pipe	161,117	47,565,393	96,064	31,584,691
Seamless black and galvanized pipe and tubes, except casing, line and boiler, and other pipes and tubes	19,048	6,354,533	22,502	6,544,562
Welded black pipe	35,583	7,891,539	12,247	3,760,584
Welded galvanized pipe	2,396	690,057	3,606	1,136,258
Malleable-iron screwed pipe fittings	1,317	1,391,406	933	1,183,782
Cast-iron pressure pipe and fittings	15,485	2,920,187	16,075	3,334,748
Cast-iron soil pipe and fittings	11,439	2,252,625	6,892	1,599,636
Iron and steel pipe, fittings, and tubing, n.e.c.	[1] 45,570	[1] 34,068,754	54,095	39,262,046
Wire and manufactures:				
Barbed wire	625	119,078	565	115,227
Galvanized wire	5,311	1,507,682	6,463	1,538,762
Iron and steel wire, uncoated	12,925	4,563,915	13,950	5,039,484
Spring wire	1,921	1,100,147	1,656	942,005
Wire rope and strand	10,217	6,212,575	9,400	5,175,155
Woven-wire screen cloth	1,301	[2] 1,630,450	1,349	[2] 1,604,638
All other	19,038	10,510,034	16,676	10,197,772
Nails and bolts, iron and steel, n.e.c.:				
Wire nails, staples, and spikes	3,060	2,736,449	4,675	3,352,351
Bolts, screws, nuts, rivets, and washers, n.e.c.	14,475	15,290,146	13,329	16,109,025
Tacks	1,034	666,763	644	446,048
Castings and forgings: Iron and steel, including car wheels, tires, and axles	[1] 89,734	[1] 25,260,743	85,450	26,175,386
Total	[1] 903,248	[1] 259,311,160	964,889	258,903,266

See footnotes at end of table.

TABLE 20.—U.S. exports of major iron and steel products—Continued

Products	1959		1960	
	Short tons	Value	Short tons	Value
Advanced manufactures:				
Buildings (prefabricated and knockdown)		15,111,272		7,244,540
Chains and parts	9,800	10,757,618	8,432	10,100,501
Construction material	6,065	4,661,866	6,650	4,962,240
Hardware and parts		[1] 23,624,560		22,199,037
House-heating boilers and radiators		9,135,741		7,696,062
Oil burners and parts		8,915,323		8,162,330
Plumbing fixtures and fittings		4,879,980		3,206,255
Tools		49,613,574		53,865,508
Utensils and parts (cooking, kitchen, and hospital)	958	3,218,988	990	3,449,296
Other		35,837,151		36,800,258
Total		[1] 165,756,073		157,686,027
Grand total		[1] 638,384,974		861,483,858

[1] Revised figure.
[2] Includes wire cloth as follows—1959: $1,103,761 (5,037,493 square feet); 1960: $1,152,568 (5,339, 940 square feet).

Source: Bureau of the Census.

WORLD REVIEW

World production of pig iron, including ferroalloys, and steel reached a new peak with a 15-percent increase in pig iron and a 13-percent increase in steel. The United States led, and the European Coal and Steel Community and the U.S.S.R. ranked second and third in both pig-iron and steel output. The United States produced 24 percent of the pig iron and 26 percent of the steel, compared with 25 and 28 percent, respectively, in 1959 and 27 percent and 29 percent in 1958.

The Economic Commission for Latin America estimated production of rolled steel products by 1965 would be as follows:

Country:	*Short tons per year*
Argentina	2,600,000
Brazil	3,800,000
Colombia	300,000
Chile	560,000
Mexico	1,800,000
Peru	120,000
Venezuela	440,000
All other South American countries	240,000
Total	9,860,000

Another projection indicated that steel production in Latin America would be 20.6 million tons by 1975.[4]

[4] Iron and Steel Engineter, vol. 38, No. 1, January 1961, p. 139.

TABLE 21.—World production of pig iron (including ferroalloys), by countries [1] [2]
(Thousand short tons)

Country [1]	1951-55 (average)	1956	1957	1958	1959	1960
North America:						
Canada	2,714	3,808	3,923	3,172	4,318	4,857
Mexico	309	455	473	547	617	733
United States	70,416	77,670	80,920	58,867	62,135	68,620
Total	73,439	81,933	85,316	62,586	67,070	74,210
South America:						
Argentina	36	32	37	32	39	198
Brazil	1,032	1,291	1,400	1,513	1,651	[3] 1,650
Chile	299	406	421	336	320	320
Colombia	[4] 104	128	158	164	138	[3] 140
Total	1,471	1,857	2,016	2,045	2,148	2,308
Europe:						
Austria	1,412	1,915	2,161	2,004	2,025	2,460
Belgium	5,266	6,350	6,160	6,084	6,575	7,222
Bulgaria	[5] 9	11	60	100	195	220
Czechoslovakia	2,847	3,618	3,928	4,160	4,679	5,172
Denmark	44	62	65	49	64	76
Finland	105	114	142	111	106	116
France	10,479	12,831	13,310	13,380	13,950	15,591
Germany:						
East	1,084	1,735	1,840	1,957	2,090	2,196
West	14,158	19,375	20,236	18,363	20,275	} 28,372
Saar	2,795	3,341	3,490	3,420	3,540	}
Hungary	789	847	923	1,213	1,236	1,389
Italy	1,501	2,198	2,432	2,389	2,416	3,113
Luxembourg	3,272	3,655	3,713	3,621	3,795	4,173
Netherlands	648	730	773	1,011	1,259	1,485
Norway	309	498	624	577	672	788
Poland	2,556	3,865	4,059	4,259	4,822	5,030
Portugal	---	---	---	43	40	43
Rumania	477	643	756	812	933	1,118
Spain	925	1,100	1,030	1,479	1,889	2,132
Sweden	1,174	1,555	1,701	1,559	1,658	1,672
Switzerland	44	45	50	[3] 40	[3] 50	[3] 60
U.S.S.R.[6]	30,350	39,410	40,830	43,650	47,370	51,590
United Kingdom	12,534	14,750	15,997	14,532	14,092	17,660
Yugoslavia	381	713	812	860	995	1,123
Total [6]	93,159	119,361	125,092	125,673	134,726	152,801
Asia:						
China	2,640	5,265	6,060	[7] 10,470	[7] 22,600	30,300
India	2,086	2,194	2,141	2,352	3,427	4,608
Japan	4,771	6,905	7,864	8,510	10,908	13,604
Korea, North	33	205	300	350	[3] 765	[3] 1,100
Taiwan (Formosa)	8	20	22	19	36	26
Thailand	4	4	4	6	8	7
Turkey	215	244	239	254	260	272
Total [6]	9,757	14,837	16,630	21,961	38,004	49,917
Africa:						
Rhodesia and Nyasaland, Federation of:						
Southern Rhodesia	44	66	88	94	[3] 80	[3] 175
Union of South Africa	1,247	1,495	1,574	1,744	1,992	2,204
United Arab Republic, (Egypt region)	([8])	[3] 4	[3] 13	[3] 45	130	[3] 140
Total	1,291	1,565	1,675	1,883	2,202	2,519
Oceania: Australia	1,875	2,324	2,474	2,553	2,804	3,226
World total (estimate)	181,000	221,900	233,200	216,700	247,000	285,000

[1] Pig iron is also produced in Republic of the Congo, but quantity produced is believed insufficient to affect estimate of world total.
[2] This table incorporates some revisions. Data do not add to totals shown because of rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Average for 1954-55.
[5] Average for 1952-55.
[6] U.S.S.R. in Asia included with U.S.S.R. in Europe.
[7] Based on figures from Chinese sources. 1958 does not include approximately 4,000,000 tons produced of substandard grade iron produced at small plants. 1959 production probably includes pig iron obtained from reworking the low-grade product of 1958 and an unreported quantity (probably relatively small) of substandard iron from small plants most of which were shut down early in the year.
[8] Data not available; no estimate included in the total.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

TABLE 22.—World production of steel ingots and castings by countries [1]

(Thousand short tons)

Country	1951–55 (average)	1956	1957	1958	1959	1960
North America:						
Canada	3,824	5,301	5,068	4,359	5,901	5,790
Mexico	640	969	1,136	1,144	1,442	1,713
United States [2]	103,065	115,216	112,715	85,255	93,446	99,282
Total	107,529	121,486	118,919	90,758	100,789	106,785
South America:						
Argentina	184	[3] 340	[3] [4] 400	269	236	305
Brazil	1,177	1,640	1,523	1,672	1,801	[4] 2,200
Chile	297	420	428	384	457	465
Colombia	21	99	126	133	120	173
Total	1,679	2,499	2,477	2,458	2,614	[4] 3,145
Europe:						
Austria	1,443	2,291	2,766	2,638	2,769	3,487
Belgium	5,616	7,035	6,917	6,626	7,096	7,925
Bulgaria	[5] 36	143	175	233	254	277
Czechoslovakia	4,840	5,381	5,695	6,074	6,764	7,460
Denmark	218	265	289	281	322	351
Finland	171	217	230	207	262	285
France	11,837	14,727	15,398	16,111	16,776	19,047
Germany:						
East	2,302	3,020	3,191	3,354	3,535	3,678
West	18,409	25,561	27,014	25,116	28,464	} 37,589
Saar	3,104	3,719	3,791	3,814	3,983	}
Greece	50	83	[4] 80	125	99	[4] 140
Hungary	1,634	1,560	1,516	1,793	1,939	2,078
Ireland [4]	25	33	28	31	44	44
Italy	4,343	6,512	7,481	6,913	7,454	9,071
Luxembourg	3,261	3,810	3,850	3,725	4,038	4,502
Netherlands	886	1,157	1,306	1,585	1,841	2,141
Norway	130	320	386	409	470	527
Poland	3,956	5,527	5,847	6,242	6,790	7,585
Rumania	762	859	952	1,030	1,564	1,991
Spain	1,163	1,365	1,526	1,734	1,995	2,157
Sweden	1,961	2,644	2,737	2,653	3,132	3,548
Switzerland [6]	171	188	247	256	270	[4] 275
U.S.S.R. [7]	42,037	53,680	56,412	60,539	66,085	71,981
United Kingdom	19,706	23,137	24,303	21,914	22,609	27,198
Yugoslavia	619	978	1,156	1,233	1,432	1,590
Total [7]	128,320	164,212	173,293	174,636	189,987	214,927
Asia:						
China	2,006	4,922	5,897	8,820	14,720	20,340
India	1,787	1,947	1,920	2,030	2,726	3,613
Israel	------	------	------	[8] 29	26	[4] 45
Japan	8,446	12,242	13,856	13,358	18,330	24,403
Korea:						
North [4]	55	210	310	400	500	610
Republic of	3	13	19	22	42	55
Philippines	------	------	63	73	[4] 70	[4] 70
Taiwan (Formosa)	31	87	98	118	175	174
Thailand	4	4	6	6	7	8
Turkey	182	213	194	176	236	293
Total [7]	12,514	19,638	22,363	25,032	36,832	49,611
Africa:						
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	39	64	72	79	88	88
Union of South Africa	1,412	1,769	1,915	2,019	2,090	2,328
United Arab Republic (Egypt Region) [4]	43	120	110	190	190	190
Total	1,494	1,953	2,097	2,288	2,368	2,606
Oceania: Australia	2,135	2,844	3,377	3,509	3,788	4,122
World total (estimate)	253,700	312,650	322,550	298,700	336,400	381,200

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] Data from American Iron and Steel Institute. Excludes production of castings by companies that do not produce steel ingots.
[3] Including castings.
[4] Estimate.
[5] Average for 1953–55.
[6] Including secondary.
[7] U.S.S.R. in Asia included with U.S.S.R. in Europe.
[8] Includes 1957 production when plant came into operation.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

NORTH AMERICA

Canada.—Despite a decline each quarter after the high steel production of the first quarter in Canada during 1960, steel production exceeded midyear expectations of steel executives and was the largest in history.

Extensive expansions in the Canadian steel industry were underway. Algoma Steel Corp., Ltd., was constructing a $15 million universal mill to include new continuous reheating furnaces for its rail, structural, and merchant mills. This mill was expected to be completed early in 1961 and was to produce wide flange beams up to maximum size of 24 inches. Algoma also was building a 6-stand-wide strip mill, as an extension to its bloom and plate mill, at an estimated cost of $30 million. The mill was scheduled for completion in 1963 and was to produce hot-rolled sheets and light plates to a maximum width of 96 inches.

Steel Company of Canada (STELCO) reported that its new open hearth furnace would be in operation during the first quarter of 1961, increasing its steelmaking capacity to approximately 3.1 million tons a year. STELCO was arranging for a supply of 200 tons of oxygen per day to be used in its open hearth furnaces and for other metallurgical applications and was planning to inject natural gas in one of its blast furnaces.

During the year, the Big Inch Pipe Corp. started operating a continuous pipe mill at Calgary, Alberta. This mill fabricated pipe in sizes from 18 to 36 inches outside diameter with a wall thickness of $3/16$ to $5/8$ inches.

In addition to experimental work on using natural gas in the blast furnace, Canadian steel companies were investigating the use of fuel oil as a partial replacement for coke in the blast furnace. Experiments were carried out by the steel companies and Imperial Oil Limited, utilizing bunker C fuel oil. The fuel oil was injected into the furnace through a series of special nozzles in blowpipes, through which hot air was blasted into the furnace.

Algoma Steel announced the development of a new steel with improved weldability and a 20 percent higher yield strength than ordinary structural steel.

The statement on page 592 of the 1959 Minerals Yearbook, referring to the production of titanium slag by Crucible Steel, was incorrect. Quebec Iron Titanium Corp. at Sorel was the only producer of titanium slag operating in Quebec Province.[5]

Mexico.—Hojalata y Lamina, one of the largest steel producers in Mexico, was engaged in a major expansion program, which included erecting a new steel plant in Mexico City. It used the HyL direct-iron process. In this process, reform natural gas is used to convert iron ore to sponge iron. The sponge iron is then hot-charged to open-top electric furnaces for refining steel.[6]

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[5] U.S. Embassy, Toronto, Canada, State Department Dispatch No. 66, Mar. 8, 1961.
U.S. Embassy, Toronto, Canada, State Department Dispatch No. 110, June 29, 1960.
Iron and Steel Engineer, vol. 38, No. 1, January 1961, p. 138.
[6] Skillings' Mining Review, vol. 49, No. 22, Aug. 27, 1960, p. 10.

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SOUTH AMERICA

Argentina.—The first blast furnace of the State-controlled St. Nicholas steel plant started operating in 1960, and production of steel was scheduled to begin in 1961.[7] This steel plant had a pier 2,225 feet long on the Parana River, two unloaders with a combined hourly capacity of 880 short tons, and capacity to store 1,500,000 tons of ore and 330,000 tons of coal. The blast furnace, installed by Arthur McKee of Cleveland, Ohio, had a hearth diameter of 28 feet and a daily capacity of 1,650 short tons of pig iron. The plant had coke ovens of German design and included 89 ovens. The coke plant will produce 1,600 tons of coke per day, of which 1,375 tons will go to the blast furnace. The coke plant installation includes a byproduct plant. Steelmaking facilities are composed of four 250-ton stationary open-hearth furnaces fired with coke oven and fuel oil or tar. The furnaces were designed by the U.S. firm, Loftus Engineering Corp., and are being built by Didier-Werke, A.G., of Germany. The blooming and slabbing mill is serviced by six batteries of soaking pits with an annual capacity of 1 million tons. Other mills include a continuous billet mill and structural mill and a continuous plate and sheet mill capable of hot-rolling 150,000 tons of heavy plate, 150,000 tons of sheet, and 335,000 tons of coils for cold reduction. The capacity of the cold reduction mill will be 315,000 tons a year, of which 170,000 tons will go for making tin plate. The tin mill will be equipped with hot-dipped tin pots and an electrolytic tinning line with an annual capacity of 110,000 tons. Steelmaking facilities are scheduled to start operating by the middle of 1961, and the plate and sheet mill will be in operation by the early part of 1962.[8]

The Governor of the Province of Buenos Aires announced early in 1960 that a plate and sheet rolling mill at Gary, Ind., had been purchased and would be transferred to a suitable site in the Province. The initial investment was reportedly $23 million.[9]

Brazil.—Supplementing the information given in the 1959 chapter, Iron and Steel preprint, pages 23 and 24, ACOS Villares S/A of São Paulo signed a license agreement with the Ohio Steel Foundry Co., Lima, Ohio, for manufacturing cast and forged steel and iron rolls for the Brazilian steel industry. The company was to make high-alloy steel, high-alloy stainless and heat-resistant steel and the higher alloy grades of construction steel, as well as carbon and alloy heavy castings and forgings.[10]

Companhia Siderurgica Paulista (COSIPA) was constructing a plant at Piacaguera to make steel by the Linz-Donawitz (L–D) oxygen steelmaking process.[11]

Peru.—Expansion plans announced by the Peruvian Santa Corp. called for doubling the steel ingot capacity of the Chimbote steel mill to 120,000 tons per year and tripling the capacity of the complementary hydroelectric powerplant in the Canondelpato to 150,000 kilowatts. The expansion was closely related to the installation of

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[7] Mining Journal (London), vol. 255, No. 6524, Sept. 2, 1960, p. 262.
[8] Metal Bulletin (London), No. 4527, Sept. 9, 1960, p. 25.
[9] Foreign Trade (Ottawa), vol. 113, No. 11, May 21, 1960, p. 31.
[10] Foreign Trade (Ottawa), vol. 115, No. 3, Feb. 11, 1961, p. 24.
[11] Skillings Mining Review, vol. 49, No. 3, Apr. 16, 1960, p. 16.

beneficiation facilities at St. Nicholas Bay by the Marcona Mining Co.[12]

Venezuela.—The Government's Matanzas stainless pipe mill near the Caroni River has been importing steel for producing seamless pipe. Planned pipe production for 1960 was 45,000 tons; 1961, 130,000 tons; 1962, 160,000 tons; and 1963, 280,000 tons.[13]

EUROPE

The European Coal and Steel Community.—The Community had its best year in 1960, and prices remained remarkably steady. Despite a rise, French prices were still the lowest in the Community. The scrap gap amounted to about 2 million tons, but at no time was there any noticable tightness in the market. New orders for rolled products and deliveries by plants totaled 57.7 million and 58.5 million short tons, respectively, compared with 55.7 million and 50.7 million tons in 1959. Exports of iron and steel products in 1960, the second highest on record, totaled 9.1 million tons, compared with 12.0 million tons in 1958, the previous peak year.

Community pig iron (including ferroalloys) production and crude steel production both reached new highs in 1960, totaling 59.6 million short tons and 80.2 million tons, respectively. The corresponding figures for 1959 were 51.4 million and 69.6 million tons. The average operating rate of the 409 blast furnace was 95 percent of capacity. New peaks in steel output were reached in all countries with the highest rate of increase 21.5 percent in Italy; the average rate of increase for the community was 15.3 percent. The Community share of world steel was 20 percent, compared with 20.7 percent in 1959. Average steel-furnace operating rate for the year was 98.1 percent of capacity with 104.1 percent for Luxemburg and 100.3 percent for France.

The percentages of total steel made by the several processes during 1960 were as follows: Basic Bessemer, 49.5; acid Bessemer, 0.3; open hearth, 37.8; electric, 10.3; and other (including L–D Rotor and Kaldo), 2.1. Corresponding figures for 1959 were 51.0, 0.3, 37.1, 10, and 1.6, respectively. The production of "new steel" by oxygen processes was increasing rapidly. In 1960, it represented 1.8 million tons or 2.1 percent of total production, compared with 1.6 percent of the total in 1959.

The quantity of pig iron produced per ton of steel capacity declined from 1,560 pounds to 1,478 pounds from 1955–59 and rose to 1,488 pounds in 1960 as a result of the investment policy adopted in 1955.

Scrap imports for 1960 increased to 1.9 million tons, compared with the low of 1.19 million tons in 1959. The decrease in foreign market demand for scrap resulted in a lower scrap price. The Community stock scrap pile increased to 13.8 million tons in 1960.

Construction projects declared for iron and steel plants in 1960 were valued at $1.8 billion, compared with $495 million in 1959. A breakdown of the 1960 investments was as follows: Coke plants, $41

[12] Mining World, vol. 2, No. 7, June 1960, p. 74.
[13] Foreign Trade (Ottawa), vol. 115, No. 1, Jan. 14, 1961, p. 14.

million; burden preparation, $132 million; blast furnaces, $149 million; steel furnaces, $357 million ($287 million, L–D and similar processes); rolling mills, $930 million; and power generation and miscellaneous, $193 million.[14]

Austria.—Austrian steel production in 1960 surpassed 3.5 million short tons for the first time. Per capita consumption of steel based on ingot production in Austria is now higher than that of the U.S.S.R. Production and shipments of steel both rose 20 percent over 1959 output. Of the total steel produced, 1.8 million tons was made at Linz and 1 million tons was made at Donawitz. Plans called for expanding annual steel output by another 550,000 tons at Linz. Virtually all of the steel in Austria is made in oxygen converters or by the Linz-Donawitz process.[15]

U.S.S.R.—In 1960 the U.S.S.R. reportedly blew in the largest blast furnace in the world at the Krivoi Rog Steel Works in the Ukraine. It was claimed that natural gas and superheated oxygen-enriched blast would be used to obtain high efficiencies. Previous reports on the 32-foot-hearth-diameter furnace called for a daily output of 5,000 tons of pig iron. The U.S.S.R. planned to build four more such furnaces. The largest blast furnace in the United States is that of National Steel Corps., Ecorse, Mich. with a hearth diameter of 30.25 feet.[16]

Soviet engineers were planning a new 6-furnace open hearth plant with an annual capacity of 3.5 million tons. Each of the large furnaces was to have a heat capacity of 900 to 1,000 short tons and be able to make 700,000 to 825,000 tons of steel annually. Output per man hour was expected to be increased at least 25 percent as compared with 550-ton furnaces.[17]

The 7-year plan of economic development for 1959 to 1965 for the Soviet Union called for increasing steel production to 95 million or 100 million tons by 1965, a growth rate of 7.5 percent per year. Blast furnace capacity will be increased by 26 million to 33 million tons; steelmaking capacity, by 31 million to 40 million tons; and rolling-mill capacity, by 25 million to 32 million tons. During 1960, new large blast furnaces, 10 open hearth furnaces, 3 electric furnaces, 6 rolling mills, and 8 coke oven batteries were commissioned. By 1963 two large blast furnaces, seven large open hearth furnaces, two converters, shops, and five rolling mills were to be built in the Dondas or Stalino economic area. These blast furnaces will utilize oxygen-enriched blast at temperatures exceeding 1,800° F., and half of the furnaces will use natural gas. In the Dniepropetropsk area, all blast furnaces will be put on natural gas injections. Some have oxygen-enriched blast and high top pressures up to 22 p.s.i., which is considerably higher than that used in the United States.

Large metallurgical plants were planned for the Ukraine and in the Urals with plants to be built east of the Urals in Siberia and Kazakhstan. In the Kazakhstan area, the Karaganda plant was put in operation, and the West Siberian Iron and Steel Works was under construction. Metallurgical plants were planned at Kustanai and

[14] European Coal and Steel Community, Ninth General Report on the Activities of the Community: January 31, 1961. pp. 153, 158, 223, 428–432. (In French.)
[15] Iron and Coal Trade Review (London), vol. 182, No. 4829, Feb. 3, 1961, p. 260.
[16] General Metals, vol. 13, No. 3, March 1961, p. 185.
[17] General Metals, vol. 12, No. 12, December 1960, p. 900.

Transbaikal, near the ore deposits of Kazakhstan. The Soviets also were planning to expand existing plants. For example, at the Magnitogorski Iron and Steel Works rolled steel capacity was to be increased to 9.3 million tons by 1965. In general, steel plants in the U.S.S.R. are designed to specialize in a minimum number of products. For example, wire products will be made at one plant; another will emphasize pipe; and another will produce flat rolled products.[18]

United Kingdom.—The United Kingdom planned to increase its steelmaking capacity by 30 percent by 1965, or 33 million net tons per year. Outlay for 1960 was reported at about $370 million, and substantially more was to be spent in 1961. The program called for adding two wide strip mills and expanding the capacity of one of the three operating mills. Meanwhile, an appreciable quantity of wide sheet was being imported from the United States. Four new blast furnaces were blown in during 1960. These included a 31-foot-hearth-diameter unit by the Steel Company of Wales, Limited, and a 25-foot-hearth-diameter furnace at South Durham Iron and Steel Company, Limited. A new 45-inch slab mill was installed at Appleby-Frodingham, Scunthorpe. Stewart and Lloyds started its 40- and 32-inch mills, and Patent Shaft Steel Works, Limited, began a 96-inch four-high plate mill. Richard Thomas and Baldwins, Limited, England, ordered a slab mill, a fourstand tandem cold mill, and a temper pass mill from the United States.[19] England's first steelmaking oxygen converter (the L–D process) started operating on a full three-shift basis during the year at the Ebbw Vale Works of Richard Thomas and Baldwins. The vessel was a 30-ton-capacity unit and had provision for injecting powdered lime through the oxygen lance.[20] The Ford Motor Company, Limited, exclusively owned by the parent United States firm, awarded a contract to the Davy-Ashmore group—Ashmore, Benson, Pease and Company, Limited to construct a 20-foot-diameter-hearth blast furnace at Dagehnham (Essex). The furnace was scheduled to go into production in the summer of 1962. This would be the 50th blast furnace constructed by Ashmore-Benson-Pease in 30 years.[21]

Yugoslavia.—The Yugoslavia iron and steel industry was reportedly composed of self-managed, socialized enterprises, which included nine steel works coordinated by the Government and the Yugoslav Association of Iron and Steel Works. Government control was exercised through legislation and the basic investment policy, as well as through party, trade unions, and local-government organizations.

Since 1956, gross investments in the Yugoslav iron and steel industry averaged about $12 million per annum. In March 1960, a loan of $8.5 million from the development and loan fund was completed for the expansion of the Sizak Iron and Steel Works, and in August 1960, $6.3 million was made available to the steel industry to buy hard coal, coke, and scrap.

Yugoslav iron and steel production in 1960 was 13 percent greater than in 1959, and the industry set a target of 3.4 million short tons by 1972. The increased production was attributed to improved pro-

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[18] Iron and Steel Engineer, vol. 38, No. 1, January 1961, p. 141.
[19] Work cited in footnote 18, p. 139.
[20] Journal of Metals, vol. 12, No. 9, September 1960, p. 663.
[21] Iron and Coal Trade Review, London, vol. 182, No. 4827, Jan. 20, 1961, p. 160.

duction methods and modernization and expansion of the Niksic, Ilisjas, Store, Zenica, and Jesenica plants.[22]

ASIA

China.—Despite heavy losses incurred by the metallurgical industries because of natural disasters during 1960, China met its steel-production target of 20.2 million short tons. August floods caused destructive damage to plants producing steel ingots, pig iron, and coal. Electrical power production and transport had to be temporarily suspended.[23]

After several revisions, China's targets for steel production through 1972 were established as follows: 1962, 27–29 million short tons (including 10 million tons produced in small plants; 1967, 31.5 million short tons (small plant production not given); 1972, 44 million short tons.[24]

A brief summary of China's steelmaking centers sponsored by the U.S.S.R. was as follows:

Anshan—Capacity 6.5 million short tons; uses 600-ton open-hearth furnaces tapping into 3 ladles simultaneously, using a trifurcated spout. This mill produced a well-balanced group of steel products including rails, structurals, sheets, seamless pipe, plates, and almost all other multiple purpose steels. U.S.S.R.-designed blast furnaces at this plant were using a 100 percent sinter charge.

Wuhan—Capacity 3.3 million short tons; furnaces are similar to those at Anshan. Size of furnaces compares with those at the Fontana, Calif., plant of Kaiser Steel Co. Products of this plant are equal to those at Anshan. Blast furnaces are similar to those at Anshan.

Paotow—Capacity 3.3 million short tons; this plant is similar to Wuhan and is not near fabricating plants.

Chi-Chi-Ha-Erh—Capacity 550,000 short tons; specializes in high-quality steel suitable for aircraft and computers. This plant also produces high-strength steel in the range of 110,000 pounds per square inch.

A summary of plants expanded with Soviet and European satellite assistance was as follows:

Tayeh—Capacity 1.4 million short tons; uses open hearth and electric furnaces and is being expanded with East European aid. Capable of producing products similar to those at Wuhan.

Tai-Yuan—Capacity 2.2 million short tons; open hearth and electric furnaces. East German blooming mills and Russian rolling mills have been added recently.

Ma-An-Shan—Capacity 1.1. million short tons; 21 converters and 2 electric furnaces.

Chungking—Capacity 1.7 million short tons; open hearth furnaces capable of producing 330 tons per melt. Czechoslovakian rolling mills and new converters have been added since 1959.

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[22] U.S. Embassy, Belgrade, Yugoslavia, State Department Dispatch No. 705, May 4, 1961.
[23] Far East Iron and Steel Trade Reports, No. 73, February 1961, p. 16.
[24] The British Steelmaker, July 1960, p. 259.

Shih-Chinang-Shan—Capacity 1.4 million short tons; open hearth furnaces of about 220 tons capacity. A pipe mill of U.S.S.R.-design has been installed, which reportedly will supply the petroleum industry.

Huhan—Capacity 1.3 million short tons; open hearth furnaces of about 220 tons capacity. This plant will be fully integrated by 1965.

Existing partially integrated plants were as follows:

Dairen—Capacity 110,000 short tons; 55-ton electric furnaces and rolling mill.

Shenyang—Capacity 330,000 short tons; open hearth and electric furnaces. Center of heavy machinery industry where such items as rolling mills, hydraulic forging presses, and turbines are produced.

Fushun—Capacity 770,000 short tons; electric furnaces and rolling mills.

Penchi—Capacity 110,000 short tons; 55-ton electric furnace.

Integrated plants now being built by the Chinese were:

Chiu-Chuan—Capacity 1.6 million short tons; open hearth furnaces about the size of those at Chungking.

Hsi-Chang—Capacity 2.2 million short tons.

Lung-Yen—Capacity 1.7 million short tons.

Shao-Kuan—Capacity 1.7 million short tons.

The sum of the capacities of the foregoing listed steel plants was 29.8 million short tons. However, steel experts in the United States believe that China could produce 39 million short tons of steel by 1965, and experts in England set the figure at 28.5 million tons. Accurate information on the Chinese steel industry was difficult to obtain. Historically, steel produced in China was considered inferior to that produced in other countries.[25]

India.—In India steel demand far exceeded steelmaking capacity, and plans were underway to make India not only self-sufficient, but a steel-exporting country. The target for India's steelmaking capacity in 1961 was 6.6 million short tons with an increase to 11.2 million tons by 1966. A breakdown of steel capacity by plants projected to 1966 was as follows: Bhilai—2,750,000 tons; Durgapur—1,800,000 tons; Rourkela—2,000,000 tons; Bokaro—1,100,000 tons, a new plant; Tata Iron and Steel Company—2,200,000 tons; Burnpur—1,100,000 tons; Mysore—100,000 tons; and miscellaneous places—200,000 tons.

Construction of the Durgapur plant was scheduled for completion by July 1961. Two blast furnaces operated during 1960. Other units remaining to be built at the Durgapur plant were a third coke oven battery, a third blast furnace, four open hearth furnaces, a 24-inch medium section mill, a continuous merchant mill, a foundry, and a wheel and axle plant. At Rourkela, three blast furnaces, four 90-ton open hearths, and three 45-ton oxygen converters were operating in the spring of 1960. This plant will have a steelmaking capacity of 1,100,000 tons. Rourkela was operating a new wide strip mill, consisting of two 4-high roughing stands and six 4-high finishing stands. This mill could produce strip 1/16 to 3/8 of an inch thick with a maximum width of 62 inches. Strip leaves the final finishing stands at 2,400 feet per minute. At Tata Iron and Steel Company, Ltd., Jamshedpur, a new lightsection continuous mill was put into operation.

[25] American Metal Market, vol. 67, No. 108, June 7, 1960, pp. 1–2.

This mill consisted of four stands with horizontal rolls and an edger, a finishing train consisting of 2 stands with horizontal rolls and 2 stands with vertical rolls, and a single-stand rack-type rolling bed with automated facilities. Rounds, squares, flats, angles, tees, and channels from 3 by 3, 4 by 4, and 4 by 5 inch billets could be made.[26]

Japan.—The Japanese steel industry made a striking increase in output during 1960. Pig iron, crude steel, and ordinary hot-rolled steel advanced 26 percent, 33 percent, and 33 percent, respectively. Special steels increased 41 percent. To meet the high demand for pig iron, nearly 1 million tons was imported.

At the beginning of 1960, Japan had 29 blast furnaces in operation with a monthly production capacity of 885,000 short tons. Four new blast furnaces were built: In April, a 1,650 ton-per-day furnace at the Chiba Works of Kawasaki Steel and a 330-ton furnace by Osaka Steel; in October, a 1,650-ton furnace at the Hirohata Works of Fuji Steel and a 1,650-ton furnace at the Tobata Works of Yawata Steel. These 4 furnaces increased the annual pig-iron capacity of Japan to 12.7 million short tons, a 20-percent increase.

To meet the expected additional increase in pig iron requirements, the Ministry of International Trade and Industry authorized the construction of six additional blast furnaces: A 1,800 ton-per-day furnace at Muroran, Fuji; a 2,200-ton furnace at Tobata, Yawata; a 1,100-ton furnace at Nadahama, Kobe; a 1,650-ton furnace at Mizue Works; a 1,650-ton furnace at Chiba Works; and a 1,650-ton furnace at the Kure Works of Nisshin Steel.

Crude steel production for 1960 was 24.4 million short tons, 1.33 times the 1959 level. Percentage production by type of furnace was 67.9 by open hearth, 11.9 by converter, and 20.2 by electric furnace. The corresponding figures for 1959 were 74.0, 71.3, and 18.7.

TABLE 23.—Production of crude steel during 1960

(Thousand metric tons)

Type of furnace and stul	Total	Index (1959—100)
Open hearth furnace	15,045	122.2
Converter	2,629	218.1
Electric furnace	4,469	143.6
Total	22,143	133.2
Ordinary steel	19,937	132.3
Special steel	2,206	141.4

New steelmaking furnaces added during 1960 were one 165-ton open hearth at Kawasaki Steel Corporation's Chiba Works, two 110-ton open hearth furnaces at Otani Steel Works, Ltd., and two 75-ton open hearth furnaces at Nakayama Steel Works, Ltd., Nagoya Works. Seven new converters were added at various locations. The type was not given, but it was assumed they all were the L–D type. Among the large size electric furnaces put into operation was a 65-ton furnace at the Kobe Steel Works, Ltd.

[26] Iron and Steel Engineer, vol. 38, No. 1, January 1961, p. 141.

There was a marked increase in the output of most steel products during the year. Leading products included wide strips, plates, small bars, hoops, ordinary wire rods, sheet, medium plate, medium sections, large sections, and tube rounds.

For steel pipe, electric-resistance-welded tube registered a notable advance. The output of special hot-rolled steel totaled 1.3 million tons, a 41-percent increase over 1959. Estimated output of stainless steel for the year was 200,000 tons, compared with 110,000 tons in 1959.

Imports of steel mill products for the year were 275,000 short tons; exports were 2.8 million tons. A considerable part of the imports was old rails and tinplate.

Bars, plates, cold-rolled sheet, wire rods, and galvanized sheet were the important export items, and the principal buyers were the United States, India, Australia, the Philippines, and Thailand.

According to the long-range expansion programs of the six major steel producers in Japan, steel production in 1965 would be 38.6 million short tons. These six producers planned to produce 89.2 percent of the expected total production, compared with 66.6 percent in 1960 (table 24). The companies planned to double pig iron production by building 19 new blast furnaces.

In steel expansion many new oxygen steelmaking converters were to be built, and some of the existing open hearth furnaces were to be replaced with oxygen converters. Many steel products have been produced by one or two companies. The expansion plan calls for a greater number of producers of these products, which include silicon sheet, large structural sections, tin plate, and strip.[27]

TABLE 24.—Production expansion program of six big steel makers

	1960		1965		Equipment investment 1961–65 (thousands)
	Crude steel output (thousand metric tons)	Percent of national total	Crude steel output (thousand metric tons)	Percent of national total	
Yawata Iron and Steel Co., Ltd	5,130	22.0	9,080	25.9	$89,100
Fuji Iron and Steel Co., Ltd	3,640	15.6	7,600	21.7	74,670
Nippon Kokan Kabushiki Kaisha	2,350	10.1	4,690	13.4	47,100
Kawasaki Steel Corp	2,060	8.8	4,360	12.4	37,140
Sumitomo Metal Industries, Ltd	1,350	5.8	3,340	9.5	27,350
Kobe Steel Works, Ltd	1,010	4.3	2,220	6.3	42,250
Total	15,540	66.6	31,290	89.2	317,610

Source: Far East Iron and Steel Trade Reports.

North Korea.—U.S.S.R. engineers were working on plans for expanding the Kim Chak Iron and Steel Works at Chong-din in North Korea to make it one of the largest and most up-to-date steel plants on the Asian continent. In 1960 the plants consisted of two batteries of coke ovens and two blast furnaces. Four new coke oven batteries and two modern blast furnaces identical in size to the latest installed

[27] Far East Iron and Steel Trade Reports, No. 73, February 1961, pp. 3–9.

in the U.S.S.R. were to be added. Also included was a new converter shop, utilizing 100-ton capacity converters of Soviet design.[28]

Pakistan.—The Pakistan Government announced its decision for establishing a steel mill in Karachi. A report outlining the feasibility of such a venture was submitted to the British consultants, John Miles and Partners, who contacted firms in the United Kingdom, United States, Canada, and Japan. Koppers Co., Inc., Pittsburgh, submitted its feasibility report on a 250,000-ton plant for Karachi, and a Japanese team of experts completed its report for a 100,000-ton plant at Chittagong-East Pakistan.[29]

Philippines.—After an economic and technical study by a West German firm, Santa Ines Steel Company, planned to build a new steel plant in the Philippines with a daily steelmaking capacity of 220,000 tons, based on Santa Ines ore deposits. Plans called for the refining of pig iron to steel by the L–D process. Semifinished products, ingot molds, and gray iron casting were suggested as possible products.[30]

Turkey.—The following supplements the information given in the 1959 Minerals Yearbook on the new integrated steel plant to be built at Eregli on the Black Sea coast. The Development and Loan Fund agreed to loan $129.6 million to finance half the cost of this plant. This was reportedly the largest single U.S. Government loan ever made for an overseas industrial project. A byproduct coke plant, a blast furnace, basic oxygen converter, rolling mills, and power and steam plants were to be built. Output was expected to be 470,000 tons a year initially and later to be expanded to 1.2 million tons.[31]

AFRICA

Rhodesia and Nyasaland, Federation of.—A $24 million expansion program was underway at the Redcliff Works of the Rhodesian Iron and Steel Company, which will boost annual steel output to 150,000 tons. Equipment at the new plant included a 500-ton-a-day blast furnace, a 200-ton-a-day open hearth furnace, coke oven, cogging mills and soaking pits, reheating furnaces, and a black and galvanized sheet mill. The blast furnace, fourteenth in Africa, will increase pig iron output in Rhodesia to 750 tons a day. The additional open hearth doubles steel capacity to 400 tons a day.[32]

United Arab Republic (Egypt Region).—The Egyptian Iron and Steel plant erected by the West German firm, Demag, at Helwan, that began producing in June 1958 had operated at less than 50 percent of capacity and was reportedly operating at a loss. The mill was equipped with two blast furnaces, each designed for a daily output of 400 tons of molten pig. Blast furnace coke was imported from West Germany and China. Through 1960, only one blast furnace had been used. Three basic Bessemer converters were used for steelmaking. The rolling mills had an annual capacity of about 20,000 tons

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[28] Iron and Coal Trades Review, London, England, vol. 80, No. 47 AD 1, March 4, 1960, p. 543.
[29] Mining Magazine (London), vol. 104, No. 3, March 1961, p. 166.
Iron Age, vol. 186, No. 11, Sept. 15, 1960, p. 13.
[30] Mining World, vol. 13, No. 8, July 1960, p. 73.
[31] Mining World, vol. 23, No. 3, March 1961, p. 75.
[32] Steel, vol. 148, No. 4, January 23, 1961, p. 31.

of billets, rail sections, heavy and medium plate, and some sheet. In 1960 output of billets was less than 300 tons per day, part of which was sent to other smaller mills in Egypt. The cost of producing pig iron at this plant was reportedly double the cost of imported material.

Most of the operating difficulties were attributed to variable iron ore composition. Other problems included lack of adequate rail transportation and an inexperienced labor force. Two International Cooperation Administration iron and steel experts were studying the company's technical operating problems.

The Soviet-Egyptian economic assistance agreement contained the following projects relevant to the iron and steel plant: (1) Coke cehmical plant in Helwan, including shop for coal preparation, one battery of 45 coke oven, and a coke-oven-byproduct plant; (2) Projecting work and delivery of equipment for a strip mill with an annual capacity of 70,000 tons of sheets on a two-shift-per-day basis; (3) Projecting work and delivery of equipment for strip and cold-rolling sheet mill for producing 25,000 tons of sheet for tinning.[33]

OCEANIA

Australia.—Australian production of pig iron, crude steel, and shipments of steel mill products reached new records in 1960. Despite the large increase in productive capacity, demand of the rapidly expanding Australian economy continued to exceed production in many fields. The main shortages occurred in structural steel. However, Australia was on its way toward balancing its steel production and needs. Current outlay calls for doubling output. Australia might become a net exporter of steel by the midsixties. Some evidence of growing self-sufficiency in Australia was shown by the drop in U.S. exports of iron and steel products from 59,000 short tons in 1955 to less than 6,500 tons in 1959. Some of the long-term projects were announced for the expanding Australian steel industry: (1) Installation of four Linz-Donawitz oxygen-type steelmaking converters, which could increase steel ingot capacity by as much as 95 percent; (2) installation of important new rolling mills at New Castle and Whyalla; (3) establishment of a $90 million integrated steel industry at Kwinana, Western Australia; (4) construction of an iron ore treatment plant at Iron Knob, in Southern Australia, about 200 miles northwest of Adelaide; and (5) construction of a spun-cast-iron pipe mill with an annual capacity of 90,000 short tons in the Sidney area. This last mill, which was to cost over $4.5 million, would produce pipe 4 to 20 inches in diameter. A similar plant was planned for the Melbourne area at a later date.[34]

New Zealand.—New Zealand planned to produce a substantial part of its needs for reinforcing bars, angles, rounds, flats, and squares by the end of 1961 through constructing a $10.1 million merchant bar mill at Auckland. The mill was to be totally financed by New Zealand and United Kingdom firms.[35]

[33] Mineral Trade Notes, vol. 50, No. 3, pp. 23–24, March 1960.
[34] Foreign Commerce Weekly, vol. 65, No. 12, March 20, 1961, p. 40.
Steel Magazine, vol. 147, No. 14, Oct. 3, 1960, p. 49.
Mining and Chemical Engineering Review, Melbourne, Australia, vol. 52, No. 9, June 15, 1960, p. 10.
[35] Iron and Coal Trade Review, London, England, vol. 180, No. 4755, Jan. 22, 1960, p. 206.

TECHNOLOGY

The Bureau of Mines, U.S. Department of the Interior, published several reports on its blast furnace research program. In one study, natural gas was used to replace 30 percent of the coke charge, and output was increased 25 percent in the Bureau's experimental blast furnace.[36] In another experiment with this furnace, raw (unfired) iron ore pellets were successfully smelted with no significant change in coke consumption and only moderate increase in dust losses.[37] A third test showed that part of the coke charge can be replaced by injecting anthractite directly into the smelting zone. Hot blast temperature should be increased to compensate for chilling effect of cold anthracite; use of finer anthracite will permit reduction in carbon-to-iron ratio and, therefore result in a higher production rate.[38]

Another experiment included enrichment of the blast with steam, natural gas, and oxygen. Results showed that natural gas with oxygen increased output and reduced coke requirement and that varying the moisture content of the blast was an effective tool for controlling the operation of the furnace.[39]

Fuel oil was atomized into the natural gas stream as it passed through the tuyeres of a blast furnace in one experiment. Fuel oil supplements the natural gas, which can only be added in limited amounts.[40]

Results of tests on the use of natural gas in the blast furnace of Lone Star Steel, Lone Star, Texas, in 1960 were promising. With a 3-percent injection of natural gas, production increased 30 percent and coke consumption decreased 20 percent. Hot blast temperature was increased 25 percent. During the tests, savings of 17 percent in fuel cost and 15 percent in operating cost were realized.[41]

Tests at Pittsburgh Coke and Chemical Company at Pittsburgh, Pa., showed that merchant pig iron could be made with undesulfurized coke oven gas, containing hydrogen sulphide by injection in the tuyeres of a blast furnace. The injection resulted in increased metal output and decreased coke consumption.[42]

In Germany the efficiency of the blast furnace was increased by adding oxygen and carbon dioxide to the blast; in trial smelting in a 0.6-meter-diameter furnace, the blast was enriched to 16.6 percent carbon dioxide and 45.0 percent oxygen, resulting in a 40-percent increase in efficiency.[43]

In the Low Shaft Blast Furnace at Liege, Belgium, the thermal aspects and shaft efficiency of indirect reduction were established with or without fuel oil and gas injection with or without top pressure.

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[36] Melcher, N. B., Morris, J. P. Ostrowski, E. J., and Woolf, P. L., Use of Natural Gas in an Experimental Blast Furnace: Bureau of Mines Rept. of Investigations 5621, 1960, 15 pp.

[37] Melcher, N. B., and Royer, M. B., Smelting Unfired Iron Ore Pellets in an Experimental Blast Furnace: Bureau of Mines Rept. of Investigations 5640, 1960, 9 pp.

[38] Ostrowski, E. J., Royer, M. B., and Ropelewski, L. J., Injecting Solid Fuels Into Smelting Zone of an Experimental Blast Furnace: Bureau of Mines Rept. of Investigations 5648, 1960, 14 pp.

[39] Blast Furnace Coke Oven and Raw Materials Proceedings, A.I.M.E., 1960, vol. 19, pp. 279–300.

[40] Iron and Steel Engineer, vol. 38, No. 1, January 1961, p. 147.

[41] Blast Furnace and Steel Plant, vol. 49, No. 4, April 1961, pp. 317–323.

[42] Journal of Metals, vol. 13, No. 1, January 1961, pp. 49–50.

[43] Stahl und Eisen, vol. 81, No. 3, Feb. 2, 1961, pp. 149–154.

The effect of varying the quantity of carbon monoxide and hydrogen on indirect reduction also was established.[44]

A method for continuous refining of molten pig iron in a blast furnace runner by injecting pure oxygen through a porous bottom plate was described. In the experiment, silicon was reduced; iron losses due to oxidation were low; and brown smoke did not occur.[45]

The use of electronic computers for predicting effects of oxygen, moisture, and fuel additions in blast furnace operations evoked considerable interest. Essential elements of methods developed were described, and results of computed predictions for several iron blast furnaces were compared with actual results.[46]

Radioactive tracers were used to determine the movement of the blast furnace charge under normal working condtions. The results of 193 experiments carried out in 1956-57 at the Azovstal works in U.S.S.R. were described.[47]

At the Colorado Fuel and Iron Corporation, Pueblo, Colo., radioactive cobalt (Co) was used to show brick wear in areas of extreme erosion. Radioactive cobalt needles were mixed with castable refractories, placed in the furnace wall, and monitored outside with Geiger counters. A sudden drop in radiation indicates wear. Cobalt 60 is a satisfactory isotope since its half life of 5.3 years corresponds to a normal furnace-lining life.[48]

In Rumania and Bulgaria lead-bearing iron ores were successfully smelted in a blast furnace. It was demonstrated that lead can be recovered without disturbing the working and operating conditions of the furnace and without producing dangerous concentrations of lead oxide in air when tapping metal.[49]

All the recent advances in blast furnace technology will be considered in an ultramodern blast furnace with a 28-foot hearth diameter to be built by U.S. Steel at its Duquesne Works, Pittsburgh, Pa. The furnace was scheduled for completion in 2 years and was expected to produce about 850,000 tons of molten iron annually. Technological advances to be incorporated in the plant include blast furnace stoves that will deliver increased hot-blast temperature up to 2,000° F., refractories-lined bustle pipe, high hot-pressure up to 30 pounds per square inch, automatic probing of the stock column, and advanced instrumentation. A modern turboblower and a new raw materials trestle will be constructed. U.S. Steel also was constructing a small experimental blast furnace, similar to the Bureau of Mines Experimental furnace, at Universal, Pa.[50]

The Armco Steel No. 3 blast furance at Middletown, Ohio, produced a record tonnage of 2,804 tons of pig iron a day for a period of 1 month during 1960. Its output for the entire year totaled 884,407 tons, an average of 2,500 tons per day. This high output was realized through the use of sized material in the furnace and through the use of large quantities of pellets.[51]

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[44] Journal of Metals, vol. 13, No. 1, January 1961, pp. 41–44.
[45] P. Leroy, R. Simon, Revue de Metallurgie, vol. 57, No. 1, January 1960, pp. 21–43.
[46] A. L. Hodge, Blast Furnace and Steel Plant, vol. 48, No. 7, July 1960, pp. 665–675, 689.
[47] Stal, vol. 19, No. 8, August 1959, pp. 571–576, 676, 683.
[48] Steel, vol. 147, No. 4, July 25, 1960, pp. 126, 128.
[49] Stal, vol. 20, No. 7, July 1960, p. 473–475.
[50] U.S. Steel Corporation—Annual Report 1960; Iron Age, vol. 186, No. 5, August 4, 1960, p. 81.
[51] Armco Steel Corporation, 60th Annual Report for the Year Ended, December 31, 1960.

In steelmaking, developments continued to revolve around some phase of exygen use. One dramatic example was by Ford Motor Company, Dearborn, Mich., where steelmaking time was reduced more than 50 percent by using oxygen. Production rates of 70 tons per hour on a 200-ton furnace and 105 tons per hour on a 400-ton furnace were reported. These production rates compare favorably with rates achieved in oxygen converters. In the operation, rapid charging of the furnace is stressed, and lime is sandwiched in with scrap during charging. Maximum end-firing goes on during charging at the rate of 14 gallons of oil enriched with 5,000 cubic feet of oxygen per minute in the 200-ton furnace. Additional heat is also supplied from lances, lowered about a foot through the roof, furnishing 30,000 cubic feet of natural gas mixed with 48,000 cubic feet of oxygen per hour, a heat input from both sources of about 190 million B.t.u. per hour.

After charging, which takes 23 minutes, the roof lances are lowered to about 2 feet above the scrap, and as the scrap melts down, the lances are lowered still farther. About one-half hour after charging, 11 minutes are required to add molten pig iron. The natural gas is then shut off, and oxygen at the rate of 48,000 cubic feet per hour is surface-blown onto the melt through lances lowered to 4 inches above the bath. Thirty minutes after the hot metal addition, end-firing virtually ceases. About two tons of iron ore are added during the refining period. Total charge-to-tap time runs about 2 hours and 50 minutes. Fuel and oxygen requirements per ton run 1,368,000 B.t.u. and 1,575 cubic feet, respectively. Ford is continuing its research in this field, employing many new techniques.[52]

An interesting variation in open-hearth design was a 250-ton furnace without a front wall built in U.S.S.R. The steel framework is all-welded construction, and instead of a front wall with a number of water-cooled door frames and doors, seven water-cooled free-hanging doors cover the 5-foot-9-inch-by-40-foot-long opening. A furnace so designed can be charged faster and more uniformly, and the worry of hitting the door frames with charging boxes is eliminated. One reported drawback is higher heat losses from cooling water.

Open-hearth furnaces of 660-ton capacity were under construction in the U.S.S.R. in 1960, and plans for 880-ton units, which could be increased to 1,000 tons, were being designed.[53]

Wheeling Steel at Steubenville, Ohio, used steam-oxygen blowing in the Bessemer converter process. In the process a mixture of 50 percent steam and 50 percent oxygen preheated to 300° F. was blown through the bottom tuyeres of the converter in place of air. The nitrogen content of the steel made by this method was 0.0018 percent, compared with the normal range of 0.002 to 0.005 percent for low-carbon open-hearth steel. Hydrogen content averaged 0.3 to 0.4 parts per million—about the same as air-blown Bessemer or open-hearth steel. The heat cycle time, from charge to finish tap, was reduced from 12 to 9 minutes, and the blowing time was decreased from 9 to 7 minutes. Metallic yield was increased by 0.5 to 1 percent.[54]

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[52] Iron Age, vol. 186, No. 16, Oct. 20, 1960, pp. 158–160.
[53] Madsen, I. E., Developments in the Iron and Steel Industry During 1960: Iron and Steel Eng., vol. 38, No. 1, January 1961, p. 152.
[54] Steel, vol. 147, No. 8, August 22, 1960, pp. 82, 85.

The feasibility of using Krupp-Renn processed iron and sponge iron instead of iron and steel scrap as cooling agents was demonstrated in an experimental L–D 3-ton oxygen-blown converter in Germany.[55]

The British Oxygen Research and Development firm in England introduced argon experimentally through hollow electrodes in an electric furnace. Qualitative and quantitative results showed that the argon had a stabilizing effect on the arc, decreased melting time 22 percent and decreased electrical consumption 13 percent in a 1-cwt. manually operated electric-arc furnace.[56]

Considerable work was done at the Indian Institute of Metals on the use of rare-earth compounds in steels. The possibility of using rare-earth compounds for desulfurization was demonstrated. Limited quantities of oxides and fluorides of rare-earth metals and LanCerAmp alloy tended to reduce the size of inclusions and distribute them more uniformly; excessive rare earth caused inclusions to appear again; rare-earth oxides and LanCerAmp appear to refine grain size of low-alloy steel, while rare-earth fluorides result in grain coarsening.[57]

In evaluating high-strength steels for rocket motor casings, small size pressure bottles were used. Steels evaluated included: AISI, H–11, AMS 6434, and PH 15–7 Molybdenum alloy steel. When there was proper control of optimum tempering range, effects of weld mismatch, porosity, improper weld repairs, ground flush welds, and ovality, consistent burst strengths could be expected for vessels heat-treated in range of 240,000 to 260,000 p.s.i. tensile strength.[58]

The use of vinyl-clad steel increased during the year. Ford Motor Company was the first automobile company to use the laminating technique, called the Marvibond process and developed in 1953 by Naugatuck Chemical Co. Ford used vinyl-clad steel extensively in the interior of the 1959 Thunderbird and was considering its use in other models.[59]

Armco Steel Corporation, Sheffield Division, Kansas City, Mo., was using molten cupola metal to increase open-hearth output. The metal was made in cupolas with 108-inch shell diameters of the continuous casting type from which hot metal runs into a 150-ton holding ladle. Metal from the cupola contains about 3 percent carbon, 0.20 percent phosphorus, and 0.13 percent sulfur. The metal is desulfurized by introducing sodium carbonate into the hot metal as it is poured from the holding ladle. The normal charge for the cupola is 40 percent cast iron and pig iron and 60 percent steel scrap. In addition, coke and limestone are charged. About 300 pounds of coke and 50 pounds of limestone per ton of iron is required.[60]

The Bureau of Mines continued its research program on the use of uranium in steel. Studies were directed toward establishing the hardenability factor of uranium and in developing safety measures in its use. Ingots weighing 300 pounds were successfully air-melted by the Bureau, but a 1,000-pound ingot failed during forging at a commercial laboratory.

[55] Technische Mitteilungen Krupp, vol. 18, No. 1, August 1960, pp. 1–8.
[56] Iron and Coal Trade Review, vol. 180, No. 4778, Feb. 12, 1960, pp. 353–358.
[57] Indian Institute Metals, Transactions: Vol. 13, September 1960, pp. 265–276.
[58] Aerospace Engineering, vol. 19, No. 12, December 1960, pp. 30–36.
[59] American Metal Market, vol. 66, No. 141, July 21, 1959, p. 8.
[60] Iron and Steel Engineer, vol. 37, No. 2, February 1960, p. 93.

The Canadian Department of Mines and Technical Surveys had been conducting research on using depleted uranium as an alloying agent in steel at an annual cost of about $250,000. In tests conducted in Canada, uranium was successfully added to a 500-pound heat by wrapping the material in aluminum foil to avoid high oxidation losses. Recoveries in the range of 75 to 85 percent for 0.4 percent carbon steels and 55 to 60 percent for 0.10 percent carbon steel were realized. Uranium is an excellent deoxidizer, and steel can be fully killed with this element.

The experiment showed that 0.7 percent uranium in steel increases hardenability. It was also determined that uranium improved the corrosion resistance of steel in tests, utilizing a 5 percent hydrochloric acid solution. In fatigue studies, the endurance limit of a 0.4 percent carbon steel was found to increase from 29,000 p.s.i. to 36,000 p.s.i. by adding 0.02 percent uranium and to 40,000 p.s.i. with 0.20 percent. Creep studies at elevated temperatures of AISI 1010 and AISI 1040 steels showed that uranium increased the time to rupture at a given temperature and stress. This feature might be of interest to steel consumers for high temperature application such as steampiping and for nuts and bolts used in high temperature surroundings.[61]

Since World War II, large tonnages of depleted uranium have become available as the result of Atomic Energy Commission activities.

The British Iron and Steel Research Association (BISRA) had a number of interesting programs on iron and steel, and expenditures for the year 1959 were nearly $2.3 million. In blast furnace chemistry, BISRA used a special apparatus with a stationary charge in controlled environment to simulate actual blast furnace conditions. In this apparatus, full-sized blast furnace materials are subject to the conditions experienced by a normal charge during its passage down the blast furnace stack. The materials remain stationary, and gas of controlled composition and temperature is circulated through them in a closed system.

Using this apparatus in experiments on sintering, the strongest sinter is produced when the quantity of air slightly exceeds that needed for gaseous combustion and the waste gas flow is just sufficient to draw gasses from the bed. The practicability of injecting pulverized coal and oxygen, with or without iron ore fines, in the blast furnace hearth was examined.

In new ironmaking techniques, BISRA continued its steady progress in developing the flame smelting process. Problems connected with constant rates of feed of powdered coal and ore to the high temperature reactor were solved, and the reliability of the unit was improved so that molten metal and slag could be made at will.

In steelmaking, a survey of the use of gaseous oxygen in open hearth furnaces showed that the greatest use of oxygen was in combustion of the fuel for melting or refining the charge. The use of oxygen shortens steelmaking time and reduces cost. In oxygen-converter steelmaking research, extensive trials were made at the Vale and the Daubessy laboratories using the flame-brightness method for determining the end point of the refining period. In ingot practice,

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[61] Department of Mines and Technical Surveys, Uranium in Steel: Ottawa, Canada, January 30, 1961, 9 pp.

experiments were carried out, comparing the yield obtained by chemical capping to that obtained with rimmed steel ingots.

At the Sheffield laboratories, valuable operating data were developed on the design of continuous casting equipment. Of particular interest was a pneumatic spring-mounted mold system that was designed to give good surface quality and high casting speeds. In this system the mold is mounted on springs to take care of friction as the metal passes through the vertically mounted mold. As the friction increases, the mold is pulled downward against the springs, and then at a predetermined moment the pneumatic cylinders are automatically actuated to give the mold a downward impulse. At the bottom of the stroke, an upward impulse aids the springs in returning the mold to its topmost position.

In research conducted at the Centre National de Recherchesmetallurgiques, Charleroi, Belgium, in cooperation with BISRA, 4-inch-square ingots of killed steel were cast at speeds of 9 feet per minute. Also considerable progress was made in continuous casting of rimmed steel in 8-inch squares in the BISRA spring-mounted metal. Research was conducted on improving forging equipment, automatic forging, cold-rolling, tinning, plastic-coated steel, and lacquered strip.

An optical instrument was developed for continuously gaging bar in four planes on an experimental rolling mill.

Considerable progress was made in manufacturing high-speed steel rounds and shapes by extrusion of cast material.

At the Sheffield laboratories, a pilot plant fluidized bed was used for rapidly and uniformly cooling 10-cwt. ingot molds in 46 minutes, compared with 380 minutes by normal, natural cooling methods. Provisional patents were filed for a double fluidized-bed recuperator in which strip is fed through the fluidized-bed system without loss of the granular material.

In experiments on the vacuum-degassing of steel with pressures about 0.01 mm. of mercury, the Roots-type blower was successfully used in an experimental plant. However steam ejectors, which are used in the United States, were believed to be the best solution for larger plants.

In electrical sheets the effect of impurities on the magnetic properties were studied. It was determined that sulfur had a marked effect on magnetic properties: both hysteresis loss and coercive force vary linearly with sulfur content. Manganese in quantities up to 0.2 percent was found to modify the effect of sulfur by altering the form and dispersion of the precipitated sulphide phase. Automatic magnetic testing equipment, which enables rapid measurements of the fundamental properties and thus facilitates studies on electrical sheet, was installed.

Alloy steel studies included internal friction techniques to study grain boundary properties. A report on these studies states: "The spectrum of relaxation peaks forming the damping/temperature curve contains a peak which is associated with the movement of grain boundaries and it has been shown that there are differences in the damping curves of temper-embrittled and non-embrittlement of high purity iron-nitrogen alloys."

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The research association has been granted some 37 patents in the United Kingdom with 111 applications pending. Income from royalties on patents in 1959 was $44,960.[62]

Research, financed by the High Authority of the European Coal and Steel Community, in progress in 1960 was as follows: Prospecting for iron and manganese ores in certain African countries, utilization of liquid and gaseous hydrocarbons in blast furnaces, direct reduction of iron ore, study of flames, improvement and utilization of blast-furnce gas, and dedusting of reddish-brown fumes produced by converting molten pig iron by means of oxygen.

Research on using liquid fuel in the blast furnace resulted in a 20-percent decline in coke consumption and a 15-percent increase in productivity. Each 80 to 90 kilograms of fuel used per ton of pig iron required a 100° C. increase in hot-blast temperature. The use of oxygen (24 percent of the blast) resulted in a 30-percent decrease in coke consumption and up to a 55-percent increase in output. Improvements were also realized by using residual gas, containing 60 percent methane and coke oven gas. Studies on the combustion of unpurified blast-furnace gas were begun, and work on flames continued satisfactorily. Considerable progress was made in producing a high-quality direct iron product in a rotary kiln for steel-furnace use. Ring formations in the kiln and desulfurization of the iron product were overcome. Dedusting of reddish-brown fumes was technically feasible, but the cost of recovering the vapor and heat to make the process economical was not realized in the apparatus used.[63]

[62] Iron and Coal Trades Review, vol. 181, No. 4812, Oct. 7, 1960, pp. 787–791.
[63] European Coal and Steel Community, Ninth General Report on the Activities of the Community: Jan. 31, 1961, pp. 240–246.

Iron and Steel Scrap

By James E. Larkin[1] and Selma D. Harris[2]

LOW PRICES and decreased domestic demand were of great concern to suppliers of purchased iron and steel scrap. However, the encouraging factors for these suppliers were the record exports, the high consumption rate during the first quarter, and an increase in the scrap-to-pig-iron ratio during the last 5 months.

The increased demand for domestic scrap that began in December 1959 continued through the first 3 months of 1960 when steel mills operated at a record high level. Demand for scrap then lessened and dropped in July to a monthly low for the year of 4.1 million short tons, the lowest rate, excluding strike months, since July 1958.

The combined use of scrap and pig iron in steelmaking furnaces was 6 percent higher than in 1959. Scrap and pig iron used in these furnaces rose 2 percent and 9 percent, respectively. The use of scrap in steelmaking furnaces comprised 46 percent of the combined total of scrap and pig iron used, 2 percent lower than the previous year. However, the daily consumption rate for scrap increased from 136,000 short tons in 1959 to 139,000 tons in 1960. In line with the record national steel production in January, steelmaking furnaces consumed a record high quantity of scrap—80 percent of the scrap used for all purposes.

TABLE 1.—Salient ferrous scrap and pig iron statistics in the United States

(Short tons)

	1959	1960
Stocks Dec. 31:		
Scrap at consumer plants	9,993,488	9,251,827
Pig iron at consumer and supplier plants	2,979,257	3,770,431
Total	12,972,745	13,022,258
Consumption:		
Scrap	66,061,516	66,468,708
Pig iron	61,773,191	66,626,336
Imports for consumption, scrap, (including tinplate scrap)	309,448	179,457
Exports, iron and steel scrap	[1] 4,939,043	7,189,614
Price: Scrap, No. 1 Heavy-Melting, Pittsburgh, average per long ton	[2] $43.40	$32.92
Value: Scrap, all grades, for export [3]	[1] $33.96	$37.68

[1] Revised figure.
[2] Iron Age.
[3] As computed from export data obtained from the Bureau of the Census.

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LEGISLATION AND GOVERNMENT PROGRAMS

On February 1, 1960, the Bureau of Foreign Commerce, U.S. Department of Commerce, added alloy steel scrap containing 5 percent or more nickel and alloy steel scrap containing 1 percent or more tungsten to the list of commodities requiring licenses for export to friendly foreign nations. This action was taken to bring these grades of scrap under the same licensing procedures as those applying to all other grades of iron and steel scrap.

Legislation continuing suspension of import duties on metal scrap to June 30, 1961, was enacted by Congress on July 7, 1960, and made retroactive to midnight June 30, 1960, the expiration date of the previous law.

AVAILABLE SUPPLY

During 1960, consumers of ferrous scrap had a net supply made available at their plants of 65.7 million short tons, a slight decrease from the supply made available during the previous year. Home scrap produced increased 6 percent, but scrap received from dealers and other sources decreased 9 percent. These data exclude scrap on hand at dealers' yards.

TABLE 2.—Ferrous scrap supply[1] available for consumption in 1960, by districts and States

(Short tons)

District and State	Home production	Receipts from dealers and all others	Total new supply	Shipments[2]	New supply available for consumption
New England:					
Connecticut	74,529	63,156	137,685	7,125	130,560
Maine and New Hampshire	8,375	10,338	18,713	746	17,967
Massachusetts	122,617	137,459	260,076	24,043	236,033
Rhode Island	47,190	60,781	107,971	2,939	105,032
Vermont	9,768	10,389	20,157	140	20,017
Total: 1960	262,479	282,123	544,602	34,993	509,609
1959	257,063	292,711	549,774	35,052	514,722
Middle Atlantic:					
New Jersey	181,002	449,141	630,143	29,047	601,096
New York	1,788,096	1,258,487	3,046,583	74,020	2,972,563
Pennsylvania	9,168,744	4,886,070	14,054,814	635,630	13,419,184
Total: 1960	11,137,842	6,593,698	17,731,540	738,697	16,992,843
1959	10,479,972	7,533,269	18,013,241	686,707	17,326,534
East North Central:					
Illinois	3,483,187	3,248,562	6,731,749	187,271	6,544,478
Indiana	5,101,258	2,389,815	7,491,073	148,723	7,342,350
Michigan	3,176,695	2,657,157	5,833,852	35,167	5,798,685
Ohio	7,059,106	4,616,928	11,676,034	382,899	11,293,135
Wisconsin	474,493	356,806	831,299	133,689	697,610
Total: 1960	19,294,739	13,269,268	32,564,007	887,749	31,676,258
1959	18,438,772	14,277,624	32,716,396	870,410	31,845,986
West North Central:					
Iowa	153,707	195,269	348,976	3,367	345,609
Kansas and Nebraska	46,265	98,097	144,362	5,022	139,340
Minnesota	237,973	233,131	471,104	2,065	469,039
Missouri	180,972	641,905	822,877	6,729	816,148
Total: 1960	618,917	1,168,402	1,787,319	17,183	1,770,136
1959	606,632	1,348,878	1,955,510	3,865	1,951,645

TABLE 2.—Ferrous scrap supply[1] available for consumption in 1960, by districts and States—Continued

(Short tons)

District and State	Home production	Receipts from dealers and all others	Total new supply	Shipments[2]	New supply available for consumption
South Atlantic:					
Delaware and Maryland	2,445,665	841,069	3,286,734	88,435	3,198,299
Florida and Georgia	68,479	242,374	310,853	921	309,932
North Carolina	26,842	42,531	69,373	8,396	60,977
South Carolina	18,021	20,978	38,999	18	38,981
Virginia and West Virginia	758,294	815,590	1,573,884	31,952	1,541,932
Total: 1960	3,317,301	1,962,542	5,279,843	129,722	5,150,121
1959	3,002,909	1,859,808	4,862,717	95,528	4,767,189
East South Central:					
Alabama	1,338,298	1,255,444	2,593,742	205,602	2,388,140
Kentucky, Mississippi, and Tennessee	566,116	910,829	1,476,945	53,897	1,423,048
Total: 1960	1,904,414	2,166,273	4,070,687	259,499	3,811,188
1959	1,833,448	2,169,433	4,002,881	254,615	3,748,266
West South Central:					
Arkansas, Louisiana, and Oklahoma	39,425	139,447	178,872	1,486	177,386
Texas	640,194	927,491	1,567,685	56,425	1,511,260
Total: 1960	679,619	1,066,938	1,746,557	57,911	1,688,646
1959	735,900	1,172,873	1,908,773	38,655	1,870,118
Rocky Mountain:					
Arizona and Nevada	16,187	65,318	81,505	5,063	76,442
Colorado, Idaho, Montana, and Utah	1,086,176	491,445	1,577,621	6,526	1,571,095
Total: 1960	1,102,363	556,763	1,659,126	11,589	1,647,537
1959	912,884	712,008	1,624,892	9,746	1,615,146
Pacific Coast:					
California	1,194,693	1,043,717	2,238,410	227,136	2,011,274
Oregon	39,139	136,452	175,591	5,874	169,717
Washington	80,594	222,949	303,543	3,825	299,718
Total: 1960	1,314,426	1,403,118	2,717,544	236,835	2,480,709
1959	1,150,619	1,761,648	2,912,267	90,469	2,821,798
U.S. total: 1960	39,632,100	28,469,125	68,101,225	2,374,178	65,727,047
1959	37,418,199	31,128,252	68,546,451	2,085,047	66,461,404

[1] New supply available for consumption is a net figure computed by adding home production to receipts from dealers and all others and deducting consumers scrap shipped, transferred, or otherwise disposed of during the year. The plus or minus difference in stock levels at the beginning and end of the year are not taken into consideration.

[2] Includes scrap shipped, transferred, or otherwise disposed of during the year.

TABLE 3.—Consumption of ferrous scrap and pig iron in the United States in 1960, by type of consumer and type of furnace or equipment

(Short tons)

Type of furnace or equipment	Type of consumer		
	Manufacturers of steel ingots and castings [1]		
	Scrap	Pig iron	Total
Open-hearth	39,023,869	55,146,638	94,170,507
Basic oxygen converter	1,150,034	2,936,727	4,086,761
Bessemer	134,238	1,301,345	1,435,583
Electric [2]	8,274,790	319,482	8,594,272
Total steelmaking furnaces	48,582,931	59,704,192	108,287,123
Cupola	796,136	379,269	1,175,405
Air	36,642	13,655	50,297
Blast [3]	3,593,827		3,593,827
Direct castings		1,683,642	1,683,642
Miscellaneous	199,921		199,921
Total: 1960	53,209,457	61,780,758	114,990,215
1959	51,518,522	56,375,296	107,893,818
	Manufacturers of steel castings [4]		
Open-hearth	589,177	123,766	712,943
Bessemer	10,575	673	11,248
Electric	1,479,797	31,379	1,511,176
Total steelmaking furnaces	2,079,549	155,818	2,235,367
Cupola	418,681	22,428	441,109
Air	227,470	44,884	272,354
Total: 1960	2,725,700	223,130	2,948,830
1959	3,054,588	216,907	3,271,495
	Iron foundries and miscellaneous users		
Bessemer	2,170	513	2,683
Electric [2]	165,777	21,212	186,989
Total steelmaking furnaces	167,947	21,725	189,672
Cupola	8,830,213	3,420,330	12,250,543
Air	821,822	151,622	973,444
Direct castings		1,028,771	1,028,771
Ferroalloy	283,777		283,777
Miscellaneous	429,792		429,792
Total: 1960	10,533,551	4,622,448	15,155,999
1959	11,488,406	5,180,988	16,669,394
	Total		
Open-hearth	39,613,046	55,270,404	94,883,450
Basic oxygen converter	1,150,034	2,936,727	4,086,761
Bessemer	146,983	1,302,531	1,449,514
Electric [2]	9,920,364	372,073	10,292,437
Total steelmaking furnaces	50,830,427	59,881,735	110,712,162
Cupola	10,045,030	3,822,027	13,867,057
Air	1,085,934	210,161	1,296,095
Blast [3]	3,593,827		3,593,827
Direct castings		2,712,413	2,712,413
Ferroalloy	283,777		283,777
Miscellaneous	629,713		629,713
Total: 1960	66,468,708	66,626,336	133,095,044
1959	66,061,516	61,773,191	127,834,707

[1] Includes only those castings made by companies producing steel ingots.
[2] Includes small quantities of scrap and pig iron consumed in crucible furnaces.
[3] Includes consumption in all blast furnaces producing pig iron.
[4] Excludes companies that produce both steel ingots and steel castings.

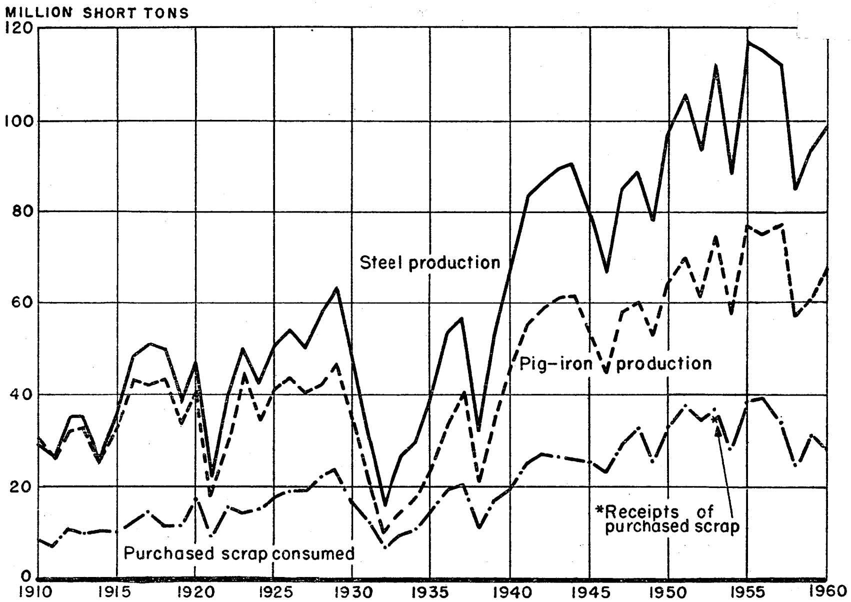

FIGURE 1.—Consumption of purchased scrap in the United States, 1910–52, and output of pig iron and steel, 1910–60. Figures on consumption of purchased scrap for 1910–32, are from *State of Minnesota* v. *Oliver Iron Mining Co., et al.*, Exhibits, vol. 5, 1935, p. 328; those for 1933–34 are estimated by authors; and those for 1935–52 are based on Bureau of Mines records. Data for 1953–60 represent receipts of purchased scrap by consumers, based on Bureau of Mines records. Data on steel output were supplied by the American Iron and Steel Institute.

TABLE 4.—Proportion of ferrous scrap and pig iron used in furnaces in the United States

(Percent)

Type of furnace	1959		1960	
	Scrap	Pig iron	Scrap	Pig iron
Open-hearth	43.0	57.0	41.7	58.3
Basic oxygen converter	26.9	73.1	28.1	71.9
Bessemer	12.1	87.9	10.1	89.9
Electric [1]	96.4	3.6	96.4	3.6
Cupola	70.9	29.1	72.4	27.6
Air	83.5	16.5	83.8	16.2

[1] Includes crucible furnaces.

CONSUMPTION BY DISTRICTS AND STATES

The use of domestic scrap for all purposes increased in five of the nine geographical areas. The greatest increase in both tonnage and percentage was in the South Atlantic district. As in previous years, the largest consuming districts for scrap were East North Central, Middle Atlantic, and South Atlantic. The States consuming the largest quantities of scrap and the percentages consumed were: Pennsylvania, 20 (21 in 1959); Ohio, 17 (18 in 1959); Indiana, 11 (10 in 1959); and Illinois, 10 (10 in 1959).

TABLE 5.—Consumption of ferrous scrap and pig iron in the United States in 1960, by districts and States

(Short tons)

District and State	Scrap	Pig iron	Total
New England:			
Connecticut	138,517	33,756	172,273
Maine and New Hampshire	18,010	4,929	22,939
Massachusetts	229,490	73,313	302,803
Rhode Island	107,797	48,380	156,177
Vermont	20,904	7,345	28,249
Total: 1960	514,718	167,723	682,441
1959	512,984	169,477	682,461
Middle Atlantic:			
New Jersey	618,482	147,537	766,019
New York	3,125,681	3,382,392	6,508,073
Pennsylvania	13,501,711	16,295,129	29,796,840
Total: 1960	17,245,874	19,825,058	37,070,932
1959	17,403,086	18,626,954	36,030,040
East North Central:			
Illinois	6,413,376	5,244,885	11,658,261
Indiana	7,535,970	8,883,812	16,419,782
Michigan	5,806,785	5,034,654	10,841,439
Ohio	11,236,126	11,503,557	22,739,683
Wisconsin	726,085	195,801	921,886
Total: 1960	31,718,342	30,862,709	62,581,051
1959	31,650,178	28,407,222	60,057,400
West North Central:			
Iowa	356,293	69,287	425,580
Kansas and Nebraska	139,317	5,332	144,649
Minnesota	513,027	431,151	944,178
Missouri	827,811	44,649	872,460
Total: 1960	1,836,448	550,419	2,386,867
1959	1,901,398	605,301	2,506,699
South Atlantic:			
Delaware and Maryland	3,216,933	4,392,072	7,609,005
Florida and Georgia	325,164	13,048	338,212
North Carolina	61,746	26,417	88,163
South Carolina	40,208	17,986	58,194
Virginia and West Virginia	1,655,479	2,129,461	3,784,940
Total: 1960	5,299,530	6,578,984	11,878,514
1959	4,752,866	6,060,159	10,813,025
East South Central:			
Alabama	2,404,593	3,144,319	5,548,912
Kentucky, Mississippi, and Tennessee	1,457,757	905,603	2,363,360
Total: 1960	3,862,350	4,049,922	7,912,272
1959	3,647,039	3,897,197	7,544,236
West South Central:			
Arkansas, Louisiana, and Oklahoma	164,155	8,183	172,338
Texas	1,577,904	723,894	2,301,798
Total: 1960	1,742,059	732,077	2,474,136
1959	1,907,653	775,332	2,682,985
Rocky Mountain:			
Arizona and Nevada	78,638	88	78,726
Colorado, Idaho, Montana, and Utah	1,590,738	2,202,759	3,793,497
Total: 1960	1,669,376	2,202,847	3,872,223
1959	1,498,715	1,847,441	3,346,156
Pacific Coast:			
California	2,053,641	1,649,991	3,703,632
Oregon	196,986	3,327	200,313
Washington	329,384	3,279	332,663
Total: 1960	2,580,011	1,656,597	4,236,608
1959	2,787,597	1,384,108	4,171,705
U.S. total: 1960	66,468,708	66,626,336	133,095,044
1959	66,061,516	61,773,191	127,834,707

TABLE 6.—Consumption of ferrous scrap and pig iron by districts and States, by type of manufacturers in 1960

(Short tons)

District and State	Steel ingots and castings [1]		Steel castings [2]		Iron foundries and miscellaneous users	
	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron
New England:						
Connecticut	38,093		5,488	467	94,936	33,289
Maine and New Hampshire			2,930	84	15,080	4,845
Massachusetts			17,452	1,185	212,038	72,128
Rhode Island	57,427	25,849			50,370	22,531
Vermont					20,904	7,345
Total: 1960	95,520	25,849	25,870	1,736	393,328	140,138
1959	108,630	28,769	24,580	2,981	379,774	137,727
Middle Atlantic:						
New Jersey	160,050	30,602	52,530	2,108	405,902	114,827
New York	2,481,323	3,210,968	115,861	13,484	528,497	157,940
Pennsylvania	12,404,161	15,542,408	424,619	77,373	672,931	675,348
Total: 1960	15,045,534	18,783,978	593,010	92,965	1,607,330	948,115
1959	15,136,303	17,542,301	596,574	80,026	1,670,209	1,004,627
East North Central:						
Illinois	5,209,158	4,772,576	286,172	23,059	918,046	449,250
Indiana	6,803,993	8,629,405	141,141	14,341	590,836	240,066
Michigan	3,475,076	4,373,155	166,801	4,022	2,164,908	657,477
Ohio	9,586,889	10,812,556	440,280	51,653	1,208,957	639,348
Wisconsin			203,972	8,882	522,113	186,919
Total: 1960	25,075,116	28,587,692	1,238,366	101,957	5,404,860	2,173,060
1959	24,216,670	25,936,396	1,493,450	102,118	5,940,058	2,368,708
West North Central:						
Iowa			31,022	433	325,271	68,854
Kansas and Nebraska			97,975	326	41,342	5,006
Minnesota	337,597	382,811	31,948	208	143,482	48,132
Missouri	624,219	8,011	80,287	7,738	123,305	28,900
Total: 1960	961,816	390,822	241,232	8,705	633,400	150,892
1959	825,631	409,020	305,976	15,911	769,791	180,370
South Atlantic:						
Delaware and Maryland	3,103,080	4,364,955	29,534	209	84,319	26,908
Florida and Georgia	277,965		11,954	107	35,245	12,941
North Carolina					61,746	26,417
South Carolina					40,208	17,986
Virginia and West Virginia	1,328,412	2,026,294	68,774	8,489	258,293	94,678
Total: 1960	4,709,457	6,391,249	110,262	8,805	479,811	178,930
1959	4,121,698	5,845,404	105,343	7,773	525,825	206,982
East South Central:						
Alabama	1,613,582	2,467,567	67,798	187	723,213	676,565
Kentucky, Mississippi, and Tennessee	1,015,471	732,026	37,995	1,910	404,291	171,667
Total: 1960	2,629,053	3,199,593	105,793	2,097	1,127,504	848,232
1959	2,367,816	2,805,532	85,173	1,401	1,194,050	1,090,264
West South Central:						
Arkansas, Louisiana, and Oklahoma	79,916	1,887	41,991	867	42,248	5,429
Texas	1,212,687	686,044	89,068	446	276,149	37,404
Total: 1960	1,292,603	687,931	131,059	1,313	318,397	42,833
1959	1,359,276	743,301	155,744	1,877	392,633	30,154
Rocky Mountain:						
Arizona and Nevada			48,384	88	30,254	
Colorado, Idaho, Montana, and Utah	1,404,313	2,173,410	28,705	737	157,720	28,612
Total: 1960	1,404,313	2,173,410	77,089	825	187,974	28,612
1959	1,215,618	1,794,838	76,096	655	207,001	51,948

See footnotes at end of table.

TABLE 6.—Consumption of ferrous scrap and pig iron by districts and States, by type of manufacturers in 1960—Continued

(Short tons)

District and State	Steel ingots and castings [1]		Steel castings [2]		Iron foundries and miscellaneous users	
	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron
Pacific Coast:						
California	1,587,603	1,540,234	132,971	2,970	333,067	106,787
Oregon	137,589		34,823	152	24,574	3,175
Washington	270,853		35,225	1,605	23,306	1,674
Total: 1960	1,996,045	1,540,234	203,019	4,727	380,947	111,636
1959	2,166,880	1,269,735	211,652	4,165	409,065	110,208
U.S. total: 1960	53,209,457	61,780,758	2,725,700	223,130	10,533,551	4,622,448
1959	51,518,522	56,375,296	3,054,588	216,907	11,488,406	5,180,988

[1] Includes only those castings made by companies producing steel ingots.
[2] Excludes companies that produce both steel ingots and steel castings.

TABLE 7.—Consumption of ferrous scrap and pig iron in open-hearth furnaces in the United States in 1960, by districts and States

(Short tons)

District and State	Scrap	Pig iron	Total
New England and Middle Atlantic:			
New Jersey and Rhode Island	215,949	56,451	272,400
New York	2,225,582	3,216,666	5,442,248
Pennsylvania	9,543,920	13,807,676	23,351,596
Total: 1960	11,985,451	17,080,793	29,066,244
1959	12,256,403	16,188,265	28,444,668
East North Central:			
Illinois	3,219,749	3,994,647	7,214,396
Indiana	6,652,565	8,631,565	15,284,130
Michigan and Wisconsin	2,131,941	2,987,783	5,119,724
Ohio	6,454,770	9,557,866	16,012,636
Total: 1960	18,459,025	25,171,861	43,630,886
1959	17,972,869	23,130,410	41,103,279
West North Central:			
Minnesota and Missouri	586,580	397,608	984,188
Total: 1960	586,580	397,608	984,188
1959	573,395	422,680	996,075
South Atlantic:			
Delaware, Maryland, and West Virginia	4,003,151	6,378,567	10,381,718
Total: 1960	4,003,151	6,378,567	10,381,718
1959	3,432,624	5,833,605	9,266,229
East and West South Central:			
Alabama, Kentucky, Tennessee, and Texas	2,269,309	3,510,887	5,780,196
Total: 1960	2,269,309	3,510,887	5,780,196
1959	2,120,279	3,231,750	5,352,029
Rocky Mountain and Pacific Coast:			
California, Colorado, and Utah	2,309,530	2,730,688	5,040,218
Total: 1960	2,309,530	2,730,688	5,040,218
1959	2,301,696	2,443,762	4,745,458
U.S. total: 1960	39,613,016	55,270,404	94,883,450
1959	38,657,266	51,250,472	89,907,738

TABLE 8.—Consumption of ferrous scrap and pig iron in Bessemer converters in the United States in 1960, by districts and States

(Short tons)

District and State	Scrap	Pig iron	Total
New England and Middle Atlantic:			
Connecticut and Pennsylvania	59,584	330,836	390,420
Total: 1960	59,584	330,836	390,420
1959	86,987	312,227	399,214
East North Central:			
Illinois and Ohio	81,509	971,580	1,053,089
Total: 1960	81,509	971,580	1,053,089
1959	110,638	1,170,528	1,281,166
South Atlantic and West South Central:			
Delaware and Louisiana	5,521	86	5,607
Total: 1960	5,521	86	5,607
1959	5,242	117	5,359
Rocky Mountain and Pacific Coast:			
Colorado and Washington	369	29	398
Total: 1960	369	29	398
1959	337	13	350
U.S. total: 1960	146,983	1,302,531	1,449,514
1959	203,204	1,482,885	1,686,089

TABLE 9.—Consumption of ferrous scrap and pig iron in electric[1] steel furnaces in the United States in 1960, by districts and States

(Short tons)

District and State	Scrap	Pig iron	Total
New England:			
Connecticut and New Hampshire	51,773	1,045	52,818
Massachusetts	22,904	917	23,821
Total: 1960	74,677	1,962	76,639
1959	76,956	1,950	78,906
Middle Atlantic:			
New Jersey	26,023	1,092	27,115
New York	159,852	4,644	164,496
Pennsylvania	1,723,268	24,729	1,747,997
Total: 1960	1,909,143	30,465	1,939,608
1959	1,965,662	32,829	1,998,491
East North Central:			
Illinois	1,563,696	168,748	1,732,444
Indiana	97,873	2,307	100,180
Michigan	569,339	7,654	576,993
Ohio	1,975,075	29,450	2,004,525
Wisconsin	133,032	4,067	137,099
Total: 1960	4,339,015	212,226	4,551,241
1959	4,788,854	260,687	5,049,541
West North Central:			
Iowa, Kansas, and Nebraska	132,637	956	133,593
Minnesota	18,089	208	18,297
Missouri	428,361	597	428,958
Total: 1960	579,087	1,761	580,848
1959	504,362	2,071	506,433
South Atlantic:			
Delaware and Maryland	95,946	1,071	97,017
Florida, Georgia, and North Carolina	290,110	262	290,372
Virginia and West Virginia	144,960	121	145,081
Total: 1960	531,016	1,454	532,470
1959	531,271	1,627	532,898

See footnote at end of table.

TABLE 9.—Consumption of ferrous scrap and pig iron in electric[1] steel furnaces in the United States in 1960, by districts and States—Continued

(Short tons)

District and State	Scrap	Pig iron	Total
East South Central:			
Alabama	517,510	113,027	630,537
Kentucky, Mississippi, and Tennessee	403,603	3,521	407,124
Total: 1960	921,113	116,548	1,037,661
1959	835,799	82,862	918,661
West South Central:			
Arkansas, Louisiana, and Oklahoma	110,089	867	110,956
Texas	449,069	3,060	452,129
Total: 1960	559,158	3,927	563,085
1959	559,982	4,880	564,862
Rocky Mountain:			
Arizona, Colorado, Nevada, and Utah	66,691	399	67,090
Total: 1960	66,691	399	67,090
1959	69,036	403	69,439
Pacific Coast:			
California	465,791	2,141	467,932
Oregon	172,412	151	172,563
Washington	302,261	1,039	303,300
Total: 1960	940,464	3,331	943,795
1959	1,020,684	4,001	1,024,685
U.S. total: 1960	9,920,364	372,073	10,292,437
1959	10,352,606	391,310	10,743,916

[1] Includes small quantities of scrap and pig iron consumed in crucible furnaces.

TABLE 10.—Consumption of ferrous scrap and pig iron in cupola furnaces in the United States in 1960, by districts and States

(Short tons)

District and State	Scrap	Pig iron	Total
New England:			
Connecticut	55,711	27,605	83,316
Maine and New Hampshire	11,554	2,821	14,375
Massachusetts	184,369	68,631	253,000
Rhode Island	42,267	21,240	63,507
Vermont	20,904	7,345	28,249
Total: 1960	314,805	127,642	442,447
1959	309,316	127,075	436,391
Middle Atlantic:			
New Jersey	339,354	115,237	454,591
New York	426,848	151,102	577,950
Pennsylvania	546,560	208,896	755,456
Total: 1960	1,312,762	475,235	1,787,997
1959	1,280,348	507,079	1,787,427
East North Central:			
Illinois	783,383	191,316	974,699
Indiana	524,741	231,432	756,173
Michigan	2,419,807	738,574	3,158,381
Ohio	1,318,550	466,154	1,784,704
Wisconsin	458,656	162,226	620,882
Total: 1960	5,505,137	1,789,702	7,294,839
1959	5,866,876	2,019,772	7,886,648
West North Central:			
Iowa	211,521	65,632	277,153
Kansas and Nebraska	41,341	5,007	46,348
Minnesota	152,280	45,292	197,572
Missouri	101,889	27,255	129,144
Total: 1960	507,031	143,186	650,217
1959	624,415	171,354	795,769

TABLE 10.—Consumption of ferrous scrap and pig iron in cupola furnaces in the United States in 1960, by districts and States—Continued

(Short tons)

District and State	Scrap	Pig iron	Total
South Atlantic:			
Maryland	96,348	40,387	136,735
Florida	7,771	2,663	10,434
Georgia	26,401	10,277	36,678
North Carolina	61,500	26,263	87,763
South Carolina	35,592	17,987	53,579
Virginia	250,586	39,459	290,045
West Virginia	13,709	53,548	67,257
Total: 1960	491,907	190,584	682,491
1959	537,673	213,803	751,476
East South Central:			
Alabama	645,757	678,476	1,324,233
Kentucky	116,227	34,569	150,796
Tennessee	278,603	138,494	417,097
Total: 1960	1,040,587	851,539	1,892,126
1959	1,115,631,	1,094,193	2,209,824
West South Central:			
Arkansas, Louisiana, and Oklahoma	49,514	7,316	56,830
Texas	289,719	70,807	360,526
Total: 1960	339,233	78,123	417,356
1959	413,278	93,129	506,407
Rocky Mountain:			
Colorado, Idaho, Montana, and Utah	162,584	53,671	216,255
Total: 1960	162,584	53,671	216,255
1959	177,811	75,968	253,779
Pacific Coast:			
California	327,778	106,942	434,720
Oregon	21,803	3,175	24,978
Washington	21,403	2,228	23,631
Total: 1960	370,984	112,345	483,329
1959	401,217	109,743	510,960
U.S. total: 1960	10,045,030	3,822,027	13,867,057
1959	10,726 565	4,412,116	15,138,681

TABLE 11.—Consumption of ferrous scrap and pig iron in air furnaces in the United States in 1960, by districts and States

(Short tons)

District and State	Scrap	Pig iron	Total
New England:			
Connecticut	33,100	5,095	38,195
Massachusetts, New Hampshire, and Rhode Island	22,368	7,079	29,447
Total: 1960	55,468	12,174	67,642
1959	48,780	10,928	59,708
Middle Atlantic:			
New Jersey and New York	25,749	10,044	35,793
Pennsylvania	153,956	47,307	201,263
Total: 1960	179.705	57,351	237,056
1959	175,688	58,102	233,790
East North Central:			
Illinois	154,196	15,315	169,511
Indiana	73,690	18,047	91,737
Michigan	131,167	4,489	135,656
Ohio	331,041	61,525	392,566
Wisconsin	85,837	22,641	108,478
Total: 1960	775,931	122,017	897,948
1950	961,141	158,815	1,119,956

TABLE 11.—Consumption of ferrous scrap and pig iron in air furnaces in the United States in 1960, by districts and States—Continued

(Short tons)

District and State	Scrap	Pig-iron	Total
West North Central:			
Iowa, Minnesota, and Missouri	10,810	7,666	18,476
Total: 1960	10,810	7,666	18,476
1959	13,331	9,013	22,344
South Atlantic:			
Delaware, North Carolina, and West Virginia	14,356	8,294	22,650
Total: 1960	14,356	8,294	22,650
1959	20,253	11,005	31,258
East and West South Central:			
Alabama and Texas	40,638	1,905	42,543
Total: 1960	40,638	1,905	42,543
1959	44,961	2,226	47,187
Pacific Coast:			
California	9,026	754	9,780
Total: 1960	9,026	754	9,780
1959	8,275	643	8,918
U.S. total: 1960	1,085,934	210,161	1,296,095
1959	1,272,429	250,732	1,523,161

TABLE 12.—Consumption of ferrous scrap in blast furnaces in the United States in 1960, by districts and States

(Short tons)

District and State	Scrap
Middle Atlantic:	
New York	193,198
Pennsylvania	1,124,042
Total: 1960	1,317,240
1959	1,181,903
East and West North Central:	
Illinois	351,181
Indiana	184,309
Michigan and Minnesota	171,950
Ohio	943,963
Total: 1960	1,651,403
1959	1,400,314
South Atlantic, East and West South Central:	
Alabama	154,897
Kentucky, Maryland, Tennessee, Texas, and West Virginia	381,544
Total: 1960	536,441
1959	530,326
Rocky Mountain:	
Colorado and Utah	88,743
Total: 1960	88,743
1959	76,043
U.S. total: 1960	3,593,827
1959	3,188,586

TABLE 13.—Consumption of ferrous scrap by ferroalloy producers in the United States in 1960, by districts

(Short tons)

District	Scrap
Middle Atlantic: 1960	35,348
1959	47,691
East North Central: 1960	52,464
1959	53,782
West North Central: 1960	107,287
1959	135,374
South Atlantic: 1960	15,348
1959	13,671

District	Scrap
East South Central: 1960	65,922
1959	59,148
Pacific Coast: 1960	7,408
1959	5,533
U.S. total: 1960	283,777
1959	315,199

TABLE 14.—Consumption of ferrous scrap in miscellaneous uses in the United States in 1960, by districts and States

(Short tons)

District and State	Scrap
New England and Middle Atlantic:	
Massachusetts and New York	71,976
New Jersey	93,512
Pennsylvania	70,097
Total: 1960	235,585
1959	296,656
East North Central:	
Illinois and Indiana	105,104
Michigan and Wisconsin	8,181
Ohio	79,586
Total: 1960	192,871
1959	241,781
West North Central:	
Minnesota and Missouri	39,946
Total: 1960	39,946
1959	43,801
South Atlantic:	
Georgia, Virginia, and West Virginia	8,489
Total: 1960	8,489
1959	20,746
East South Central and West South Central:	
Alabama and Texas	61,751
Total: 1960	61,751
1959	66,674
Rocky Mountain:	
Arizona, Colorado, Montana, and Utah	42,571
Total: 1960	42,571
1959	41,544
Pacific Coast:	
California and Washington	48,500
Total: 1960	48,500
1959	53,958
U.S. total: 1960	629,713
1959	765,160

TABLE 15.—Consumption of ferrous scrap, by grades, by districts and States, in 1960

(Short tons)

District and State	No. 1 Heavy-melting steel	No. 2 Heavy-melting steel	No. 1 and electric furnace bundles	No. 2 and all other bundles	Low phos-phorus scrap	Cast-iron scrap, other than borings	All others
New England:							
Connecticut	3,518	----------	1,669	395	30,377	35,198	67,360
Maine and New Hampshire	3,208	----------	----------	----------	256	11,325	3,221
Massachusetts	9,258	1,149	----------	----------	14,572	164,664	39,847
Rhode Island	3,601	32,540	2,938	----------	12,588	24,501	31,629
Vermont	3,988	430	----------	----------	----------	16,486	----------
Total: 1960	23,573	34,119	4,607	395	57,793	252,174	142,057
1959	21,253	35,019	5,241	451	65,963	251,740	133,317
Middle Atlantic:							
New Jersey	12,111	24,271	41,890	23,149	43,228	308,396	165,437
New York	1,235,286	38,261	121,059	278,555	109,456	413,304	929,760
Pennsylvania	5,237,750	639,143	1,123,644	563,006	720,785	1,298,503	3,918,880
Total: 1960	6,485,147	701,675	1,286,593	864,710	873,469	2,020,203	5,014,077
1959	6,514,657	736,395	1,457,505	862,463	972,159	2,109,709	4,750,198
East North Central:							
Illinois	1,733,066	980,550	506,000	617,662	358,118	776,770	1,441,210
Indiana	3,695,182	146,866	933,528	365,271	178,257	720,321	1,496,545
Michigan	917,949	3,333	768,856	390,729	501,384	1,368,131	1,856,403
Ohio	3,219,215	425,167	1,195,459	392,887	969,097	1,291,384	3,742,917
Wisconsin	47,145	14,732	848	25,912	182,555	260,292	194,601
Total: 1960	9,612,557	1,570,648	3,404,691	1,792,461	2,189,411	4,416,898	8,731,676
1959	9,330,223	1,528,463	3,055,450	1,809,591	2,477,899	4,649,333	8,799,219
West North Central:							
Iowa	20,391	13,281	----------	2,638	33,067	151,380	135,536
Kansas and Nebraska	2,376		----------	----------	53,410	37,430	46,101
Minnesota	135,024	60,308	4,270	35,110	13,039	138,647	126,629
Missouri	22,738	550,491	----------	9,537	20,623	154,392	70,030
Total: 1960	180,529	624,080	4,270	47,285	120,139	481,849	378,296
1959	185,166	576,531	752	46,804	142,438	561,939	387,768

TABLE 15.—Consumption of ferrous scrap, by grades, by districts and States, in 1960—Continued

(Short tons)

District and State	No. 1 Heavy-Melting steel	No. 2 Heavy-Melting steel	No. 1 and electric furnace bundles	No. 2 and all other bundles	Low phosphorus scrap	Cast-iron scrap, other than borings	All others
South Atlantic:							
Delaware and Maryland	1,586,650	87,662	223,968	210,494	29,762	268,943	809,454
Florida and Georgia	81,343	151,857	80	3,400	2,747	28,310	57,427
North Carolina	----------	----------	----------	----------	1,485	57,321	2,940
South Carolina	28	----------	----------	----------	----------	28,404	11,776
Virginia and West Virginia	87,449	97,539	99,088	367,768	82,666	226,856	694,113
Total: 1960	1,755,470	337,058	323,136	581,662	116,660	609,834	1,575,710
1959	1,492,937	341,802	275,963	352,834	107,108	640,820	1,541,402
East South Central:							
Alabama	772,229	127,753	128,865	237,624	85,475	629,207	423,440
Kentucky, Mississippi, and Tennessee	561,551	148,010	105,389	132,898	69,440	282,629	157,840
Total: 1960	1,333,780	275,763	234,254	370,522	154,915	911,836	581,280
1959	1,124,815	249,907	189,472	361,850	104,276	1,018,160	598,559
West South Central:							
Arkansas, Louisiana, and Oklahoma	----------	55,447	----------	19,658	37,536	40,205	11,309
Texas	62,939	861,053	15,672	60,173	68,068	333,523	176,476
Total: 1960	62,939	916,500	15,672	79,831	105,604	373,728	187,785
1959	76,022	898,766	5,929	153,418	132,292	445,729	195,497
Rocky Mountain:							
Arizona and Nevada	5,709	----------	----------	----------	----------	1,120	71,809
Colorado, Idaho, Montana, and Utah	892,454	71,903	29,189	69,737	3,875	195,258	328,322
Total: 1960	898,163	71,903	29,189	69,737	3,875	196,378	400,131
1959	769,983	39,861	5,417	35,059	3,031	277,827	367,537
Pacific Coast:							
California	914,094	140,142	140,291	130,142	58,871	375,657	294,444
Oregon	80,743	53,422	16,762	----------	3,264	16,429	26,366
Washington	143,500	52,610	2,391	47,248	17,922	25,265	40,448
Total: 1960	1,138,337	246,174	159,444	177,390	80,057	417,351	361,258
1959	1,159,721	309,836	181,088	217,216	80,485	455,057	384,194
U.S. total: 1960	21,490,495	4,777,920	5,461,856	3,983,993	3,701,923	9,680,251	17,372,270
1959	20,674,777	4,716,580	5,176,817	3,839,686	4,085,651	10,410,314	17,157,691

STOCKS

Consumer Stocks.—Total ferrous-scrap stocks held by consumers fluctuated during the first 7 months of 1960 and reached a yearly high of 9,700,000 short tons on July 31. However, beginning in August these stocks decreased continuously to a low of 9,252,000 tons on December 31. These stocks were 7 percent lower than at the beginning of the year but were equivalent to a 54-day supply at an average daily scrap-consumption rate of 182,000 short tons. Decreases occurred in all nine districts; the largest decrease—281,000 tons—was in the Middle Atlantic district. Stocks of pig iron held by consumers and suppliers on December 31, 1960, were 27 percent greater than those on hand December 31, 1959.

Supplier Stocks.—A combined total of 739 dealers, brokers, and automobile wreckers, which is only a small segment of this industry, reported to the Bureau of Mines that they had 1,526,000 short tons of ferrous scrap in their yards on December 31, 1960.

TABLE 16.—Consumer stocks of ferrous scrap and pig iron, Dec. 31, in the United States by districts and States

(Short tons)

District and State	1959		1960	
	Scrap	Pig iron	Scrap	Pig iron
New England:				
Connecticut	21,448	8,508	11,812	4,639
Maine and New Hampshire	1,443	358	1,432	456
Massachusetts	32,769	52,634	40,749	12,805
Rhode Island	9,192	3,172	9,895	6,673
Vermont	1,697	826	855	610
Total	66,549	65,498	64,743	25,183
Middle Atlantic:				
New Jersey	96,861	31,337	78,399	29,598
New York	725,741	314,495	564,589	509,681
Pennsylvania	2,000,858	478,193	1,899,850	801,657
Total	2,823,460	824,025	2,542,838	1,340,936
East North Central:				
Illinois	1,035,819	253,120	1,161,191	317,944
Indiana	1,125,334	165,515	940,510	128,604
Michigan	521,064	244,716	498,125	299,374
Ohio	1,409,411	405,694	1,467,753	620,145
Wisconsin	78,308	32,689	52,896	17,006
Total	4,169,936	1,101,734	4,120,475	1,383,073
West North Central:				
Iowa	36,866	28,037	25,358	36,681
Kansas and Nebraska	17,417	582	17,558	843
Minnesota	132,457	82,466	95,302	83,149
Missouri	251,476	21,332	238,587	14,289
Total	438,216	132,417	376,805	134,962
South Atlantic:				
Delaware and Maryland	258,138	147,827	239,923	118,131
Florida and Georgia	24,643	2,061	22,923	2,010
North Carolina	4,935	2,217	4,298	1,588
South Carolina	2,366	2,924	7,589	3,145
Virginia and West Virginia	260,929	65,867	146,414	46,608
Total	551,011	220,896	421,147	171,482
East South Central:				
Alabama	319,050	343,260	311,324	350,776
Kentucky, Mississippi, and Tennessee	225,344	82,752	188,700	93,048
Total	544,394	426,012	500,024	443,824
West South Central:				
Arkansas, Louisiana, and Oklahoma	23,112	1,986	31,704	1,648
Texas	332,987	28,225	286,259	78,254
Total	356,099	30,211	317,963	79,902
Rocky Mountain:				
Arizona and Nevada	17,385	157	14,538	92
Colorado, Idaho, Montana, and Utah	308,524	115,912	287,488	124,317
Total	325,909	116,069	302,026	124,409
Pacific Coast:				
California	539,577	60,576	474,648	64,611
Oregon	51,020	253	29,533	655
Washington	127,317	1,566	101,625	1,394
Total	717,914	62,395	605,806	66,660
U.S. total	9,993,488	2,979,257	9,251,827	3,770,431

TABLE 17.—Consumer stocks of ferrous scrap, by grades, by districts and States, Dec. 31, 1960

(Short tons)

District and State	No. 1 Heavy-Melting steel	No. 2 Heavy-Melting steel	No. 1 and electric-furnace bundles	No. 2 and all other bundles	Low phosphorus scrap	Cast iron scrap, other than borings	All others
New England:							
Connecticut	578	----------	260	22	1,378	2,887	6,687
Maine and New Hampshire	172	----------	----------	----------	19	978	263
Massachusetts	3,248	352	1	----------	7,039	12,022	18,087
Rhode Island	1,462	4,024	75	----------	32	1,851	2,451
Vermont	146	1	----------	----------	--------	708	----------
Total: 1960	5,606	4,377	336	22	8,468	18,446	27,488
1959	3,951	3,426	153	22	12,646	21,696	24,655
Middle Atlantic:							
New Jersey	2,321	2,681	10,991	1,924	7,008	38,107	15.367
New York	230,939	3,787	108,376	73,023	14.857	26,406	107,201
Pennsylvania	602,072	93,670	159,385	98,217	138,124	195.169	613,213
Total: 1960	835,332	100,138	278,752	173,164	159,989	259,682	735,781
1959	869,835	137,900	264,049	293,918	218,640	241,382	797,736
East North Central:							
Illinois	238,332	71,339	126,992	200,707	188,987	70.834	264,000
Indiana	406,085	26,720	199,103	21,847	36,541	106,261	143.953
Michigan	44,956	132	145,853	52,903	79,453	74,375	100,453
Ohio	465,504	57,126	222,895	62,127	141,102	111,137	407,862
Wisconsin	3,427	412	34	221	22,429	15,404	10,969
Total: 1960	1,158,304	155,729	694,877	337,805	468,512	378,011	927,237
1959	1,193,900	161,820	664,960	446,896	393,426	422,886	886,048
West North Central:							
Iowa	2,775	363	----------	386	2,630	8,355	10,849
Kansas and Nebraska	67	----------	----------	----------	4,108	9,903	3,480
Minnesota	10,768	19,184	22	9,972	1,876	18,442	35,038
Missouri	3,128	96,806	----------	1,429	1,650	80,997	54,577
Total: 1960	16,738	116.353	22	11,787	10,264	117,697	103,944
1959	38,052	134,838	141	27,612	14,104	113.510	109,959
South Atlantic:							
Delaware and Maryland	101,575	3,546	5,393	12,270	3,687	82,748	30,704
Florida and Georgia	13,483	5,046	745	753	53	1,425	1,418
North Carolina	457	----------	----------	----------	44	3,512	285
South Carolina	----------	----------	----------	----------	--------	1,157	6,432
Virginia and West Virginia	4,971	12,451	497	50,444	11,634	39,685	26,732
Total: 1960	120,486	21,043	6,635	63,467	15,418	128,527	65,571
1959	129,775	28,241	1,118	135,762	15,412	145.247	95,456
East South Central:							
Alabama	109,571	22,264	11,054	27,595	20,993	66,174	53,673
Kentucky, Mississippi, and Tennessee	69,200	10,816	23,975	27,254	689	17,286	39,480
Total: 1960	178,771	33,080	35,029	54,849	21,682	83,460	93,153
1959	202,451	66,425	33,086	59,288	16,815	71,389	94,940
West South Central:							
Arkansas, Louisiana, and Oklahoma	----------	23,473	----------	12	2,159	3,817	2,243
Texas	4,365	160,133	29,304	218	7,850	26,695	57,694
Total: 1960	4,365	183,606	29,304	230	10.009	30,512	59,937
1959	3,943	229,900	346	37,434	11,597	39,916	32,963
Rocky Mountain:							
Arizona and Nevada	880	----------	----------	----------	--------	209	13,449
Colorado, Idaho, Montana, and Utah	60,321	65,820	33,253	64,266	734	46,063	17,031
Total: 1960	61,201	65,820	33,253	64,266	734	46,272	30,480
1959	97,433	61,457	18,509	97,558	704	20,296	29,952

TABLE 17.—Consumer stocks of ferrous scrap, by grades, by districts and States, Dec. 31, 1960—Continued

(Short tons)

District and State	No. 1 Heavy-Melting steel	No. 2 Heavy-Melting steel	No. 1 and electric-furnace bundles	No. 2 and all other bundles	Low phosphorus scrap	Cast iron scrap, other than borings	All others
Pacific Coast:							
California	186.051	51,461	67,344	34,271	8,404	44,421	82,696
Oregon	16,991	2,874			324	877	8,467
Washington	54,252	27,090	243	854	1,653	4,557	12,976
Total: 1960	257,294	81,425	67,587	35,125	10,381	49,855	104,139
1959	251,963	137,182	66,716	68,381	13,995	71,252	108,425
U.S. total: 1960	2,638,097	761,571	1,145,795	740,715	705,457	1,112,462	2,147,730
1959	2,791,303	961,189	1,049,078	1,166,871	697,339	1,147,574	2,180,134

TABLE 18.—Consumer stocks, production, receipts, consumption, and shipments of ferrous scrap, by grades, in 1960

(Short tons)

Grades of scrap	Stocks Jan. 1	Scrap produced	Receipts from dealers and all others	Total consumption	Shipments	Stocks Dec. 31
No. 1 Heavy-Melting steel	2,791,303	16,503,035	4,591,994	21,490,495		2,638,097
No. 2 Heavy-Melting steel	961,189	1,671,736	2,904,688	4,777,920		761,571
No. 1 and electric furnace bundles	1,049,078	1,005,592	4,614,271	5,461,856	306,969	1,145,795
No. 2 and all other bundles	1,166,871	232,923	3,389,142	3,983,993		740,715
Low-phosphorus scrap	697,339	1,092,441	2,626,286	3,701,923		705,457
Cast-iron scrap, other than borings	1,147,574	5,984,972	4,077,070	9,680,251		1,112,462
All others	2,180,134	13,141,401	6,265,674	17,372,270	2,067,209	2,147,730
Total, all grades	9,993,488	39,632,100	28,469,125	66,468,708	2,374,178	9,251,827

TABLE 19.—Stocks of ferrous scrap and pig iron at major consuming industries plants, Dec. 31

(Short tons)

Year	Manufacturers of steel ingots and castings	Manufacturers of steel castings	Iron foundries and miscellaneous users	Total
	SCRAP STOCKS			
1960	7,874,518	450,187	927,122	9,251,827
1959	8,482,711	486,182	1,024,595	9,993,488
	PIG-IRON STOCKS			
1960	3,233,513	37,691	499,227	3,770,431
1959	2,279,815	44,997	654,445	2,979,257

TABLE 20.—Shipments of ferrous scrap by dealers, brokers, and automobile wreckers,[1] in 1960, by grades, by districts and States

(Short tons)

District and State	Shipments [2]							
	No. 1 Heavy-Melting steel	No. 2 Heavy-Melting steel	No. 1 and electric furnace bundles	No. 2 and all other bundles	Low-phosphorus scrap	Cast-iron scrap, other than borings	All others	Total all grades
New England:								
Connecticut	9,512	12,277	4,360	12,587	7,805	7,090	7,912	61,543
Maine	1,967	2,244		1,561		1,065	1,097	7,934
Massachusetts	15,730	29,533	1,453	27,018	6,901	19,890	62,580	163,105
New Hampshire	878	1,528	4	78		1,323	1,122	4,933
Rhode Island	9,110	17,191	3,632	25,663	6,913	20,859	10,458	93,826
Vermont	1,392	2,955	59	925	74	1,565	1,089	8,059
Total	38,589	65,728	9,508	67,832	21,693	51,792	84,258	339,400
Middle Atlantic:								
New Jersey	222,843	102,804	37,481	87,712	11,851	48,042	45,385	556,118
New York	132,405	90,664	4,943	154,023	4,993	80,944	86,417	554,389
Pennsylvania	255,983	77,088	85,275	132,272	51,382	66,429	236,833	905,262
Total	611,231	270,556	127,699	374,007	68,226	195,415	368,635	2,015,769
East North Central:								
Illinois	90,214	55,583	104,238	81,899	27,940	58,076	327,281	745,231
Indiana	6,688	5,490	19,200	27,198	7,452	10,083	53,805	129,916
Michigan	15,604	18,934	86,951	41,288	42,541	32,854	104,695	342,867
Ohio	46,266	64,537	28,236	44,330	40,154	51,299	553,346	828,168
Wisconsin	13,520	12,565	18,122	43,260	31,711	45,544	82,687	247,409
Total	172,292	157,109	256,747	237,975	149,798	197,856	1,121,814	2,293,591
West North Central:								
Iowa	1,790	10,082	2,894	1,052	1,364	7,551	19,352	44,085
Kansas	3,997	13,759	1,123	8,276	3,674	7,542	12,327	50,698
Minnesota	64,020	29,228	7,510	14,296	3,863	15,066	53,345	187,328
Missouri	36,464	192,881	5,881	16,908	19,254	37,597	44,306	353,291
Nebraska	1,477	7,984	540	4,141	2,375	7,715	3,213	27,445
North Dakota	587	2,945		642		3,453	1,897	9,524
South Dakota	492	2,436		113	156	2,368	2,946	8,511
Total	108,827	259,315	17,948	45,428	30,686	81,292	137,386	680,882
South Atlantic:								
Delaware	879	2,272		263		2,013	616	6,043
District of Columbia	1,836	6,583		8,229		5,323	176	22,147
Florida	15,803	20,228	300	13,091	575	7,763	5,073	62,833
Georgia	6,748	30,373	4,967	21,211	2,374	15,544	6,924	88,141
Maryland	313,935	40,469	48,373	50,740	2,252	26,581	55,440	537,790
North Carolina	17,778	12,064	2,807	17,788	4,785	15,244	5,285	75,751
South Carolina	4,724	9,953	225	5,825	193	6,483	18,224	45,627
Virginia	23,119	22,912		31,075	5,284	18,549	19,204	120,143
West Virginia	15,952	14,028	4,482	17,182	10,556	10,418	11,011	83,629
Total	400,774	158,882	61,154	165,404	26,019	107,918	121,953	1,042,104
East South Central:								
Alabama	11,772	18,664	21,870	13,122	29,228	60,310	35,615	190,581
Kentucky	4,387	8,517	177	13,667	269	31,522	3,115	61,654
Mississippi	1,226	5,026		394		1,714	1,767	10,127
Tennessee	24,003	24,537	23,308	108,629	22,457	28,696	56,539	288,169
Total	41,388	56,744	45,355	135,812	51,954	122,242	97,036	550,531
West South Central:								
Arkansas	2,526	9,288		4,577	2,430	5,657	4,750	29,228
Louisiana	126,016	88,378	2,626	61,793	1,042	17,358	3,917	301,130
Oklahoma	7,196	20,117	266	9,555	8,142	9,271	6,969	61,516
Texas	111,377	137,672	13,525	75,887	16,704	46,712	300,249	702,126
Total	247,115	255,455	16,417	151,812	28,318	78,998	315,885	1,094,000

See footnotes at end of table.

TABLE 20.—Shipments of ferrous scrap by dealers, brokers, and automobile wreckers,[1] in 1960, by grades, by districts and States—Continued

(Short tons)

District and State	Shipments[2]							
	No. 1 Heavy-Melting steel	No. 2 Heavy-Melting steel	No. 1 and electric furnace bundles	No. 2 and all other bundles	Low-phosphorus scrap	Cast-iron scrap, other than borings	All others	Total all grades
Rocky Mountain:								
Arizona, Nevada, and New Mexico	3,530	7,409		2,728	62	2,546	1,384	17,659
Colorado and Utah	8,712	17,666		33,301	223	8,685	9,494	78,081
Idaho, Montana, and Wyoming	7,504	5,041	835	1,135	605	4,457	26,850	46,427
Total	19,746	30,116	835	37,164	890	15,688	37,728	142,167
Pacific Coast:								
California	141,413	143,774	27,289	118,709	4,715	45,964	83,696	565,560
Alaska, Oregon, and Washington	81,579	64,553	262	43,003	1,907	16,379	33,094	240,777
Total	222,992	208,327	27,551	161,712	6,622	62,343	116,790	806,337
U.S. total	1,862,954	1,462,232	563,214	1,377,146	384,206	913,544	2,401,485	8,964,781

[1] Reported by a monthly average of 794 companies shipping approximately 25 percent of the purchased scrap received by domestic consumers and exported with an adjustment for imports.
[2] Includes shipments from yards and direct shipments by dealers and brokers from other than yard operations to domestic consumers and for export.

TABLE 21.—Stocks of ferrous scrap held by dealers, brokers, and automobile wreckers,[1] on Dec. 31, 1960, by grades, by districts and States

(Short tons)

District and State	No. 1 Heavy-Melting steel	No. 2 Heavy-Melting steel	No. 1 and electric furnace bundles	No. 2 and all other bundles	Low phosphorus scrap	Cast-iron scrap, other than borings	All others	Total all grades
New England:								
Connecticut	404	647	203	432	757	1,107	8,090	11,640
Maine	159	146		146		216	706	1,373
Massachusetts	2,194	1,175	7	5,014	268	784	31,175	40,617
New Hampshire	86	127		45		109	750	1,117
Rhode Island	56	218	17	2,791	7	128	5,751	8,968
Vermont	199	227	36	884		656	216	2,218
Total	3,098	2,540	263	9,312	1,032	3,000	46,688	65,933
Middle Atlantic:								
New Jersey	17,804	5,722	4,816	12,897	42	9,097	19,529	69,907
New York	29,885	16,367	2,106	20,919	2,397	12,162	14,012	97,848
Pennsylvania	34,736	11,334	10,114	18,260	7,531	5,739	126,889	214,603
Total	82,425	33,423	17,036	52,076	9,970	26,998	160,430	382,358
East North Central:								
Illinois	16,321	2,439	20,804	30,315	1,286	3,779	58,962	133,906
Indiana	510	132	112	1,271	200	427	12,340	14,992
Michigan	15,938	3,792	21,775	17,184	10,190	4,034	33,863	106,776
Ohio	16,941	21,466	385	2,694	2,268	6,571	123,052	173,377
Wisconsin	847	3,243	813	1,578	1,849	3,711	61,422	73,463
Total	50,557	31,072	43,889	53,042	15,793	18,522	289,639	502,514

See footnote at end of table.

TABLE 21.—Stocks of ferrous scrap held by dealers, brokers, and automobile wreckers,[1] on Dec. 31, 1960, by grades, by districts and States—Continued

(Short tons)

District and State	No. 1 Heavy-Melting steel	No. 2 Heavy-Melting steel	No. 1 and electric furnace bundles	No. 2 and all other bundles	Low phosphorus scrap	Cast-iron scrap, other than borings	All others	Total all grades
West North Central:								
Iowa	523	1,835	------	926	16	1,080	6,798	11,178
Kansas	1,189	2,267	------	764	528	598	4,918	10,264
Minnesota	5,078	6,228	8,277	3,125	174	26,749	41,858	91,489
Missouri	1,754	2,353	17	3,940	715	1,667	7,814	18,260
Nebraska	459	2,286	------	914	11	1,093	4,503	9,266
North Dakota	------	242	------	------	------	161	4,729	5,132
South Dakota	196	111	------	964	------	62	7,354	8,687
Total	9,199	15,322	8,294	10.633	1,444	31,410	77,974	154,276
South Atlantic:								
Delaware	7	371	------	13	------	174	67	632
District of Columbia	------	------	------	------	------	------	------	------
Florida	997	3,959	467	836	455	1,588	12,604	20,906
Georgia	1,067	2,300	------	1,142	------	692	3,283	8,484
Maryland	1,821	1,282	------	383	605	225	23,834	28,150
North Carolina	607	1,028	299	797	------	744	8,282	11,757
South Carolina	242	196	------	852	------	178	10,976	12,444
Virginia	1,620	958	------	17,612	375	967	10,402	31,934
West Virginia	1,794	460	------	426	1,344	228	4,241	8,493
Total	8,155	10,554	766	22,061	2,779	4,796	73,689	122,800
East South Central:								
Alabama	67	67	280	------	213	166	22,473	23,266
Kentucky	993	2,022	736	1,505	------	260	3,580	9,096
Mississippi	132	1,076	------	2,016	------	286	390	3,900
Tennessee	1,012	1,339	297	781	498	552	8,635	13,114
Total	2,204	4,504	1,313	4,302	711	1,264	35,078	49,376
West South Central:								
Arkansas	4,378	6,092	------	1,400	112	1,219	3,375	16,576
Louisiana	592	3,474	542	1,285	56	567	6,113	12,629
Oklahoma	524	486	------	858	216	1,016	9,741	12,841
Texas	6,503	5,076	176	10,125	1,516	5.390	40,008	68,794
Total	11,997	15,128	718	13,668	1,900	8,192	59,237	110,840
Rocky Mountain:								
Arizona, Nevada, and New Mexico	195	460	------	759	------	361	571	2,346
Colorado and Utah	1,241	2,545	448	4,424	6	516	6,391	15,571
Idaho, Montana, and Wyoming	442	878	------	17	------	356	931	2,624
Total	1,878	3,883	448	5,200	6	1,233	7,893	20,541
Pacific Coast:								
California	8,830	13,397	4,995	7,397	309	3,242	25,684	63,854
Oregon and Washington	16,163	9,207	53	11,333	505	1,664	14,533	53,458
Total	24,993	22,604	5,048	18,730	814	4,906	40,217	117,312
U.S. total	194,506	139,030	77,775	189,024	34,449	100,321	790,845	1,525,950

[1] Reported by 739 companies representing approximately 15 percent of the scrap collection industry with or without processing equipment, as shown in the 1958 Census of Business, Wholesale Trade.

PRICES [3]

The price of No. 1 Heavy-Melting scrap at Pittsburgh was at a yearly high of $43.75 per long ton in January—$3.50 below the highest price during the previous year. The price for this grade of scrap dropped to $26.00 per ton in November, low for the year and the lowest since March 1954, and then rose to $26.75 in December, 39 percent lower than at the beginning of the year.

No. 1 Heavy-Melting scrap at Chicago averaged $30.72 per long ton for the year—$8.18 lower than the average for the previous year, and the lowest since 1954. The highest price was $40.25 per ton in January, and the lowest price was $25.50 in November.

The average composite price of No. 1 Heavy-Melting iron and steel scrap was $32.91 for the year, $7.58 lower than the 1959 average. The composite price fluctuated between a high of $41.83 per long ton in January and a low of $28.33 in November. The price rose to $28.66 in December, $13.17 lower than at the beginning of the year.

The lowest average composite price for No. 2 Bundles in 1960, quoted at $18. 50 in November, was the lowest since March 1954. The price for this grade of scrap increased to $18.75 per ton during December, 33 percent lower than in January.

The average value of exports (see table 1), including all grades of scrap, from the United States during 1960 was $37.68 per long ton, $3.72 higher than the 1959 average.

TABLE 22.—Average monthly price and composite price for No. 1 Heavy-Melting scrap in 1960

(Per long ton)

Month	Chicago	Pittsburgh	Philadelphia	Composite price [1]
January	$40.25	$43.75	$41.50	$41.83
February	38.06	41.50	39.75	39.77
March	30.90	34.90	35.20	33.67
April	31.25	34.50	34.50	33.42
May	30.10	34.10	34.50	32.90
June	29.25	31.00	33.50	31.25
July	29.88	30.50	33.50	31.29
August	31.50	31.10	34.10	32.23
September	29.75	31.50	34.50	31.92
October	26.50	29.00	33.50	29.67
November	25.50	26.00	33.00	28.33
December [2]	25.75	26.75	33.50	28.66
Average: [2] 1960	30.72	32.92	35.08	32.91
1959	38.90	43.40	39.17	40.49

[1] Composite price, Chicago, Pittsburgh, and Philadelphia.
[2] Estimate.

[3] Iron Age, vol. 187, No. 1, Jan. 5, 1961, p. 236.

FOREIGN TRADE [4]

The export-licensing regulations governing the exportation of ferrous scrap remained in effect through 1960.

Imports.—Imported ferrous scrap, including tinplate, dropped 42 percent in quantity and 45 percent in value when compared with 1959. The largest quantity imported was from Canada (89 percent of the total imports), followed by Ireland (4 percent), and the Netherlands (2 percent); 5 percent was from other countries. Of the total imports, 23 percent was tinplate, mostly from Canada, compared with 13 percent during 1959.

TABLE 23.—U.S. imports for consumption of ferrous scrap, by countries

(Short tons)

Country	1959	1960	Country	1959	1960
North America:			Europe—Continued		
Bahamas	372	150	Ireland		6,720
Canada	258,712	160,561	Netherlands	383	3,992
Costa Rica	467		Sweden	1,112	11
Cuba	3,576	3,152	United Kingdom	13,219	284
El Salvador		349	Other	88	
French West Indies		720			
Haiti	159	50	Total	45,737	13,960
Mexico	107	222			
Netherlands Antilles		155	Asia:		
Other	10	3	Japan	118	105
			Other	25	
Total	263,403	165,362			
			Total	143	105
Europe:			Africa	107	
Belgium-Luxembourg	21,103	2,823	Oceania	58	30
Czechoslovakia	218				
Finland	154		Grand total:		
France	5,273		Short tons	309,448	179,457
Germany, West	4,187	130	Value	$11,590,695	$6,386,081

Source: Bureau of the Census.

Exports.—Total exports, the largest on record, rose 46 percent over 1959. Total ferrous scrap, excluding rerolling materials, exported during 1960 increased 44 percent in quantity and 42 percent in value over 1959. Scrap exported to Japan, including rerolling materials, totaled 3.5 million short tons, an increase of 12 percent over 1959 and the largest quantity on record purchased by this country.

[4] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 24.—U.S. exports of ferrous scrap, by countries

(Short tons)

Destination	Iron and steel scrap including tinplate and terneplate scrap [1]		Rerolling material	
	1959	1960	1959	1960
North America:				
Canada	[2] 606,313	528,840	818	570
Mexico	419,027	399,766	6,817	26,370
Nicaragua	5,451	9,390	----------	----------
Other	53	61	----------	2
Total	[2] 1,030,844	938,057	7,635	26,942
South America:				
Argentina	1,086	663	----------	----------
Chile	----------	18,175	----------	----------
Colombia	788	31	----------	----------
Other	26	32	----------	----------
Total	1,900	18,901	----------	----------
Europe:				
Belgium-Luxembourg	[2] 14,040	9,127	----------	----------
Finland	23,481	25,697	----------	----------
France	10,159	112,902	----------	----------
Germany, West	95,037	553,756	----------	----------
Italy	370,794	1,032,497	----------	----------
Netherlands	445	34,716	----------	----------
Norway	----------	7,880	----------	----------
Spain	77,579	148,598	----------	----------
Sweden	[2] 78,251	226,093	----------	----------
Switzerland	3,360	12,509	----------	----------
United Kingdom	27	249,099	----------	1,051
Yugoslavia	----------	20,377	----------	----------
Other	71	----------	----------	----------
Total	[2] 673,244	2,433,251	----------	1,051
Asia:				
Hong Kong	[2] 6,950	107,868	552	----------
Israel	----------	8,099	----------	----------
Japan	[2] 3,109,952	3,436,942	[2] 27,204	82,199
Nansei and Nanpo Island	----------	----------	6,208	3,189
Taiwan	74,188	119,497	----------	13,247
Other	72	309	294	----------
Total	[2] 3,191,162	3,672,715	[2] 34,258	98,635
Africa	----------	62	----------	----------
Grand total: Short tons	[2] 4,897,150	7,062,986	[2] 41,893	126,628
Value	[2] $165,117,732	$235,226,517	[2] $2,597,848	$6,672,872

[1] Excludes circles, cobbles, strip and scroll shear butts from tinplated scrap.
[2] Revised figure.
Source: Bureau of the Census.

TABLE 25.—U.S. imports for consumption and exports of ferrous scrap, by classes

Class	1959		1960	
	Short tons	Value	Short tons	Value
Imports:				
Iron and steel scrap	267,839	$10,492,866	138,687	$5,281,452
Tinplate scrap	41,609	1,097,829	40,770	1,104,629
Total	309,448	11,590,695	179,457	6,386,081
Exports:				
Nos. 1 and 2 Heavy-Melting steel scrap	[1] 3,143,821	[1] 112,138,261	4,060,267	143,634,022
Nos. 1 and 2 baled steel scrap	[1] 1,021,753	[1] 28,032,074	1,663,613	46,619,684
Borings, shovelings, and turnings	[1] 87,442	[1] 2,108,785	115,703	2,555,360
Iron scrap	[1] 410,095	[1] 14,417,907	640,426	22,923,422
Rerolling material	[1] 41,893	[1] 2,597,848	126,628	6,672,872
Other steel scrap (terneplated and tinplated) [2]	[1] 234,039	[1] 8,420,705	582,977	19,494,029
Total	[1] 4,939,043	[1] 167,715,580	7,189,614	241,899,389

[1] Revised figure.
[2] Excludes circles, cobbles, strip and scroll shear butts from tinplated scrap.
Source: Bureau of the Census.

WORLD REVIEW

European Coal and Steel Community (ECSC).—A study by the High Authority of the ECSC showed that the gap between supply and demand of scrap in 1960 was balanced by imports of 1.8 million tons. This balance was achieved despite an approximately 4 million ton increase in the use of scrap over 1959.[5]

Argentina.—The Argentine steel industry association reported that the use of iron and steel scrap rose during 1960 and totaled an estimated 331,000 short tons. The rise was due to greater demand by steel producers, who increased their output 30 percent over 1959.[6] As is past years, little difficulty was encountered in obtaining an adequate supply to meet requirements. Self-generated scrap of the steel producers, old iron and steel collections, and railways, which have been consistent suppliers of scrap, were the principal sources of this material.

Australia.—The Minister for Trade reduced Australia's export quota of iron and steel scrap by 50 percent on January 1, 1960. The sharp increase in the demand for scrap from Australian steel mills caused this change in export quotas.[7]

TECHNOLOGY

A process for upgrading contaminated ferrous scrap to make a product more suitable for charging iron or steel furnaces was described in a patent.[8]

Removal of combustibles from scrapped automobile bodies continued to be a major problem for all automobile wreckers, particularly small wreckers. With these small operators in mind, the Institute of Scrap Iron and Steel began research to design an incinerator to burn 15 automobile bodies per day. A design which could be used for a larger volume, up to 150 bodies per day, also was considered.[9]

The Institute of Scrap Iron and Steel, Inc., and the American Iron and Steel Institute cosponsored research by the Battelle Memorial Institute during 1960[10] to develop a method of controlling scrap quality, particularly No. 2 bundles.

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[5] U.S. Mission to the European Community, Luxembourg, State Department Dispatch COLUX D-114: Apr. 19, 1961, 2 pp.
[6] U.S. Embassy, Buenos Aires, Argentina, State Department Dispatch 1271: Apr. 10, 1961, 2 pp.
[7] Iron and Coal Trades Review, vol. 181, No. 4806, Aug. 26, 1960, p. 491.
[8] Proler, S., Scrap Refining Process and Product: U.S. Patent 2,943,930, July 5, 1960.
[9] Ellsworth, Richard D., and Ballinger, Edward P., Final Report on Preliminary Survey on Development of an Incinerator for Removal of Combustibles From Scrapped Automobile Bodies to Institute of Scrap Iron and Steel, Inc.: Battelle Memorial Inst., Aug. 30, 1957, 14 pp.
[10] Swager, W. L., The Measurement and Improvement of Scrap Quality: Battelle Memorial Inst., Nov. 30, 1960, 28 pp.

Iron Oxide Pigments

By John W. Hartwell[1] and Betty Ann Brett[2]

DOMESTIC sales of crude iron oxide pigments increased to a new record in 1960, but sales of finished pigments decreased below those of 1959.

DOMESTIC PRODUCTION

Demand for pigment-grade iron oxide during 1960 was strong. Production from iron ore mines increased about 63 percent over 1959, a new record, whereas iron oxide from pigment mines increased only slightly. Crude iron oxide pigments sold or used increased 32 percent, also a new record. Finished pigments sold or used decreased 10 percent in quantity and 6 percent in value.

Crude iron oxide pigments mined and sold or used in the United States were produced by 10 companies in 7 States. Sales of finished iron oxide pigments were made by 16 producers in 9 States.

Larger quantities of iron oxide pigment-grade material were being used to manufacture products other than those requiring colors. These products included magnetic tapes and inks, catalysts, ferrites, and miscellaneous electronic components. Over 6,000 tons of iron oxide

TABLE 1.—Salient iron oxide pigments statistics in the United States

	1951–55 (average)	1956	1957	1958	1959	1960
Mine production:						
Iron oxide pigment mines short tons	[1] 23,300	21,400	20,300	30,100	29,000	29,600
Iron ore mines do	[1] 27,600	32,500	29,000	24,600	24,900	40,700
Crude pigments sold or used:						
Iron oxide pigment mines do	[1] 19,300	17,300	18,400	30,700	29,100	30,400
Value thousands	[1] $168	$168	$193	$234	$251	$262
Iron ore mines short tons	[1] 27,600	32,500	29,000	24,600	24,900	40,700
Value thousands	[1] $227	$300	$269	$211	$219	$373
Finished pigments sold or used short tons	[2] 110,700	113,900	104,900	98,400	117,600	106,000
Value thousands	[2] $14,790	$17,104	$16,405	$15,822	$19,037	$17,948
Imports for consumption short tons	11,700	13,100	13,100	11,700	14,800	14,500
Value thousands	$910	$1,202	$1,314	$1,160	$1,495	$1,422
Exports short tons	4,200	5,100	3,700	3,900	4,300	3,900
Value thousands	$727	$909	$1,038	$1,065	$1,040	$1,113

[1] Averagef or 1954–55 only.
[2] Includes mineral blacks, 1951.

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.

pigment-grade material was reportedly used annually for production of these commodities.[3]

TABLE 2.—Crude iron oxide pigments produced and sold or used by processors in the United States, by kinds

Pigment	1959			1960		
	Mined (short tons)	Sold or used		Mined (short tons)	Sold or used	
		Short tons	Value		Short tons	Value
Brown iron oxide:						
Sienna	11,259	11,186	$100,700	14,293	13,627	$109,800
Umber	468	600	5,800	495	724	7,200
Red iron oxide	31,203	31,203	307,700	46,396	46,396	454,200
Ocher	7,135	7,135	32,400	6,072	6,072	28,300
Other [1]	3,853	3,923	23,300	3,077	4,335	35,800
Total	53,918	54,047	469,900	70,333	71,154	635,300

[1] Includes metallic brown (1960 only), natural yellow iron oxide, sulfur mud, and miscellaneous pigments.

TABLE 3.—Finished iron oxide pigments sold by processors in the United States, by kinds

Pigment	1959		1960	
	Short tons	Value	Short tons	Value
Natural:				
Black: Magnetite	321	$26,700	196	$16,500
Brown:				
Iron oxide (metallic)	6,618	636,100	6,297	666,700
Umbers:				
Burnt	2,950	453,100	2,786	445,700
Raw	637	91,000	662	96,800
Vandyke brown	192	45,300	353	65,500
Red:				
Iron oxide	19,398	994,800	16,068	841,800
Sienna, burnt	1,157	242,400	970	209,000
Pyrite cinder	1,097	58,700	888	50,700
Yellow:				
Iron oxide	46	4,600	18	2,300
Ocher	4,844	209,000	4,133	178,900
Sienna, raw	789	166,100	779	155,000
Total natural	38,049	2,927,800	33,150	2,728,900
Manufactured:				
Black: Magnetic	2,043	606,100	1,945	581,700
Brown: Iron oxide	2,024	533,800	2,060	603,500
Red:				
Pure red iron oxides:				
Calcined copperas	16,694	4,789,800	15,192	4,355,400
Other chemical processes	6,395	1,900,000	6,445	1,887,200
Other manufactured red iron oxides	25,202	2,611,800	21,125	2,369,900
Venetian red	3,098	364,400	2,536	305,500
Yellow: Iron oxide	14,533	3,502,000	14,304	3,488,600
Total mauufactured	69,989	14,307,900	63,607	13,591,800
Mixtures of natural and manufactured red iron oxides	6,635	1,139,900	6,348	1,110,000
Other and unspecified	2,931	661,400	2,917	517,300
Grand total	117,604	19,037,000	106,022	17,948,000

[3] Oil, Paint and Drug Reporter, Iron Oxide Picture Is Seen Brighter Than Ever This Year As Pigments, Ferrites Surge: Vol. 177, No. 25, June 13, 1960, pp. 3, 58, 60.

Plans were announced for constructing a plant in West Memphis, Ark., to make inorganic pigments, stains, and colors. Production was expected to start in January 1961.[4]

Another plant for the manufacture of a soil additive using iron oxide and sulfur was planned for construction in Delta, Colo.

PRICES

Prices quoted for metallic brown natural red, and natural French ocher pigments were lower in September 1960, but by yearend they were back to their original level. All other iron oxide pigment prices remained constant.

TABLE 4.—Prices quoted on finished iron oxide pigments, per pound, in bags, unless otherwise specified, in 1960

Pigment	High	Low	Pigment	High	Low
Black:			Red:		
Pure	$0.1475	$0.1475	Domestic (pure)	$0.1425	$0.1425
Synthetic	(1)	(1)	Natural (75–85 percent ferric oxide)	.0625	.0525
Brown:					
Pure	.1425	.1425	Persian Gulf	.0875	.0875
Metallic	.0550	.0525	Spanish (barrels)	.0575	.0575
Umber, American, burnt	.0750	.0750	Sienna, burnt	.0650	.0650
Umber ,Turkey, burnt	.0825	.0825	Venetian, 40 percent	.0675	.0675
Umber, American, raw	.0775	.0775	Yellow:	.0675	.0625
Umber, Turkey, raw	.0850	.0850	Ocher, natural, French		
Vandyke (barrels)	.0950	.0950	Ocher, natural, Peruvian	.0230	.0230
			Ocher, hydrated, pure	.1225	.1225
			Sienna, raw	.0675	.0675

[1] Data not available.

Source: Oil, Paint and Drug Reporter.

FOREIGN TRADE[5]

All imports of crude ocher (28 tons) and 97 percent of the refined ocher (196 tons) came from the Union of South Africa. The remainder of the refined ocher (6 tons) originated in Canada.

Malta and Italy supplied all the crude sienna imported; the refined sienna came from the United Kingdom (10 percent), Malta (17 percent), and Italy (73 percent).

Crude umber imports came from Malta. The refined umber was from Malta (81 percent), United Kingdom (17 percent), and Italy (2 percent).

Vandyke-brown imports from West Germany were 72 percent compared with 86 percent in 1959 and 75 percent in 1958. The balance came from the Netherlands.

WORLD REVIEW

Australia.—A subsidiary of Imperial Chemical Industries, Ltd., was planning to build a $3.4 million plant to make pigments. This would be the first pigment plant in Australia.

[4] Brick and Clay Record, Announce Plans for Color Specialties: Vol. 137, No. 4, October 1960, p. 34.

[5] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 5.—U.S. imports for consumption of selected iron oxide pigments

Pigment	1959		1960	
	Short tons	Value	Short tons	Value
Natural:				
Ocher, crude and refined	213	$13,427	230	$13,703
Siennas, crude and refined	1,399	95,143	649	63,983
Umber, crude and refined	2,078	68,195	2,894	97,969
Vandyke brown	202	13,875	195	14,214
Other [1]	3,161	160,250	2,976	132,078
Total	7,053	350,890	6,944	321,947
Manufactured (synthetic)	7,776	1,144,198	7,516	1,099,736
Grand total	14,829	1,495,088	14,460	1,421,683

[1] Classified by the Bureau of the Census as "Natural iron oxide and iron hydroxide pigments, n.s.p.f."
Source: Bureau of the Census.

TABLE 6.—U.S. imports for consumption of iron oxide and iron hydroxide pigments, n.s.p.f., by countries

Country	Natural				Synthetic			
	1959		1960		1959		1960	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
North America: Canada					1,480	$302,311	1,130	$219,303
Europe:								
France	331	$24,635	1	$413			(1)	153
Germany, West	19	2,502	8	994	5,255	694,651	5,252	720,289
Italy							(1)	522
Netherlands					101	12,160		
Spain	2,640	117,273	2,838	119,494	79	3,177	104	4,247
Sweden					[2] 2	4,597	1	798
United Kingdom	171	15,840	129	11,177	859	127,302	1,029	154,424
Total	3,161	160,250	2,976	132,078	6,296	841,887	6,386	880,433
Grand total	3,161	160,250	2,976	132,078	[2] 7,776	1,144,198	7,516	1,099,736

[1] Less than 1 ton.
[2] Revised figure.
Source: Bureau of the Census.

Brazil.—In 1959 seven manufacturers produced 3,417 short tons of iron oxide pigments valued at $1,067,000.[6]

Canada.—Production of natural iron oxide pigments declined to 1,220 short tons in 1959 compared with 1,632 tons (revised) in 1958. Imports of ochers, siennas and umbers increased to 833 tons in 1959 compared with 680 tons in 1958, whereas other iron oxides increased to 6,103 tons from 4,923 tons in 1958.

Consumption of iron oxide in the gas and coke industries declined from 6,000 tons in 1957 to 237 tons in 1958. The paint industry used about 2,090 tons of calcined and synthetic iron oxide in 1958. Consumption data for 1959 were not available.[7]

[6] U.S. Consulate, São Paulo, Brazil, State Department Dispatch 413: May 12, 1960, p. 2.
[7] Woodrooffe, H. M., Mineral Pigments and Fillers, 1959 (Prelim.): Canadian Min. Ind., Dept. Mines and Tech. Surveys, Ottawa, Rev. 43, 1959, pp. 1–4.

TABLE 7.—U.S. exports of iron oxide pigments, by countries

Destination	1959		1960	
	Short tons	Value	Short tons	Value
North America:				
Canada	3,093	$507,205	2,304	$418,770
Cuba	184	58,812	88	26,811
Dominican Republic	30	9,158	8	2,746
Guatemala	25	5,887	35	9,399
Mexico	56	35,056	30	20,601
Netherlands Antilles	22	5,090	14	4,046
Other North America	28	9,353	38	12,881
Total	3,438	630,561	2,517	495,254
South America:				
Chile	70	31,487	6	2,438
Colombia	86	28,996	65	23,301
Ecuador	5	1,491	12	3,118
Peru	12	4,010	14	7,271
Venezuela	46	17,334	52	13,822
Other South America	5	2,591	20	6,846
Total	224	85,909	169	56,796
Europe:				
Belgium-Luxembourg	16	6,451	31	35,043
France	28	15,949	82	30,225
Germany, West	8	7,427	35	16,913
Iceland	2	735	2	700
Italy	1	750	24	22,622
Netherlands	34	1,395	277	75,279
Portugal	10	3,195	13	3,931
Sweden	2	560	4	1,725
Switzerland	25	5,237	26	12,655
United Kingdom	21	9,740	53	24,358
Other Europe	1	788	4	1,744
Total	148	52,227	551	225,195
Asia:				
Hong Kong			16	5,417
Japan	33	15,747	52	17,573
Philippines	182	82,762	225	84,108
Other Asia	9	5,821	15	10,424
Total	224	104,330	308	117,522
Africa:				
Union of South Africa	98	33,122	99	32,570
Other Africa	6	2,794		
Total	104	35,916	99	32,570
Oceania	199	130,621	218	185,787
Grand total	4,337	1,039,564	3,862	1,113,124

Source: Bureau of the Census.

France.—Ocher production was reported at 12,125 short tons valued at about US$475,000 in 1959.[8]

Iran.—Red iron oxide was mined on Hormuz Island. Reserves were estimated at 500,000 tons, and annual output approximated 10,000 tons.[9] Persian Gulf iron oxide production in 1959 was 5,220 short tons compared with 3,307 tons in 1958.[10]

Mexico.—A plant to produce organic and inorganic pigments was being constructed by Sun Chemical Corp. of New York. The plant was expected to be the largest of its kind and would supply Latin

[8] U.S. Embassy, Paris, France, State Department Dispatch 86: July 21, 1960, encl. 1, p. 2.
[9] Mining Journal (London), Review of Mineral Resources in Iran: Vol. 254, No. 6505, Apr. 22, 1960, pp. 460–461.
[10] U.S. Embassy, Tehran, Iran, State Department Dispatch 25: July 19, 1960, p. 1.

American manufacturers of printing ink, textiles, and coating and finishing materials.

Morocco.—Production of iron oxide pigments in 1959 was 2,323 short tons compared with 2,124 tons in 1958. The 1959 exports of 1,781 tons were to France, Algeria, United Kingdom, Viet-Nam, and the Republic of the Congo (formerly Belgian Congo).[11]

United Arab Republic (Egypt Region).—In 1959 Egypt produced 824 tons of iron oxide pigment material compared with 1,096 tons in 1958. Proposals were made under a 5-year plan to increase production within a 2-year period.[12]

TECHNOLOGY

The descriptions of 21 mineral pigment deposits in Washington were published.[13]

The thermal decomposition of ferrous sulfate yielded a pigment of excellent quality with minute traces of impurities, and sulfuric acid and 96-percent concentration.[14]

X-ray and differential thermal analysis investigations on the formation and stability of various iron oxides were described.[15]

A study was made on the pigment-binder relationship in terms of volume rather than weight. This concept, known as the pigment volume concentration, had almost universal acceptance by the paint industry in Czechoslovakia.[16]

Studies were made on production of black, red, and yellow iron oxide, and other inorganic pigments.[17] Experiments were made on the production of black iron oxide pigments using a nitrate to reduce the oxidizing time, during aeration, of solutions containing calcium hydroxide and ferrous chloride.[18]

Coatings used to protect iron and steel from corrosion due to outdoor weathering and salt spray were described. With the exception of phosphate coatings, black oxide films were the most widely used.[19]

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[11] Bureau of Mines, Mineral Trade Notes: Vol. 51, No. 6, December 1960, p. 40.

[12] U.S. Embassy, Cairo, Egypt, State Department Dispatch 525: Jan. 11, 1961, encl. 1, pp. 1–2.

[13] Valentine, G. M., and Hunting, M. T., Inventory of Washington Minerals: Wash. Dept. of Conservation, Division of Mines and Geol., Bull. 37, vol. 1, pt. 1, 1960, pp. 63–64 (text); vol. 2, pt. 1, 1960, p. 61 (map).

[14] Suchkov, A. B., Borok, B. A., and Morozova, Z. I. [Thermal Decomposition of a Mixture of $MnSO_4$ and $FeSO_4$ in a Current of Steam]: Jour. of Appl. Chem. (U.S.S.R.), vol. 32, No. 7, July 1959, pp. 1649–1651 (English Trans. by Consultants Bureau, Inc., New York, N.Y.)

[15] Schwertmann, U. [Synthesis of Defined Iron Oxides Under Various Conditions]: Ztschr. anorg. u. allgem. Chem., vol. 298, Nos. 5 and 6, 1959, pp. 337–348; Jour. Am. Ceram. Soc., Ceram. Abs., vol. 43, No. 5, May 1960, p. 128.

[16] Korinsky, J. [Volume-Formulating Principle in Paint Technology]: Chemicky-prûmysl, Res. Inst. of Synthetic Resins and Paints, Pardubice, Czechoslovakia, No. 4, 1960, pp. 220–223.

[17] Sziklai Géza (University of Chemical Industry, Veszprém, Hungary) [Manufacture of Red Iron Oxide Pigment by Roasting of Ferrous Sulfate]: Veszprémi Vegyipari Egyetem Közleményei, vol. 2, 1958, pp. 267–272; Chem. Abs., vol. 55, No. 3, Feb. 6, 1961, col. 3087f.

Polinszky, Károly (University of Chemical Industry, Veszprém, Hungary) [Studies on Inorganic Pigments at the University of Chemical Industry, Veszprém, Hungary]: Veszprémi Vegyipari Egyetem Közleményei, vol. 2, 1958, pp. 253–259; Chem. Abs., vol. 55, No. 3, Feb. 6, 1961, col. 3087h.

[18] Szigeti, Gyorgy (University of Chemical Industry, Veszprém, Hungary) [Manufacture of Black Iron Oxide in the Presence of Nitrates]: Veszprémi Vegyipari Egyetem Közleményei, vol. 2, 1958, pp. 261–266; Chem. Abs., vol. 55, No. 3, Feb. 6, 1961, col 3088c.

[19] Spencer, Lester F., Conversion Coatings, Oxide Films: Metal Finishings, vol. 58, April 1960, pp. 62–66.

A rust-inhibiting paint containing red lead and precipitated red iron oxide was described. The red iron oxide gave additional weathering resistance and hardness to the film.[20]

The accelerated weathering of paint by exterior exposure was described.[21]

The general properties and classifications of bright inorganic colors and organic pigments were given.[22]

The Chemistry of Ferromagnetic Iron Oxide published by the U.S.S.R. was being translated by the U.S. Department of Commerce.

Oxides of iron and other metals calcined at 2,000° F. form compounds during the firing of porcelain enamel coatings, but since some red pigments are unstable during firing and may fade with use, improvements in stability may be obtained by using sodium fluoride or silicate, zinc oxide, or other compounds in the enamel coatings. Tests and classifications for fade-resistant enamels were described.[23]

A revised summary of materials that may be used to control firing, drying, forming, texture, color, porosity, weight, strength, and size of manufactured clay products was published. The coloring agents mentioned included crocus martis, ocher, umber, and other iron oxides.[24]

Methods which could be used to accelerate weathering of protective and decorative coatings were studied. Certain techniques yield reliable results only when used with comparative tests made by normal time-consuming outdoor exposures. Ultraviolet radiation was considered a major factor influencing the lightfastness of colored pigments. Therefore, accelerated exposure devices were equipped with this type of light source, with or without water sprays. Iron oxide and other pigment materials were tested and compared.[25]

A process for producing red ferric oxide by converting a gamma oxide into a red nonmagnetic alpha oxide was patented.[26]

In another process of manufacturing iron oxide, alpha ferric oxide was precipitated from an aqueous ferrous salt solution by an oxygen-containing gas through the solution forming ferric oxide and hydrogen ions.[27]

A patent was issued for the manufacture of a ferrite of mixed composition containing 47 to 49 percent iron oxide.[28]

A process of producing red iron oxide by introducing oxygen into an aqueous solution of a ferrous salt containing metallic iron

[20] South African Mining and Engineering Journal (Johannesburg), Anti-Rust Paint: Vol. 71, No. 3513, pt. 1, June 3, 1960, p. 1385.

[21] Bose, S. K., and Mukerji, S. N., Assessment of Paint Durability: Paint Manufacture, vol. 30, March 1960, pp. 88–92.

[22] Stacy, E. R., Dunn, Michael J., Love, Charles H., and Venuto, L. J., Review of Colored Pigments, Organic Pigments, Bright Inorganic, Oxide Pigments, and Carbon Blacks: Paint Industry, vol. 75, May 1960, pp. 14–22.

[23] Wesley, Reynolds, Oxides and Architectural Colors: Proc. Porcelain Inst. Forum, vol. 29, 1958, pp. 83–86.

[24] Brick and Clay Record, Clay Modifiers Issue: Vol. 137, No. 4, October 1960, pp. 63–75.

[25] Spengeman, W. F., and Wormald, G., Lightfastness Testing of Pigment Colors: ASTM Bull. No. 249, October 1960, pp. 29–34.

[26] Martin, John (assigned to Columbian Carbon Co.), Manufacture of Ferric Oxide: U.S. Patent 2,935,379, May 3, 1960.

[27] Martin, John (assigned to Columbian Carbon Co.), Manufacture of Iron Oxides: U.S. Patent 2,939,767, June 7, 1960.

[28] Piekarski, L. T. (assigned to General Electric Co.), Mixed Ferrite Composition: U.S. Patent 2,961,407, Nov. 22, 1960.

and involving the growth of iron oxide crystals upon colloidal ferric oxide seed was patented.[29]

A process of forming iron salts by oxidizing iron from the divalent to the trivalent stage was patented.[30]

A method of producing magnetic iron oxide with oil-absorptive characteristics used in the making of magnetic records was patented.[31]

The conversion of a ferric halide to finely divided magnetic iron oxide by heating in a flame was patended.[32]

A fireproof paint which would resist temperatures up to 1,000° F. was patented in Japan. The paint pigment used was composed of 20 percent Fe_2O_3, 20 percent Cr_2O_3, and 60 percent ZnO.[33]

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[29] Ayers, Joseph W. (assigned to C. K. Williams & Co.), Production of Red Oxide of Iron Pigments: U.S. Patent 2,937,927, May 24, 1960.

[30] Moser, Gerhard (assigned to VEB Fettchemie Karl-Marx-Stadt), Oxidation Process: U.S. Patent 2,922,698, Jan. 26, 1960.

[31] Westcott, Horace C. (assigned to American Pigment Corp.), Production of Ferromagnetic Oxide: U.S. Patent 2,954,303, Sept. 27, 1960.

[32] Wagner, Ernst (assigned to Deutsche Gold und Silber Scheideanstalt), Magnetic Iron Oxide: U.S. Patent 2,950,955, Aug. 30, 1960.

[33] Yamanoto, Yoshizumi, and Hamaguchi, Noriyuki, Heat-Resisting and Fireproofing Paints: Japanese Patent 8330, September 1959; Chem. Abs., vol. 54, No. 14, July 25, 1960, col. 14720b.

Kyanite and Related Minerals

By James D. Cooper [1] and Gertrude E. Tucker [2]

DOMESTIC production of kyanite in 1960 increased 4 percent over 1959. No output was reported for other minerals of the kyanite group. Production of synthetic mullite in the United States rose 18 percent in 1960. Apparent consumption of kyanite and related minerals and synthetic mullite was 7 percent greater than in 1959.

Kyanite, sillimanite, andalusite, dumortierite, topaz, and synthetic mullite are discussed in this chapter because all are aluminum silicates with similar properties that can be used to produce mullite refractories.

DOMESTIC PRODUCTION

Production of kyanite, recovered as minus 35-mesh flotation concentrate, increased about 4 percent over 1959. The two companies producing kyanite were Commercialores, Inc., from deposits near Clover, S.C., and Kyanite Mining Corp., from deposits near Farmville, Prince Edward County, Va., and Willis Mountain, near Dillwyn, Buckingham County, Va.

Synthetic mullite, essentially $3Al_2O_3 \cdot 2SiO_2$, is made by fusing or sintering raw materials such as alumina or bauxite with the proper proportions of silica or clay. Domestic kyanite is sometimes used as an ingredient. Production of synthetic mullite, 1951–60, is shown in table 1. Six companies made synthetic mullite in 1960:

The Babcock & Wilcox Co., Refractories Div., New York, N.Y. (plant at Augusta, Ga.).

The Carborundum Co., Niagara Falls, N.Y. (plant at Niagara Falls, N.Y.).

Harbison-Walker Refractories Co., Pittsburgh, Pa. (plant at Vandalia, Mo.).

H. K. Porter Co., Inc., Refractories Div., St. Louis, Mo. (plant at Shelton, Conn.).

Remmey Division of A. P. Green Fire Brick Co., Philadelphia, Pa. (plant at same address).

The Chas. Taylor Sons Co. (a subsidiary of National Lead Co.), Cincinnati, Ohio (plant at South Shore, Ky.).

CONSUMPTION AND USES

Mullite was used almost entirely in manufacturing superduty refractory brick and shapes and in mortars, cements, plastics, and ramming mixtures. About 90 percent of all mullite refractories was used in the metallurgical and glass industries, and most of the remaining 10 percent was used to make kiln furniture for the ceramic industry.

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[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

TABLE 1.—Synthetic mullite production in the United States

Year	Short tons	Value (thousands)
1951–55 (average)	[1] 17,000	[1] $1,700
1956	[1] 24,000	[1] 2,500
1957	[2] 19,873	2,009
1958	[2] 16,280	1,632
1959	[2] 18,218	2,017
1960	21,497	2,212

[1] Estimate.
[2] Revised figure.

The initial cost of mullite refractories is considerably higher than that of fire-clay refractories; however, in furnace areas where temperatures are unusually high or where slagging is severe, the lower maintenance cost of mullite refractories more than offsets their higher initial cost.

PRICES

Prices reported by industry for domestic kyanite were: Per short ton, f.o.b. point of shipment, 35-mesh, carlots, in bulk, $42 to $44, in bags, $45 to $47; 200-mesh, in bags, carlots, $53 to $55; additional cost for calcining, per ton, $9 to $10. Prices reported in E&MJ Metal and Mineral Markets for imported kyanite (60-percent grade) in bags were $76 to $81 per ton, c.i.f. Atlantic ports.

FOREIGN TRADE [3]

Imports of kyanite and related minerals were 7 percent above 1959. The general decline of imports which started in 1952 and was due primarily to increased domestic production of synthetic mullite, appeared to have ended after reaching a low of 1,965 tons in 1958. Exports of kyanite and related minerals increased 19 percent over 1959 and for the second consecutive year were the highest on record.

WORLD REVIEW

Australia.—Sillimanite production in the first half of 1960 was 2,947 short tons, an increase of 774 tons over the same period of 1959. Total production for 1959 was 4,069 tons.[4]

Rhodesia and Nyasaland, Federation of.—Geological mapping and drilling of the Kapiridimba kyanite deposit in 1959 indicated the presence of three main lenticular bodies containing reserves of more than 300,000 tons. Testing of the drill samples was in progress.[5]

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

[4] Australia Bureau of Mineral Resources, Geology and Geophysics, The Australian Mineral Industry: Vol. 12, No. 2, pt. 2, November 1959, p. 9; vol. 13, No. 2, pt. 2, December 1960, p. 9.

[5] Nyasaland Geological Survey, Annual Report, 1959: 1960, p. 9.

TABLE 2.—U.S. imports for consumption and exports of kyanite and related minerals

Imports

Year and country	Short tons	Value
1951-55 (average)	9,531	[1] $405,256
1956	6,951	306,181
1957	5,999	263,375
1958	1,965	95,489
1959:		
Europe: Netherlands	41	3,663
Asia: India	3,452	172,044
Africa: Union of South Africa	2,140	75,931
Total	5,633	251,638
1960:		
Asia: India	4,684	213,764
Africa: Union of South Africa	1,368	51,600
Total	6,052	265,364

Exports

Year and country	Short tons	Value
1951-55 (average)	1,203	$54,985
1956	1,331	63,193
1957	2,588	129,963
1958	2,493	126,862
1959:		
North America:		
Canada	1,829	108,535
Mexico	562	28,082
South America: Argentina	30	1,980
Europe:		
France	14	2,782
Germany, West	105	5,992
Italy	11	949
Netherlands	12	811
United Kingdom	15	4,023
Asia: Japan	156	14,278
Total	2,734	167,432
1960:		
North America:		
Canada	1,630	108,718
Mexico	788	39,983
South America:		
Chile	5	330
Venezuela	65	4,759
Europe:		
Austria	17	941
Belgium-Luxembourg	2	533
France	143	8,403
Germany, West	288	17,893
Italy	63	3,660
United Kingdom	86	11,442
Asia:		
Japan	163	12,452
Jordan	5	836
Total	3,255	209,950

[1] 1954 data known to be not comparable with other years.

Source: Bureau of the Census.

South-West Africa.—Production of sillimanite and kyanite totaled 1,438 tons in 1960. Local sales and exports were only 159 tons.[6]

Union of South Africa.—Production for the period January–September 1960 was 40,720 tons of sillimanite and 4,346 tons of andalusite. Exports for the same period were 34,329 tons of sillimanite, valued at US$1,409,898, and 3,304 tons of andalusite, valued at US$92,239. The United Kingdom, Japan, and West Germany were the principal importing countries.[7]

TECHNOLOGY

Reports published on kyanite and related minerals in the Southeastern United States, included location data, geology, type and size

[6] U.S. Consulate, Cape Town, Union of South Africa, State Department Dispatch 110, Annual Summary and Assessment for South-West Africa for 1960: Encl. 2, Mar. 30, 1961, p. 1.

[7] Union of South Africa Department of Mines (Minerals), Quarterly Information Circular: July–September 1960, pp. 26, 61–63.

of deposits, and descriptions of the kyanite group and accessory minerals.[8]

Results of X-ray, optical, and chemical studies were published for a wide variety of sillimanites and synthetic and natural mullites. A new type of mullite, called S mullite, was described.[9] A study was made to obtain data on the solid solubility of Fe_2O_3, Cr_2O_3, and TiO_2 in the $3Al_2O_3 \cdot 2SiO_2$ mullite composition, using X-ray lattice parameters and cell volumes as the major criteria. New X-ray data were obtained and lattice constants determined for pure mullite.[10]

A study was made to determine if the polymorphic relations of kyanite, sillimanite, and andalusite might be influenced by the trace elements present. Although certain trace-element anomalies were found, the investigators concluded that the anomalies were not responsible for the polymorphic relations.[11]

Research indicated that alumina-mullite ceramic reinforced with molybdenum fiber can be produced that has a modulus of rupture greater than 30,000 p.s.i. after four thermal shocks at 2,200° F. and that the modulus of rupture is actually increased by thermal shock. The material may find use in the leading edges of hypersonic aircraft.[12]

Production methods were described and chemical and physical properties were compared for fused and sintered synthetic mullite made from various raw materials.[13]

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[8] Espenshade, G. H., and Potter, D. B., Kyanite, Sillimanite, and Andalusite Deposits of the Southeastern States: Geol. Survey Prof. Paper 336, 1960, 121 pp.
Furcron, A. S., Kyanite, Sillimanite, and Andalusite in Georgia: Georgia Miner. Newsletter, vol. 13, No. 1, spring 1960, pp. 9–21.

[9] Agrell, S. O., and Smith, J. V., Cell Dimensions, Solid Solution, Polymorphism, and Identification of Mullite and Sillimanite: Jour. Am. Ceram. Soc.—Ceram. Abs., vol. 43, No. 2, February 1960, pp. 69–76.

[10] Murthy, M. Krishna, and Hummel, F. A., X-Ray Study of the Solid Solution of TiO_2, Fe_2O_3, and Cr_2O_3 in Mullite ($3Al_2O_3 \cdot 2SiO_2$): Jour. Am. Ceram. Soc.—Ceram. Abs., vol. 43, No. 5, May 1960, pp. 267–273.

[11] Pearson, G. R., and Shaw, D. M., Trace Elements in Kyanite, Sillimanite, and Andalusite: Am. Mineral., vol. 45, Nos. 7 and 8, July–August, 1960, pp. 808–817.

[12] Swica, J. J., and others, Metal Fiber Reinforced Ceramics: State University of New York, College of Ceramics, Alfred Univ., WADC Tech. Rept. 58–452, pt. 2, Project 7350, January 1960, 41 pp.

[13] Thomas, Everett A., and Smith, Karl W., Synthetic Mullite as a Ceramic Raw Material: Paper pres. at Ann. Meeting, AIME, New York City, Feb. 17, 1960, 11 pp.

Lead

By G. Richards Gwinn [1] and Edith E. den Hartog [2] [3]

Contents

INCREASES were counted in output of lead at primary refineries, in lead recovered at secondary smelters, and in consumption of lead-base and tin-base scrap in 1960. Simultaneously, declines were noted in mine output of recoverable lead, in lead consumption, and in imports of metal. Import quotas remained in effect throughout the year. The price of common grade lead (New York market) remained at 12 cents a pound until December 13 when it declined to 11 cents a pound. This latter price held through the remainder of the year.

TABLE 1.—Salient lead statistics

	1951–55 (average)	1956	1957	1958	1959	1960
United States:						
Production:						
Domestic ores, recoverable lead content...short tons..	356,883	352,826	338,216	267,377	255,586	246,669
Value.........thousands..	$107,921	$110,787	$96,730	$62,566	$58,785	$57,722
Primary lead (refined):						
From domestic ores and base bullion short tons..	339,483	349,188	347,675	269,082	225,270	228,899
From foreign ores and base bullion short tons..	125,378	193,120	185,858	201,074	115,661	153,537
Antimonial lead (primary lead content)..short tons..	18,745	13,657	19,870	16,446	12,402	2,385
Secondary lead (lead content)..........short tons..	491,823	506,755	489,229	401,787	451,387	469,903
Imports, general:						
Lead in ores and matte short tons..	134,357	196,452	198,479	201,599	138,834	145,953
Lead in base bullion...do....	716	31	84	460	80	293
Lead in pigs, bars, and old short tons..	333,683	283,392	333,492	375,022	271,695	213,671
Exports of refined pig lead.do....	969	4,628	4,339	1,359	2,756	1,967
Stocks Dec. 31 (lead content):						
At primary smelters and refineries........short tons..	107,010	97,043	143,916	234,290	171,079	250,142
At consumer plants...do....	116,230	123,995	129,310	122,900	126,496	97,268
Consumption of metal, primary and secondary......short tons..	1,164,941	1,209,717	1,138,115	986,387	1,091,149	1,021,172
Price: New York, common lead, average, cents per pound.......	15.33	16.01	14.66	12.11	12.21	11.95
World:						
Mine production.............	2,170,000	2,490,000	2,610,000	2,560,000	2,530,000	2,560,000
Smelter production...........	2,075,000	2,400,000	2,515,000	2,490,000	2,410,000	2,530,000
Price: London, common lead, average, cents per pound......	14.56	14.52	12.05	9.13	8.88	9.04

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.
[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

LEGISLATION AND GOVERNMENT PROGRAMS

The import quotas established in October 1958 by Presidential proclamation continued without revision throughout 1960. The U.S. Tariff Commission completed an investigation, made under section 332 of the Tariff Act of 1930 pursuant to Senate resolution (S. Res. 162, 86th Cong.) adopted August 21, 1959, and published the results on March 30, 1960. Section 2 of Senate Resolution 162 requested the Tariff Commission to include in its report recommendations as to what additional import restrictions, if any (such as increased duties or import quotas or both), need be imposed in order that lead and zinc mining operations in the United States might be conducted on a sound and stable basis. The Tariff Commission, however, decided by a 4-to-2 decision that the making of recommendations or suggestions to Congress regarding the need for import restrictions was not a function of the Tariff Commission. Such a recommendation, therefore, would be an extra legal act.[4]

On September 30, 1960, the U.S. Tariff Commission made its first report under paragraph 1 of Executive Order 10401, with regard to developments in the trade in lead and zinc since the modification of the tariff concession on lead and zinc granted in the General Agreement on Tariffs and Trade. The Tariff Commission was of the opinion that developments in the trade in lead and zinc did not warrant a formal investigation under the provisions of paragraph 2 of Executive Order 10401.[5]

No surplus-agricultural-product barter contracts for lead were negotiated by the U.S. Department of Agriculture, Commodity Credit Corporation (CCC), and no Government purchases of lead were made for the strategic stockpile. The Government procurement program for purchases of lead for the strategic stockpile had terminated at the end of 1958. A total of 221,993 short tons of lead were in the supplemental stockpile on December 31, 1960.

A bill to subsidize small lead-zinc mines passed both Houses of Congress, but was vetoed by President Eisenhower. The proposed bill carried authority for subsidizing lead-zinc mines producing less than 2,000 tons of each metal a year when world prices fell below 17 cents a pound for lead and 14.5 cents a pound for zinc. The bill also limited payments to $4.84 millions a year for 5 years.

The Office of Minerals Exploration (OME), which limited Government participation to one-half of approved costs and a maximum of $250,000 for any one contract, continued its program of assistance for long-range exploration and received 13 applications for assistance for lead-bearing ore deposits. Five new contracts were executed, authorizing total expenditures of $448,000, of which the maximum Government participation was $224,000. Five of the 1960 applications were denied, and three applications plus two from 1959 were still pending at yearend. In addition, five OME contracts were terminated. Four contracts from the Defense Minerals Exploration

[4] U.S. Tariff Commission, Lead and Zinc, Report to the Congress on Investigation No. 332–26 (Supplemental, under sec. 332 of the Tariff Act of 1930). Made pursuant to Senate Resolution 162, 86th Cong. Adopted Aug. 21, 1959: Mar. 30, 1960, pp. 149–150.

[5] U.S. Tariff Commission, Lead and Zinc, Report to the President (1960) under Executive Order 10401: October 1960, 13 pp.

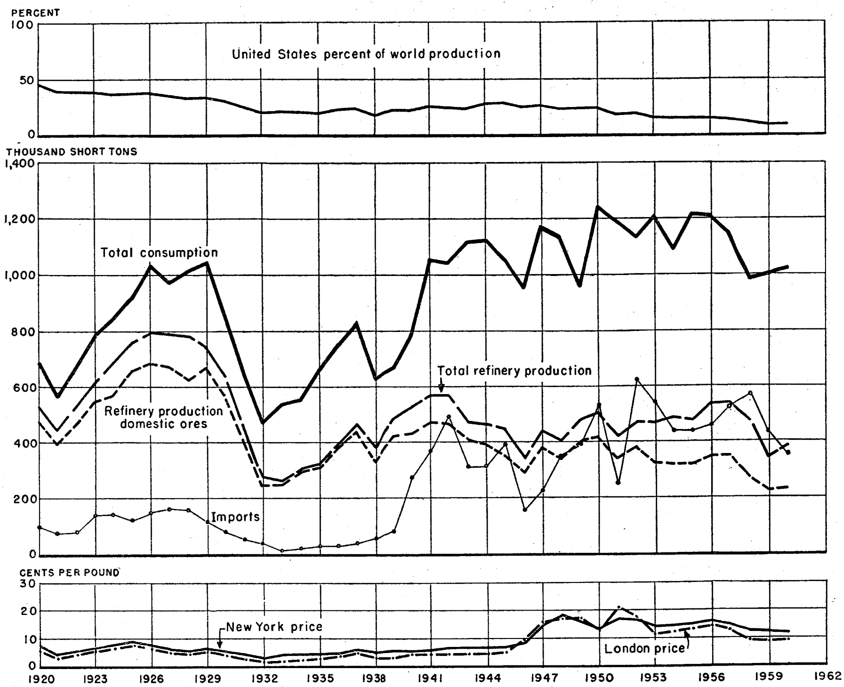

FIGURE 1.—Trends in the lead industry in the United States, 1920–60. Consumption includes primary refined, antimonial, and secondary lead and lead in pigments made directly from ore. Imports are factored to include 95 percent of the lead content or ores, mattes, and concentrates and 100 percent of pigs. bars, base bullion, and scrap.

Administration (DMEA), predecessor agency to OME, remained in force, and 14 were terminated. Discoveries were certified on 6 DMEA projects, raising to 94 the total certified discoveries or developments in lead-bearing ores accomplished under the DMEA program.

The International Lead-Zinc Study Group met at Geneva, Switzerland, from January 27 to February 3 and September 12–15, 1960, and continued its efforts to bring free-world production and consumption of lead into a favorable balance. Some progress was made as Canada and Australia, major mine and metal producers, voluntarily reduced production. The overall lead situation remained unstable, however, and a further reduction in stocks seemed necessary.

DOMESTIC PRODUCTION

MINE PRODUCTION

Mines in the United States produced 246,700 short tons of recoverable lead in 1960, the lowest domestic mine output reported since 1900. Production increased slightly through the first quarter, declined through the second quarter, turned upward in August, and then declined through the remainder of the year. Labor strikes in the Coeur d'Alene region of Idaho, beginning in May 1960, reduced national output 10 percent during the last 6 months of the year.

The four largest producing States were Missouri, 111,900 short tons; Idaho, 42,900 tons; Utah, 39,400 tons; and Colorado, 18,100 tons; this output totaled 212,300 tons—86 percent of the U.S. output.

The remaining 14 percent of U.S. output of lead came from 15 States. The major producers of this group, with a combined output of 23,100 tons, about 9 percent of the total output, were Arizona, Washington, Montana, and New Mexico.

Missouri retained its place as the largest lead-mining State. The output of lead from the mines of the Southeast Missouri Lead Belt represented about 45 percent of the U.S. total and was 6 percent above 1959. Production began from one of the three shafts of the St. Joseph Lead Co.'s Viburnum ore bodies, and plans were completed to expand refining capacity at the company's Herculaneum, Mo., smelter. Several other major lead-zinc mining companies continued intensive exploration programs in southeast Missouri.

Idaho retained its position as the second largest lead-producing State and as the largest producer in the Western States. Output, however, declined 31 percent from the 1959 total. The decrease was attributed largely to the 7-month labor strike which closed The Bunker Hill Co. and American Smelting and Refining Co. (AS&R) mines in the Coeur d'Alene region. The strikes idled about 1,500 men at The Bunker Hill operations and 500 men at the AS&R mines and mills, and reduced the monthly output from Idaho by about 2,000 tons from June through December.

The 1960 output of lead in Utah represented an increase of 8 percent over 1959. The United States and Lark Mines of the United States Smelting Refining and Mining Co. operated two shifts a

TABLE 2.—Mine production of recoverable lead in the United States, by States

(Short tons)

State	1951–55 (average)	1956	1957	1958	1959	1960
Alaska	6	1	9	2	---	23
Arizona	12,309	11,999	12,441	11,890	9,999	8,495
Arkansas	8	---	---	---	38	---
California	8,953	9,296	3,458	140	227	440
Colorado	23,157	19,856	21,003	14,112	12,907	18,080
Idaho	71,701	64,321	71,637	53,603	62,395	42,907
Illinois	3,718	3,832	2,970	1,610	2,570	3,000
Kansas	5,548	7,635	4,257	1,299	481	781
Kentucky	60	228	411	516	409	558
Missouri	125,901	123,783	126,345	113,123	105,165	111,948
Montana	18,876	18,642	13,300	8,434	7,672	4,879
Nevada	4,928	6,384	5,979	4,150	1,357	987
New Mexico	3,999	6,042	5,294	1,117	829	1,996
New York	1,256	1,608	1,667	579	481	775
North Carolina	---	10	9	---	---	424
Oklahoma	13,869	12,350	7,183	3,692	601	936
Oregon	3	5	5	1	---	---
South Dakota	3	---	---	---	---	---
Tennessee	8	5	---	---	---	---
Texas	20	---	---	---	---	---
Utah	47,521	49,555	44,471	40,355	36,630	39,398
Virginia	3,082	3,035	3,143	2,934	2,770	2,152
Washington	10,218	11,657	12,734	9,020	10,310	7,725
Wisconsin	1,739	2,582	1,900	800	745	1,165
Total	356,883	352,826	338,216	267,377	255,586	246,669

TABLE 3.—Ores yielding lead and zinc in the United States in 1960

(Short tons)

State	Lead ore			Zinc ore			Lead-zinc ore			Copper-lead, copper-zinc, and copper-lead-zinc ores			All other sources [1]			Total		
	Gross weight	Lead	Zinc	Gross weight	Lead	Zinc	Gross weight	Lead	Zinc	Gross weight	Lead	Zinc	Gross weight	Lead	Zinc	Gross weight	Lead	Zinc
Alaska	36	22	------	------	------	------	------	------	------	------	------	------	2	1	------	38	23	------
Arizona	4,202	248	12	19,370	------	3,537	337,070	8,212	23,465	147,541	16	8,635	66,246,659	19	162	66,754,842	8,495	35,811
Arkansas	------	------	------	1,000	------	50	------	------	------	------	------	------	------	------	------	1,000	------	50
California	2,294	143	4	------	------	------	3,087	281	150	------	------	------	145,963	16	311	151,344	440	465
Colorado	8,595	258	6	------	------	------	251,003	8,275	19,263	471,889	9,318	12,001	24,265	229	8	755,752	18,080	31,278
Idaho	150,670	14,883	1,258	(2)	------	------	[2] 496,113	24,835	33,709	------	------	------	458,523	3,189	1,834	1,105,306	42,907	36,801
Illinois	1,300	322	19	629,540	923	20,306	------	------	------	------	------	------	384,741	1,755	9,225	1,015,581	3,000	29,550
Kansas	------	------	------	22,600	191	867	9,672	590	1,250	------	------	------	------	------	------	32,272	781	2,117
Kentucky	------	------	------	------	------	------	------	------	------	------	------	------	68,922	558	869	68,922	558	869
Missouri	[3] 5,897,813	111,948	2,821	------	------	------	------	------	------	(3)	------	------	------	------	------	5,897,813	111,948	2,821
Montana	14,092	1,590	287	207,628	2,188	6,421	3,648	179	119	------	------	------	12,092,053	922	5,724	12,317,421	4,879	12,551
Nevada	11,267	838	137	516	5	178	131	11	8	------	------	------	11,835,856	133	97	11,847,770	987	420
New Mexico	8,176	353	18	(2)	------	------	[2] 211,121	1,452	13,669	------	------	------	7,614,767	191	83	7,834,064	1,996	13,770
Oklahoma	------	------	------	8,900	140	532	10,800	796	1,800	------	------	------	------	------	------	19,700	936	2,332
Tennessee	------	------	------	2,577,467	------	83,944	------	------	------	1,429,220	------	7,450	------	------	------	4,006,687	------	91,394
Utah	301	35	6	383	7	37	482,796	38,337	32,084	3,042	2	86	28,358,567	1,017	3,263	28,845,089	39,398	35,476
Washington	------	------	------	------	------	------	959,822	7,725	21,317	------	------	------	------	------	------	959,822	7,725	21,317
Wisconsin	------	------	------	687,078	1,165	18,410	------	------	------	------	------	------	------	------	------	687,078	1,165	18,410
New York						11,809		775	54,555								775	66,364
North Carolina	------	------	------	594,916	------	------	1,016,956	------	------	------	------	------	14,000	424	------	1,625,872	424	
Pennsylvania						13,746								------	------		------	13,746
Virginia						6,901		2,152	12,984								2,152	19,885
Total	6,098,746	130,640	4,568	4,749,398	4,619	166,738	3,782,219	93,620	214,373	2,051,692	9,336	28,172	127,244,318	8,454	21,576	143,926,373	246,669	435,427

[1] Lead and zinc recovered from other ores (copper, gold, silver, etc.) and from mill slags, tailings, and dumps.
[2] Zinc and lead-zinc combined to avoid disclosing individual company confidential data.
[3] Lead and copper-lead combined to avoid disclosing individual company confidential data.

TABLE 4.—Mine production of recoverable lead in the United States, by months

(Short tons)

Month	1959	1960	Month	1959	1960
January	23,626	21,423	August	21,922	19,857
February	21,449	22,776	September	20,719	18,268
March	21,156	25,690	October	21,208	18,339
April	21,432	24,105	November	20,279	19,089
May	20,375	20,871	December	22,129	20,152
June	21,634	19,686			
July	19,657	16,413	Total	255,586	246,669

day throughout the year. Tonnage and grade of ore was about the same as that of the past several years, and new ore developed substantially exceeded ore extracted. The strike at the Tooele smelter, which had lasted about 6 months, was settled on February 15, 1960. Evidence of high-grade silver-lead-zinc mineralization was reported in the Keystone Mining Co. properties in the Park City district of Utah, which were being developed with aid of an OME loan by Keystone and Park City Mines Co. Development of the silver-lead-zinc ore body in the Tintic district by the Bear Creek Mining Co., domestic exploration affiliate of Kennecott Copper Corp., continued throughout the year.

The output of lead from mines in Colorado increased 40 percent over 1959. Scheduled requirements for lead ore production at the Eagle mine of The New Jersey Zinc Co. at Gilman were maintained throughout the year except for the August-November period when the mine was shut down by a labor strike. The Argentine and Mountain Springs mines of the Rico Argentina Mining Co. also contributed significant quantities to the State's lead production. The newly built 500-ton-a-day ore-dressing mill, at the Camp Bird mine near Ouray, of Camp Bird Colorado Inc., subsidiary of Camp Bird Mining Ltd., of London, England, went on stream in October 1960. Progress also was made by the Standard Metals Corp. toward reopening the Shenandoah Dive mine, rehabilitating the Shenandoah-Dive's mill, and reopening the Sunnyside mine, under lease from United States Smelting Refining and Mining Co.

The Iron King mine operated by the Shattuck-Denn Mining Corp. retained its position as Arizona's leading producer. Lead-zinc and lead-zinc-copper ore also was mined at the Flux mine in the Harshaw district and Pride of the West mine in the Duquesne district. The ore from both mines was treated at the Trench mill in the Harshaw district.

The Pend Oreille mine of Pend Oreille Mines and Metals Co. and the Grandview mine of American Zinc-Lead and Smelting Co. were again the major lead-producing mines in Washington. Clayloon Uranium Co. discovered a new vein of lead ore at the Lead Trust mine in Stevens County, and Uranium-Lead-Zinc Mines, Inc., developed a chimney of lead-silver-zinc ore at the former Columbia Lead and Zinc Mining Co. property near Z Canyon, Metaline mining district.

The decline in lead production in Montana continued through 1960 and was attributed largely to the extended closure of The Anaconda

Co.'s zinc concentrator where lead was recovered as a byproduct. The testing of an enlarged cyanide mill by Spokane National Mines, Inc., at Bannock, to handle lead, zinc, silver, and copper ores from the New Departure mine near Dillion, Mont., was started. Northern Milling Co., Inc., with the assistance of an OME loan, began to explore for lead and zinc at the Marietta mine, about 15 miles west of Townsend, Broadwater County.

The 2,000 tons of lead produced in New Mexico was 141 percent more than the 1959 output. The increase was attributed largely to output from New Jersey Zinc Co.'s Hannover mine-mill unit and the leased Linchburg mine at Magdelena, both of which operated throughout the year.

About 5 percent of the U.S. output came from States east of the Mississippi River where lead was recovered almost entirely as a byproduct during the recovery of zinc; from California and Nevada of the Western States; and from Wisconsin, Kansas, and Oklahoma of the Mississippi Valley lead-zinc region.

TABLE 5.—Twenty-five leading lead-producing mines in the United States in 1960, in order of output

Rank	Mine	District or region	State	Operator	Source of lead
1	Federal	Southeastern Missouri.	Missouri	St. Joseph Lead Co.	Lead ore.
2	United States & Lark.	West Mountain (Bingham).	Utah	United States Smelting, Refining and Mining Co.	Gold-silver, lead-zinc ore.
3	Leadwood	Southeastern Missouri.	Missouri	St. Joseph Lead Co.	Lead ore.
4	Indian Creek	do	do	do	Do.
5	Lucky Friday	Coeur d'Alene	Idaho	Lucky Friday Silver-Lead Mines Co.	Do.
6	Bunker Hill	do	do	The Bunker Hill Co.	Lead-zinc ore.
7	Star	do	do	do	Do.
8	Treasury Tunnel-Black Bear-Smuggler Union.	Upper San Miguel.	Colorado	Idarado Mining Co.	Copper-lead-zinc ore.
9	Bonne Terre	Southeastern Missouri.	Missouri	St. Joseph Lead Co.	Lead ore.
10	Madison	do	do	National Lead Co.	Lead-copper ore.
11	Iron King	Big Bug	Arizona	Shattuck-Denn Mining Corp.	Lead-zinc ore.
12	Pend Oreille	Metaline	Washington	Pend Oreille Mines and Metals Co.	Do.
13	United Park City	Uintah	Utah	United Park City Mines Co.	Lead-zinc-copper ore.
14	Viburnum	Southeastern Missouri.	Missouri	St. Joseph Lead Co.	Lead ore.
15	Eagle	Red Cliff (Battle Mountain).	Colorado	The New Jersey Zinc Co.	Copper, lead-zinc ore.
16	Mayflower-Galena	Blue Ledge	Utah	New Park Mining Co.	Lead-zinc ore
17	Page	Coeur d' Alene	Idaho	American Smelting and Refining Company.	Do.
18	Austinville	Austinville	Virginia	The New Jersey Zinc Co.	Zinc-lead ore.
19	Emperius	Creede	Colorado	Emperius Mining Co.	Lead-zinc ore.
20	Butte Mines	Summit Valley	Montana	The Anaconda Company.	Zinc ore.
21	Sunshine	Coeur d'Alene	Idaho	Sunshine Mining Co.	Silver ore.
22	Grandview	Metaline	Washington	American Zinc, Lead and Smelting Co.	Lead-zinc ore.
23	Rico-Argentine	Pioneer	Colorado	Rico-Argentine Mining Co.	Do.
24	Linchburg Group	Magdalena	New Mexico	The New Jersey Zinc Co., Empire Zinc Division	Do.
25	Flux	Harshaw	Arizona	Nash & McFarland	Do.

SMELTER AND REFINERY PRODUCTION

Refined lead was produced in the United States at primary refineries that treated ore, base bullion, and small quantities of scrap, and at secondary plants that process scrap exclusively. The lead was derived from three principal sources—domestic mine production, imports of foreign ore and base bullion, and scrap material (treated largely at secondary smelters). Refined lead and antimonial (hard) lead were produced at both primary and secondary plants. Antimonial lead was the principal product at secondary plants because the smelter feed was composed largely of hard lead, much of it in the form of battery scrap.

The four smelters, five combination smelter-refineries, and two refineries which treated ore, base bullion, and other primary materials in 1960 are listed below:

- Smelters:
  - American Smelting and Refining Co.:
    - Leadville (Arkansas Valley), Colo.
    - East Helena, Mont.
    - El Paso, Tex.
  - International Smelting and Refining Co.:
    - Tooele, Utah
- Smelter-refineries:
  - American Smelting and Refining Co.:
    - Selby, Calif.
    - Barber (Perth Amboy), N.J.
  - Bunker Hill Co.:
    - Kellogg, Idaho
  - St. Joseph Lead Co.:
    - Herculaneum, Mo.
  - The Eagle-Picher Co.:
    - Galena, Kans.
- Refineries:
  - United States Smelting Lead Refinery, Inc.:
    - East Chicago, Ind.
  - American Smelting and Refining Co.:
    - Omaha, Nebr.

The list of major secondary smelting firms and their plant locations presented in the 1959 Lead Chapter remained virtually unchanged.

Refined Lead—Primary and Secondary.—Domestic primary lead smelters and refineries produced 387,200 tons of refined lead and 28,700 tons of lead in antimonial lead. Lead content of primary raw materials consumed was 425,900 tons; that of scrap was 34,100 tons.

Domestic ores were the source of 60 percent (66 percent in 1959) of the 382,400 tons of refined lead produced from primary sources, and foreign ores and bullion supplied 40 percent (34 percent in 1959).

Primary lead smelters also produced 4,800 tons of refined lead from scrap and secondary smelters 143,400 tons from scrap. Refined and remelt lead from all sources was 530,700 tons.

Antimonial Lead—Primary and Secondary.—Antimonial lead production at primary and secondary smelters was 221,700 tons (207,900 tons lead content), 28,700 tons (lead content) from primary smelters, and 179,200 tons from secondary smelters. Scrap was the source of 92 percent of the primary smelter output (mostly battery-lead plates); 4 percent came from domestic ores and 4 percent from foreign ores. Battery-lead plates accounted for 63 percent of the total lead-base scrap melted, and antimonial lead was the major product recovered.

Other Secondary Lead.—Secondary lead recovered by all plants consuming lead-base and tin-base scrap totaled 470,000 tons—an increase of 4 percent over 1959. Secondary lead smelters recovered 86 percent of the total in 235 plants; primary lead smelters 7 percent in 4 plants; and manufacturers, foundries, and secondary copper smelters, combined, 7 percent.

TABLE 6.—Refined lead produced at primary refineries in the United States, by source material

(Short tons)

	1951-55 (average)	1956	1957	1958	1959	1960
Refined lead:						
From primary sources:						
Domestic ores and base bullion	339,483	349,188	347,675	269,082	225,270	228,899
Foreign ores	124,601	193,084	185,798	200,299	115,616	153,537
Foreign base bullion	777	36	60	775	45	----------
Total	464,861	542,308	533,533	470,156	340,931	382,436
From secondary sources	4,064	4,069	3,263	2,338	1,194	4,776
Grand total	468,925	546,377	536,796	472,494	342,125	387,212
Average sales price per pound	$0.150	$0.157	$0.143	$0.117	$0.115	$0.117
Calculated value of primary refined lead thousands [1]	$139,458	$170,285	$152,590	$110,017	$78,414	$89,490

[1] 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
1951-55 (average)	61,960	4,084	6.6	10,225	8,520	39,131	57,876
1956	66,826	3,348	5.0	6,739	6,918	49,821	63,478
1957	67,786	3,064	4.5	10,271	9,599	44,852	64,722
1958	50,246	2,803	5.6	8,256	8,190	30,997	47,443
1959	37,487	1,924	5.1	6,447	5,955	23,161	35,563
1960	30,230	1,575	5.2	1,216	1,169	26,270	28,655

TABLE 8.—Stocks and consumption of new and old lead scrap in the United States in 1960

(Short tons, gross weight)

Class of consumers and type of scrap	Stocks Jan. 1 [1]	Receipts	Consumption			Stocks Dec. 31
			New scrap	Old scrap	Total	
Smelters and refiners:						
Soft lead	2,925	51,473		50,919	50,919	3,479
Hard lead	932	16,331		16,311	16,311	952
Cable lead	1,894	29,812		30,052	30,052	1,654
Battery-lead plates	28,615	371,749		382,262	382,262	18,102
Mixed common babbitt	1,008	5,107		4,971	4,971	1,144
Solder and tinny lead	591	9,481		9,638	9,638	434
Type metals	1,080	24,877		24,163	24,163	1,794
Drosses and residues	16,621	82,056	80,625		80,625	18,052
Total	53,666	590,886	80,625	518,316	598,941	45,611
Foundries and other manufacturers:						
Soft lead	39	511	175	263	438	112
Hard lead	153	284	4	250	254	183
Cable lead	40	303		256	256	87
Battery-lead plates	88	472		505	505	55
Mixed common babbitt	234	9,534		9,497	9,497	271
Solder and tinny lead	9	132	74	63	137	4
Type metals						
Drosses and residues	252	77	1		1	328
Total	815	11,313	254	10,834	11,088	1,040
Grand total:						
Soft lead	2,964	51,984	175	51,182	51,357	3,591
Hard lead	1,085	16,615	4	16,561	16,565	1,135
Cable lead	1,934	30,115		30,308	30,308	1,741
Battery-lead plates	28,703	372,221		382,767	382,767	18,157
Mixed common babbitt	1,242	14,641		14,468	14,468	1,415
Solder and tinny lead	600	9,613	74	9,701	9,775	438
Type metals	1,080	24,877		24,163	24,163	1,794
Drosses and residues	16,873	82,133	80,626		80,626	18,380
Total	54,481	602,199	80,879	529,150	610,029	46,651

[1] Revised figures.

TABLE 9.—Secondary metal recovered [1] from lead and tin scrap in the United States in 1960, by type of products

(Short tons, gross weight)

	Lead	Tin	Antimony	Other	Total
Refined pig lead	119,366				119,366
Remelt lead	28,853				28,853
Total	148,219				148,219
Refined pig tin		3,091			3,091
Remelt tin		287			287
Total		3,378			3,378
Lead and tin alloys:					
Antimonial lead	205,487	364	12,594	186	218,631
Common babbitt	16,621	1,127	1,833	113	19,694
Genuine babbitt	42	265	27	10	344
Solder	24,754	5,058	357	97	30,266
Type metals	30,887	1,802	4,879	118	37,686
Cable lead	27,786	6	273		28,065
Miscellaneous alloys	1,210	429	141	78	1,858
Total	306,787	9,051	20,104	602	336,544
Composition foil					
Tin content of chemical products		1,015			1,015
Grand total	455,006	13,444	20,104	602	489,156

[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)

	1951–55 (average)	1956	1957	1958	1959	1960
As refined metal:						
At primary plants	4,064	4,069	3,263	2,338	1,194	4,776
At other plants	132,720	129,323	123,308	113,719	124,185	143,443
Total	136,784	133,392	126,571	116,057	125,379	148,219
In antimonial lead:						
At primary plants	39,131	49,821	44,852	30,997	23,161	26,270
At other plants	196,071	202,761	195,299	151,956	181,185	179,217
Total	235,202	252,582	240,151	182,953	204,346	205,487
In other alloys	119,837	120,781	122,507	102,777	121,662	116,197
Grand total:						
Quantity	491,823	506,755	489,229	401,787	451,387	469,903
Value (thousands)	$147,986	$159,121	$139,919	$94,018	$103,819	$109,957

TABLE 11.—Lead recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

Kind of scrap	1959	1960	Form of recovery	1959	1960
New scrap:			As soft lead:		
Lead-base	52,101	55,856	At primary plants	1,194	4,776
Copper-base	6,098	5,214	At other plants	124,185	143,443
Tin-base	426	436	Total	125,379	148,219
Total	58,625	61,506	In antimonial lead [1]	204,346	205,487
Old scrap:			In other lead alloys	96,282	101,258
Battery-lead plates	241,639	255,879	In copper-base alloys	25,342	14,897
All other lead-base	129,848	134,011	In tin-base alloys	38	42
Copper-base	21,272	18,502			
Tin-base	3	5	Total	326,008	321,684
Total	392,762	408,397	Grand total	451,387	469,903
Grand total	451,387	469,903			

[1] Includes 23,161 tons of lead recovered in antimonial lead from secondary sources at primary plants in 1959 and 26,270 tons in 1960.

CONSUMPTION AND USES

The relatively high level of industrial activity in the first quarter, combined with a substantial drawdown in domestic producer stocks of lead, gave rise to optimistic forecasts of rising consumption of lead metal. Monthly consumption through the first quarter confirmed the forecasts, but a downtrend began in the second quarter and continued through the third and fourth quarters. Consumption for the year was 6 percent below 1959. The development of competitive materials and technological improvements were partly responsible for the decline. Consumption decreased for all uses except tetraethyl lead, red lead and litharge, annealing and galvanizing, terne metal, type metal, and weights and ballast, which showed slight increases.

Soft lead, primary and secondary, accounted for 66 percent of the total consumed; 24 percent was lead content of antimonial lead; 4 percent was lead in alloys; 1.6 percent was lead in copper-base scrap;

4 percent was lead content of scrap which went directly to an end product; and 0.4 percent was lead recovered from ore in the production of leaded zinc oxide and other pigments.

Monthly consumption varied throughout the year. The high of 91,100 tons and the low of 75,400 tons were reached in March and July, respectively.

Of the lead consumed during the year, 71 percent went to metal products, the largest quantity being for storage batteries (35 percent of all lead consumed), which took antimonial lead for grids and posts, and soft lead for oxides. The second largest quantity (16 percent) was used for chemicals, 98 percent of which was for tetraethyl lead. Lead pigments used 10 percent, and 76 percent of the lead used in pigments was for manufacturing red lead and litharge.

The two largest uses of lead, batteries and tetraethyl lead, which together represented about 50 percent of the total consumption, were related directly to the automotive industry.

TABLE 12.—Lead consumption in the United States, by products

(Short tons)

Product	1959	1960	Product	1959	1960
Metal products:			Pigments—Continued		
Ammunition	45,328	43,577	Pigment colors	13,827	11,445
Bearing metals	23,298	20,717	Other [1]	4,773	3,763
Brass and bronze	24,264	20,485			
Cable covering	61,626	60,350	Total	103,671	98,541
Calking lead	80,091	66,527			
Casting metals	8,395	7,023	Chemicals:		
Collapsible tubes	9,442	8,705	Tetraethyl lead	160,020	163,826
Foil	3,745	3,684	Miscellaneous chemicals	4,485	2,806
Pipes, traps, and bends	24,825	22,119			
Sheet lead	28,158	26,607	Total	164,505	166,632
Solder	68,871	60,013			
Storage batteries:			Miscellaneous uses:		
Anitimonial lead	187,284	175,458	Annealing	5,129	5,153
Lead oxides	193,448	177,738	Galvanizing	1,184	1,383
Terne metal	1,511	1,765	Lead plating	302	218
Type metal	27,966	28,159	Weights and ballast	8,748	9,045
Total metal products	788,252	722,927	Total	15,363	15,799
Pigments:			Other, unclassified uses	19,358	17,273
White lead	10,955	8,432			
Red lead and litharge	74,116	74,901	Grand total [2]	1,091,149	1,021,172

[1] Includes lead content of leaded zinc oxide and other pigments.
[2] Includes lead which went directly from scrap to fabricated products.

TABLE 13.—Lead consumption in the United States, by months

(Short tons)

Month	1959	1960	Month	1959	1960
January	89,122	86,781	August	92,601	90,069
February	85,124	84,563	September	95,162	86,640
March	85,431	91,055	October	97,698	85,806
April	91,564	83,011	November	84,903	83,022
May	96,443	90,321	December	86,168	77,263
June	96,285	87,197			
July	90,648	75,444	Total [1]	1,091,149	1,021,172

[1] Includes lead content of leaded zinc oxide and other pigments and lead which went directly from scrap to fabricated products.

TABLE 14.—Lead consumption in the United States in 1960, by class of products and types of material

(Short tons)

Product	Soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
Metal products	209,880	63,994	40,451	16,074	330,399
Storage batteries	177,738	175,458			353,196
Pigments	94,778	171			94,949
Chemicals	166,629	3			166,632
Miscellaneous	9,515	6,234	50		15,799
Unclassified	15,114	1,351	491		16,956
Total	673,654	247,211	40,992	16,074	[1] 977,931

[1] Excludes 39,649 tons of lead that went directly from scrap to fabricated products and 3,592 tons of lead contained in leaded zinc oxide and other pigments.

TABLE 15.—Lead consumption, by States in 1960 [1]

(Short tons)

State	Refined soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
California	74,153	23,616	1,901	738	100,408
Colorado	1,379	1,710	152	120	3,361
Connecticut	14,141	10,174	17	905	25,237
District of Columbia	122	51			173
Florida	1,730	3,476			5,206
Illinois	65,316	24,581	6,806	2,082	98,785
Indiana	52,279	32,318	2,169	684	87,450
Kansas	6,474	9,602			16,076
Kentucky	5	2,351	(2)		2,356
Maryland	5,723	12,996	835		19,554
Massachusetts	5,973	3,991	970	561	11,495
Michigan	11,199	12,218	995	713	25,125
Missouri	51,180	3,355	172	1,467	56,174
Nebraska	10,677	3,612		50	14,339
New Jersey	114,563	21,354	8,588	681	145,186
New York	37,078	4,860	9,279	1,186	52,403
Ohio	11,177	5,245	3,456	1,118	20,996
Pennsylvania	34,577	20,267	631	2,306	57,781
Rhode Island	2,411	283	85		2,779
Tennessee	275	6,722	205	307	7,509
Virginia	1,722	1,125	577	940	4,364
Washington	8,653	4,250			12,903
West Virginia	13,619	2,456			16,075
Wisconsin	686	2,753	120	141	3,700
Alabama, Georgia, and Mississippi [3]	27,376	8,191	1,512	561	37,640
Arkansas and Oklahoma	2,782	2,133	15		4,930
Hawaii and Oregon	696	2,085	(2)	265	3,046
Iowa and Minnesota	937	6,282	511	675	8,405
Louisana and Texas	111,365	10,671	1,615	350	124,001
Montana and Idaho	1,396				1,396
New Hampshire, Maine, and Delaware	3,254	1,086	369	224	4,933
North and South Carolina	26	2,467			2,493
Utah, Nevada, and Arizona	134	582			716
Undistributed	576	348	12		936
Total	673,654	247,211	40,992	16,074	977,931

[1] Excludes 39,649 tons of lead which went directly from scrap to fabricated products and 3,592 tons of lead contained in leaded zinc oxide and other nonspecified pigments.
[2] Included in "Undistributed" to avoid disclosing individual company confidential data.
[3] The following States are grouped to avoid disclosing individual company confidential data.

Shipments of 26,329,600 units of replacement batteries were reported by the Association of Battery Manufacturers, Inc., 4 percent below the record output of 27,495,400 batteries shipped in 1959.

Nine States accounted for 74 percent of the total lead consumed (excluding scrap). New Jersey used 15 percent; Louisiana and Texas combined, 13 percent; California and Illinois, 10 percent each; Indiana, 9 percent; Pennsylvania and Missouri, 6 percent each; and New York, 5 percent.

LEAD PIGMENTS[6]

Production of lead pigments declined in 1960. The major lead-pigment-consuming industries fared as follows: The production of automobiles and trucks rose 17 percent; the value of public and private construction increased slightly; paint sales were unchanged; and the combined consumption of natural and synthetic rubber declined 3 percent.

Production.—Lead shipped to manufacturers of lead pigments totaled about 265,000 tons compared with 280,000 tons in 1959, a decrease of 6 percent.

White lead, red lead, litharge, and black oxide were made from refined lead and again constituted 99 percent of all lead used in pigments. The remaining 1 percent of the lead came from ores from which leaded zinc oxide was produced. Basic lead sulfate production is withheld to avoid disclosing individual company confidential data. Lead silicate, as it is derived from litharge, is included with litharge.

Consumption and Uses.—*White Lead.*—Shipments of white lead decreased 7 percent. The requirements of the paintmaking and ceramic industries were 79 and 1 percent, respectively, of the total, unchanged from 1959. Other uses for the pigments were in chemicals, greases, plasticizers, and stabilizers for plastics. A substantial part of the amount listed as "Other" belongs properly under paint.

Basic Lead Sulfate.—Most of the lead sulfate was used in making leaded zinc oxide. Production figures are withheld to avoid disclosing individual company confidential data.

Red Lead.—The paint industry used 57 percent of the red lead consumed, compared with 55 percent in 1959. Other uses were in colors, lubricants, petroleum, rubber, and unspecified miscellaneous products.

Orange Mineral.—No consumption of this pigment was reported.

Litharge.—"Other" uses (77 percent) continued to claim most of the litharge shipped to industry. Battery makers were the largest single consumer; chemicals, chrome pigment, driers, floor covering, friction material, ink, insecticides, and unspecified uses made up the remainder of "Other" uses. Ceramics received 16 percent, varnish 4 percent, oil refining 2 percent, and rubber 1 percent. Battery makers produced

[6] Prepared by John E. Shelton, commodity specialist, and Esther B. Miller, statistical assistant.

140,000 tons of leaded litharge, commonly called black oxide or gray suboxide, for making the paste used in filling the interstices of battery plates.

Prices.—The quoted price of white lead was 18 cents a pound, or $360 a ton in carlots in 1960. The average value of shipments of dry white lead was $408 a ton, up $26 from 1959; the in-oil variety was down $13 to $455. The quoted price of red lead varied from 14.75 to 15.75 cents a pound, or $295 to $315 a ton in less than carlots; average value of shipments decreased $8 to $302 a ton. The quoted price of litharge ranged from 14.25 to 15.25 cents a pound, or $285 to $315 a ton in less than carlots; average value of shipments decreased $2 a ton to $273.

TABLE 16.—Production and shipments of lead pigments[1] in the United States

Pigment	1959				1960			
	Production (short tons)	Shipments			Production (short tons)	Shipments		
		Short tons	Value[2]			Short tons	Value[2]	
			Total	Average per ton			Total	Average per ton
White lead:								
Dry	12,352	12,436	$4,751,792	$382	11,409	11,770	$4,805,726	$408
In oil[3]	6,540	6,788	3,174,138	468	6,115	6,172	2,810,238	455
Total	18,892	19,224	7,925,930		17,524	17,942	7,615,964	
Red lead	21,949	21,905	6,789,381	310	22,518	22,631	6,843,301	302
Litharge	105,686	106,013	29,119,870	275	98,786	98,640	26,951,157	273
Black oxide	152,341				139,847			

[1] Except for basic lead sulfate, figures withheld to avoid disclosing individual company confidential data.
[2] At plant, exclusive of container.
[3] Weight of white lead only, but value of paste.

TABLE 17.—Lead content of lead and zinc pigments[1] produced by domestic manufacturers, by sources

(Short tons)

Pigment	1959				1960			
	Lead in pigments produced from—			Total lead in pigments	Lead in pigments produced from—			Total lead in pigments
	Ore		Pig lead		Ore		Pig lead	
	Domestic	Foreign			Domestic	Foreign		
White lead			15,114	15,114			14,019	14,019
Red lead			19,974	19,974			20,491	20,491
Litharge			98,288	98,288			96,810	96,810
Black oxide			147,066	147,066			133,638	133,638
Leaded zinc oxide	2,500	1,405		3,905	2,355	667		3,022
Total	2,500	1,405	280,442	284,347	2,355	667	264,958	267,980

[1] Excludes lead in basic lead sulfate; figures withheld to avoid disclosing individual company confidential data.

TABLE 18.—Distribution of white lead (dry and in oil) shipments,[1] by industries

(Short tons)

Industry	1951–55 (average)	1956	1957	1958	1959	1960
Paints	22,345	20,288	19,253	15,288	15,148	14,145
Ceramics	877	633	667	268	243	219
Other	4,666	[2] 4,777	[2] 3,654	[2] 2,804	[2] 3,833	[2] 3,578
Total	27,888	25,698	23,574	18,360	19,224	17,942

[1] Excludes basic lead sulfate; figures withheld to avoid disclosing individual company confidential data.
[2] Figures for plasticizers and stabilizers withheld to avoid disclosing individual company confidential data.

TABLE 19.—Distribution of red lead shipments, by industries

(Short tons)

Industry	1951–55 (average)	1956	1957	1958	1959	1960
Paints	13,867	14,331	15,993	13,726	12,098	12,903
Storage batteries	13,710	9,953	(1)	(1)	(1)	(1)
Ceramics	857	1,483	(1)	(1)	(1)	328
Other	2,375	2,208	11,005	8,266	9,807	9,400
Total	30,809	27,975	26,998	21,992	21,905	22,631

[1] Included with "Other."

TABLE 20.—Distribution of litharge shipments, by industries

(Short tons)

Industry	1951–55 (average)	1956	1957	1958	1959	1960
Ceramics	20,187	19,802	18,071	(1)	15,340	15,753
Chrome pigments	7,735	3,558	3,955	3,731	4,682	(1)
Floor coverings	913	(1)	(1)	(1)	(1)	(1)
Insecticides	3,348	(1)	(1)	(1)	(1)	(1)
Oil refining	4,424	3,523	3,359	2,598	3,096	2,371
Rubber	2,139	2,266	1,298	1,247	1,808	1,373
Storage batteries	96,085	82,041	(1)	(1)	(1)	(1)
Varnish	4,888	3,571	3,227	3,223	4,725	3,471
Other	7,972	16,764	76,878	81,366	76,362	75,672
Total	147,691	131.525	106,788	92,165	106,013	98,640

[1] Included with "Other."

TABLE 21.—U.S. imports for consumption of lead pigments and compounds

Kind	1959		1960	
	Short tons	Value (thousands)	Short tons	Value (thousands)
White lead	1,073	$323	1,497	$461
Red lead	463	95	537	111
Litharge	11,382	2,218	13,371	2,581
Other lead pigments	30	5	23	9
Other lead compounds	280	54	301	62
Total	13,233	2,695	15,729	3,224

Source: Bureau of the Census.

Foreign Trade.—Imports of lead pigments and salts increased 20 percent in value and 19 percent in quantity compared with 1959. Imports of white lead, red lead, litharge, and other lead compounds increased 40, 15, 17, and 8 percent, respectively, over 1959; other lead pigments decreased 7 tons (23 percent).

Exports of lead pigments and salts declined 20 percent in value and 21 percent in quantity compared with 1959. Exports of lead arsenate increased 35 percent. Data were not available for other lead compounds.

TABLE 22.—U.S. exports of lead pigments and compounds

Kind	1959		1960	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Lead pigments [1]	3,178	$1,054	2,118	$705
Lead arsenate	699	276	944	355
Total	3,877	1,330	3,062	1,060

[1] Includes white lead, red lead, and litharge.

Source: Bureau of the Census.

STOCKS

The decline in stocks of refined lead at primary producing plants, which began in March of 1959, continued through the first quarter of 1960 to a low of 95,400 tons on March 31. An upturn began in April, however, and continued through the remaining three quarters of the year. Yearend stocks, which represented physical inventories at the plants, irrespective of ownership, and did not include material in process or in transit, were 250,100 tons.

Stocks reported by the American Bureau of Metal Statistics showed an additional 25,000 tons of bullion in process at, or in transit to, refineries and about 24,000 tons of ore in process at smelters—a total of nearly 299,100 tons of primary raw materials in stocks at these plants.

Consumer and secondary smelter stocks of lead increased from 120,500 tons on January 31 to 128,200 tons on May 31, declined slightly in June, reached a peak of 128,400 tons by the end of August, and then declined to 97,300 tons by the end of December. The yearend total was 23 percent below 1959.

TABLE 23.—Stocks of lead at primary smelters and refineries in the United States, Dec. 31

(Short tons)

Stocks	1951–55 (average)	1956	1957	1958	1959	1960
Refined pig lead	43,151	30,237	74,194	176,098	107,683	148,415
Lead in antimonial lead	10,820	10,740	11,079	11,811	11,361	10,483
Lead in base bullion	14,052	11,141	8,855	9,485	12,840	26,025
Lead in ore and matte	38,987	44,925	49,788	36,896	39,195	65,219
Total	107,010	97,043	143,916	234,290	171,079	250,142

TABLE 24.—Consumer stocks of lead in the United States, Dec. 31, by types of material

(Short tons, lead content)

Year	Refined soft lead	Antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
1956	73,673	40,226	8,007	2,089	123,995
1957	80,708	39,375	7,651	1,576	129,310
1958	76,924	37,511	7,056	1,409	122,900
1959	80,277	38,688	6,435	1,096	126,496
1960	49,725	39,230	7,216	1,097	97,268

PRICES

The quoted New York price for common lead was 12 cents a pound on January 1. This price held constant until December 13 when the price dropped to 11 cents. It remained at that level to the end of the year. The weak domestic market caused by decreased consumption and increased stocks was largely responsible for the decline in prices.

Quotations on the London Metal Exchange ranged from a low of £61.75 per long ton on December 29 (equivalent to 7.74 cents a pound U.S. currency—computed on the average monthly rate of exchange) to a high of £78.50 (9.83 cents a pound) on May 24. The bid quotation on December 31 was £62.00 a long ton (7.77 cents a pound) and the average for the year was £72.15 (9.04 cents a pound).

TABLE 25.—Average monthly and yearly quoted prices of lead at St. Louis, New York, and London [1]

(Cents per pound)

Month	1959			1960		
	St. Louis	New York	London [2]	St. Louis	New York	London [2]
January	12.42	12.62	9.00	11.80	12.00	9.35
February	11.38	11.58	8.77	11.80	12.00	9.24
March	11.21	11.43	8.73	11.80	12.00	9.55
April	11.00	11.20	8.68	11.80	12.00	9.72
May	11.70	11.90	8.90	11.80	12.00	9.70
June	11.80	12.00	8.75	11.80	12.00	9.18
July	11.80	12.00	8.82	11.80	12.00	8.93
August	12.07	12.27	9.05	11.80	12.00	8.90
September	12.80	13.00	8.85	11.80	12.00	8.78
October	12.80	13.00	8.85	11.80	12.00	8.44
November	12.80	13.00	9.03	11.80	12.00	8.56
December	12.32	12.52	9.08	11.18	11.38	8.14
Average	12.01	12.21	8.88	11.75	11.95	9.04

[1] St. Louis: Metal Statistics, 1961, p. 491. New York: Metal Statistics, 1961, p. 485. London: E&MJ Metal and Mineral Markets.
[2] Based on monthly average rates of exchange by Federal Reserve Board.

FOREIGN TRADE

Imports.—General imports of lead were 12 percent under 1959. The decline was attributed partly to the failure of Peru and Mexico to meet import quota goals. Imports of ore and concentrate increased 5 percent, and bullion 266 percent, but pigs and bars and scrap decreased 22 and 8 percent, respectively. About 57 percent of the lead imported was pigs and bars, 41 percent ores and concentrates, and the remaining 2 percent scrap and bullion. Mexico, Australia, Yugoslavia, Canada, and Peru were the major suppliers of lead metal. Imports of ores and concentrates were supplied largely by the Union of South Africa, Peru, Canada, and Australia.

Exports.—Total lead exported, although slightly more than in 1959, totaled only 5,843 tons. The increase was accounted for entirely by larger exports of scrap, ore, matte, and base bullion, as exports of pigs and bars declined from 2,756 tons in 1959 to 1,967 tons in 1960.

Tariff.—The duties on pig lead and lead content of ores and concentrates remained $1\frac{1}{16}$ cents and $\frac{3}{4}$ cent a pound, respectively. Duties on scrap were the same as on pig lead.

TABLE 26.—U.S. imports[1] of lead, by countries

(Short tons, lead content)

Country	1951–55 (average)	1956	1957	1958	1959	1960
Ore, flue dust, and matte:						
North America:						
Canada	26,445	30,692	25,193	22,270	[2] 32,226	26,417
Greenland	----------	----------	----------	5,276	----------	----------
Guatemala	4,235	6,904	8,965	5,019	[2] 153	1,809
Honduras	1,292	2,969	2,955	3,581	3,639	4,906
Mexico	2,566	3,866	3,835	1,786	489	1,249
Other North America	89	8	113	45	195	----------
Total	34,627	44,439	41,061	37,977	[2] 36,702	34,381
South America:						
Bolivia	16,441	17,177	18,319	14,715	[2] 11,221	9,021
Chile	1,813	118	35	367	113	1,283
Colombia	240	1,440	1	851	[2] 570	706
Peru	32,192	55,174	55,756	70,757	[2] 36,777	36,439
Other South America	73	184	1,078	145	53	103
Total	50,759	74,093	75,189	86,835	[2] 48,734	47,552
Europe	226	24	264	246	221	222
Asia:						
Philippines	2,202	2,222	783	1,169	[2] 310	213
Other Asia	68	422	246	317	25	504
Total	2,270	2,644	1,029	1,486	[2] 335	717
Africa:						
Morocco[3]	527	----------	----------	----------	----------	5,363
Union of South Africa	28,013	44,208	43,916	49,215	27,879	39,352
Other Africa	41	----------	25	1	----------	----------
Total	28,581	44,208	43,941	49,216	27,879	44,715
Oceania: Australia	17,894	31,044	36,995	25,839	[2] 24,963	18,366
Total ore, flue dust, and matte	134,357	196,452	198,479	201,599	[2] 138,834	145,953
Base bullion:						
North America	201	31	----------	8	34	254
South America	69	----------	84	452	46	39
Europe	(4)	----------	----------	----------	----------	----------
Asia	----------	----------	(4)	----------	----------	----------
Oceania	446	----------	----------	----------	----------	----------
Total base bullion	716	31	84	460	80	293
Pigs and bars:						
North America:						
Canada	60,966	16,220	28,607	40,926	41,533	26,088
Mexico	107,735	77,541	102,504	122,864	86,827	69,930
Other North America	50	----------	(4)	----------	324	9
Total	168,751	93,761	131,111	163,790	128,684	96,027

See footnotes at end of table.

TABLE 26.—U.S. imports[1] of lead, by countries—Continued

(Short tons, lead content)

Country	1951-55 (average)	1956	1957	1958	1959	1960
Pigs and bars—Continued						
South America:						
Peru	34,094	33,540	34,999	42,473	29,311	25,197
Other South America	173		1,601	146		
Total	34,267	33,540	36,600	42,619	29,311	25,197
Europe:						
Belgium-Luxembourg	941	1,206	1,852	5,872	1,503	610
Germany [5]	2,418	168	1,550	3,118	2,893	551
Spain	4,347	6,700	3,119	14,237	9,395	4,115
United Kingdom	1,619	115	2,666	8,836	988	7
Yugoslavia	43,252	38,901	40,262	36,789	32,731	30,027
Other Europe	2,670	2,162	2,584	2,139	4,872	1,388
Total	55,247	49,252	52,033	70,991	52,382	36,698
Asia	41					
Africa: Morocco [3]	[6] 8,802	[7] 5,428	9,018	10,537	[6] 5,384	1,328
Oceania: Australia	55,944	80,673	95,517	80,515	47,655	46,783
Total pigs and bars	323,052	262,654	324,279	368,452	263,416	206,033
Reclaimed, scrap, etc.:						
North America:						
Canada	3,754	5,898	2,558	1,908	2,251	4,059
Mexico	2,095	9,701	2,583	1,939	1,293	1,054
Other North America	1,255	1,549	652	420	245	160
Total	7,104	17,148	5,793	4,267	3,789	5,273
South America:						
Peru	171	299	4	48	(4)	
Venezuela	503	230				
Other South America	44		53		120	
Total	718	529	57	48	120	
Europe:						
Belgium-Luxembourg	156	117		7		
Denmark	69	1,000	84			
Germany [5]	12	348	168		1	1
Netherlands	217	157				
Other Europe	399	179	32			4
Total	853	1,801	284	7	1	5
Asia:						
Japan (including Nansei and Nanpo Islands)	170	4		19	18	5
Other Asia	108	1				
Total	278	5		19	18	5
Africa	3					
Oceania:						
Australia	1,572	1,255	3,079	2,229	4,351	2,355
Other Oceania	103					
Total	1,675	1,255	3,079	2,229	4,351	2,355
Total reclaimed, scrap, etc	10,631	20,738	9,213	6,570	8,279	7,638
Grand total	468,756	479,875	532,055	577,081	[2] 410,609	359,917

[1] Data are "general imports"; that is, they include lead imported for immediate consumption plus material entering the country under bond.
[2] Revised figure.
[3] French Morocco prior to Jan. 1, 1957.
[4] Less than 1 ton.
[5] West Germany, effective Jan. 1, 1952.
[6] Includes 90 tons from Northern Rhodesia in 1951-55 (average) and from the Federation of Rhodesia and Nyasaland, 1,052 tons in 1959, and 224 tons in 1960.
[7] Includes material classified by the Bureau of the Census as being from Algeria but believed by Bureau of Mines to be from French Morocco.

Source: Bureau of the Census.

TABLE 27.—U.S. imports for consumption[1] of lead, by countries

(Short tons)

Country	1951–55 (average)	1956	1957	1958	1959	1960
Ore, flue dust, and matte (lead content):						
North America:						
Canada	26,225	26,733	30,302	31,394	[2] 28,633	27,944
Greenland				5,276		
Guatemala	3,610	5,613	12,129	4,944	157	1,519
Honduras	565	3,018	6,108	3,577	3,649	4,457
Mexico	1,904	2,829	6,602	3,167	627	943
Other North America	97	1	16	12	8	
Total	32,401	38,194	55,157	48,370	[2] 33,074	34,863
South America:						
Bolivia	10,632	19,771	14,874	22,501	[2] 10,822	10,581
Chile	4,369	2,957	1,758	88	113	27
Colombia	131	852	1,000	850	[2] 370	628
Peru	25,132	58,363	50,506	92,027	[2] 38,872	33,716
Other South America	262	152	676	465	56	103
Total	40,526	82,095	68,814	115,931	[2] 50,233	45,055
Europe	208	24		21	107	(3)
Asia:						
Philippines	2,202	2,227	816	1,169	293	188
Other Asia	69	187	308	311	25	427
Total	2,271	2,414	1,124	1,480	318	615
Africa:						
Morocco [4]	526					5,363
Union of South Africa	21,956	35,417	65,289	37,993	28,939	30,784
Other Africa	38		25	1	1,821	
Total	22,520	35,417	65,314	37,994	30,760	36,147
Oceania:						
Australia	13,776	32,999	44,207	33,829	[2] 22,034	20,894
Other Oceania		159				
Total	13,776	33,158	44,207	33,829	[2] 22,034	20,894
Total ore, flue dust, and matte	111,702	191,302	234,616	237,625	[2] 136,526	137,574
Base bullion (lead content):						
North America	203	31		8	34	254
South America	10		25	408		39
Europe	(3)					
Asia			(3)			
Oceania	534					
Total base bullion	747	31	25	416	34	293
Pigs and bars (lead content):						
North America:						
Canada	60,966	16,220	28,607	40,926	41,478	26,154
Mexico	106,116	76,242	99,208	117,938	82,762	73,548
Other North America	50				261	29
Total	167,132	92,462	127,815	158,864	124,501	99,731
South America:						
Peru	34,070	33,540	34,999	42,533	29,311	25,197
Other South America	173		1,601	146		
Total	34,243	33,540	36,600	42,679	29,311	25,197
Europe:						
Belgium-Luxembourg	941	1,206	1,852	4,604	1,569	1,733
Denmark	1,524	1,389	1,916	1,452	187	88
Germany [5]	2,418	168	1,550	3,008	2,613	654
Spain	4,347	6,700	3,119	9,505	11,270	6,056
United Kingdom	1,619	115	2,666	8,556	1,035	133
Yugoslavia	43,251	38,901	40,262	36,789	32,376	30,159
Other Europe	1,142	773	667	507	2,984	1,877
Total	55,242	49,252	52,032	64,421	52,034	40,700
Asia	41					

See footnotes at end of table.

TABLE 27.—U.S. imports for consumption[1] of lead, by countries—Continued

(Short tons)

Country	1951–55 (average)	1956	1957	1958	1959	1960
Pig and bars—Continued						
Africa:						
Morocco[4]	8,712	[6] 5,428	9,018	9,760	5,032	1,243
Other Africa	110	849	726	----------	703	460
Total	8,822	6,277	9,744	9,760	5,735	1,703
Oceania: Australia	55,944	80,673	95,517	76,035	51,051	45,816
Total pigs and bars	321,424	262,204	321,708	351,759	262,632	213,147
Reclaimed, scrap, etc. (lead content):						
North America:						
Canada	3,781	5,881	2,558	1,787	2,396	4,053
Mexico	2,095	10,109	4,000	2,433	1,350	1,189
Other North America	1,265	1,542	645	228	602	220
Total	7,141	17,532	7,203	4,448	4,348	5,462
South America:						
Peru	171	299	4	274	(3)	----------
Venezuela	503	230	----------	----------	----------	----------
Other South America	44	----------	53	34	120	----------
Total	718	529	57	308	120	----------
Europe:						
Belgium-Luxembourg	156	117	----------	7	----------	----------
Denmark	69	1,000	84	----------	----------	----------
Germany[5]	12	348	168	278	1	1
Netherlands	217	157	----------	----------	----------	----------
Other Europe	398	179	32	172	----------	15
Total	852	1,801	284	457	1	16
Asia	278	4	----------	19	17	5
Africa	3	----------	----------	----------	----------	----------
Oceania:						
Australia	746	598	32	3,387	3,411	115
Other Oceania	102	----------	----------	----------	----------	----------
Total	848	598	32	3,387	3,411	115
Total reclaimed, scrap, etc	9,840	20,464	7,576	8,619	7,897	5,598
Sheets, pipe, and shot:						
North America:						
Canada	153	136	101	252	452	213
Canal Zone	----------	----------	19	----------	----------	----------
Mexico	272	6,830	4,770	559	----------	----------
Total	425	6,966	4,890	811	452	213
South America	14	----------	----------	----------	----------	----------
Europe	139	688	1,027	1,813	3,156	2,641
Asia	----------	----------	----------	1	(3)	1
Total sheets, pipe, and shot	578	7,654	5,917	2,625	3,608	2,855
Grand total	444,291	481,655	569,842	601,044	[2] 410,697	359,467

[1] Excludes imports for manufacture in bond and export, which are classified as "imports for consumption" by the Bureau of the Census.
[2] Revised figure.
[3] Less than 1 ton.
[4] French Morocco prior to Jan. 1, 1957.
[5] West Germany, effective Jan. 1, 1952.
[6] Includes material classified by the Bureau of the Census as being from Algeria but believed by the Bureau of Mines to be from French Morocco.

Source: Bureau of the Census.

TABLE 28.—U.S. imports for consumption of lead, by classes [1] [2]

Year	Lead in ores, flue dust or fume, and mattes, n.s.p.f. (lead content)		Lead in base bullion (lead content)		Pigs and bars (lead content)		Sheets, pipe, and shot		Not otherwise specified value (thousands)	Total value (thousands)
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)		
1951–55 (average)	111,702	[3] $28,492	747	$288	321,424	$93,088	578	[3] $171	$190	[3] $124,547
1956	191,302	50,621	31	11	262,204	[3] 77,719	7,654	2,017	[3] 184	[3] 135,820
1957	234,616	62,284	25	8	321,708	85,146	5,917	1,377	[3] 360	[3] 150,816
1958	237,625	50,772	416	136	351,759	71,404	2,625	596	446	124,795
1959	[4] 136,526	[4] 27,035	34	19	262,632	54,667	3,608	850	586	[4] 84,461
1960	137,574	27,816	293	[5] 62	213,147	45,017	2,855	696	710	75,335

[1] Excludes imports for manufacture in bond and export, which are classified as "imports for consumption" by the Bureau of the Census.
[2] In addition to quantities shown (value included in total value), "reclaimed, scrap, etc.," imported as follows—1951–55 (average): 9,840 tons, [3] $2,317,557; 1956: 20,464 tons, [3] $5,268,423; 1957: 7,576 tons, [3] $1,640,902; 1958: 8,619 tons, $1,440,639; 1959: 7,897 tons, $1,304,107; 1960: 5,598 tons, $1,034,141.
[3] Data known to be not comparable with other years.
[4] Revised figure.
[5] Adjusted by Bureau of Mines.

Source: Bureau of the Census.

TABLE 29.—U.S. imports for consumption of miscellaneous products containing lead

Year	Babbitt metal, solder, white metal, and other combinations containing lead			Type metal and antimonial lead		
	Gross weight (short tons)	Lead content (short tons)	Value (thousands)	Gross weight (short tons)	Lead content (short tons)	Value (thousands)
1951–55 (average)	2,009	1,237	[1] $1,710	9,024	7,935	[1] $3,110
1956	4,106	2,526	[1] 3,381	9,544	8,500	2,763
1957	3,502	2,100	[1] 3,049	5,275	4,858	1,527
1958	4,244	2,049	4,677	5,170	4,525	1,190
1959	11,840	3,751	16,820	5,612	5,020	1,204
1960	[1] 9,274	[1] 1,512	[1] 16,024	4,460	3,819	956

[1] Data known to be not comparable with other years.

Source: Bureau of the Census.

TABLE 30.—U.S. exports of lead, by countries [1]

(Short tons)

Destination	1951-55 (average)	1956	1957	1958	1959	1960
Ore, matte, base bullion (lead content):						
North America:						
Canada	492	6	54	----------	3	16
Mexico	264	1,049	851	912	108	107
Total	756	1,055	905	912	111	123
Europe	----------	----------	----------	30	----------	----------
Asia	17	----------	1	70	113	1,174
Total ore, matte, base bullion	773	1,055	906	1,012	224	1,297
Pigs, bars, anodes:						
North America:						
Canada	48	38	266	19	11	24
Cuba	38	44	62	33	37	10
Mexico	14	2	18	4	28	60
Other North America	87	53	136	79	153	149
Total	187	137	482	135	229	243
South America	466	306	194	96	93	18
Europe	12	2,128	560	3	9	30
Asia:						
Japan	6	1,176	2,305	----------	5	----------
Nansei and Nanpo Islands	1	5	16	7	3	----------
Philippines	158	180	451	427	473	34
Taiwan	17	2	224	566	1,916	1,536
Other Asia	120	688	106	125	27	103
Total	302	2,051	3,102	1,125	2,424	1,673
Africa	2	6	1	----------	1	2
Oceania	(2)	----------	----------	(2)	----------	1
Total pigs, bars, anodes	969	4,628	4,339	1,359	2,756	1,967
Scrap:						
North America	124	11	----------	5	7	1,220
South America	----------	----------	----------	----------	(2)	2
Europe:						
Belgium-Luxembourg	178	20	----------	----------	----------	6
Germany [3]	142	563	264	292	51	129
Netherlands	29	788	304	157	460	297
United Kingdom	803	554	125	382	513	851
Other Europe	107	14	55	178	110	74
Total	1,259	1,939	748	1,009	1,134	1,357
Asia:						
Japan	667	186	137	----------	----------	----------
Other Asia	----------	----------	----------	1	----------	(2)
Total	667	186	137	1	----------	(2)
Total scrap	2,050	2,136	885	1,015	1,141	2,579
Grand total	3,792	7,819	6,130	3,386	4,121	5,843

[1] In addition foreign lead was reexported as follows: Ore, matte, base bullion 1951-55 (average): Less than 1 ton; 1956: 6 tons; 1957: 4 tons; 1958-60: None. Pigs, bars, anodes, 1951-55 (average): 160 tons; 1956: 50 tons; 1957: 300 tons; 1958: 25 tons; 1959: 83 tons; 1960: None. Scrap: 1951-55 (average): 24 tons; 1956-58: None; 1959: 11 tons; 1960: None.
[2] Less than 1 ton.
[3] West Germany, effective Jan. 1, 1952.

Source: Bureau of the Census.

WORLD REVIEW[7]

World production of lead in 1960 was essentially equal to that of 1959 as voluntary curbs on output by some of the major free-world producing countries and U.S. import quotas continued in force. World smelter production was estimated at 2.6 million short tons and free-world consumption at 2.4 million tons, resulting in a further increase in stocks. This imbalance in supply and demand was one of the major problems of the free-world lead mining and refining industries. Demand for lead continued at a relatively strong rate in the European markets throughout the year, and Soviet lead was admitted to trading on the London Metal Exchange during the year.

NORTH AMERICA

Canada.[8]—Mine production from complex lead-zinc-copper ores at 19 mines reached 205,000 tons and refined lead output 160,000 tons. Refined-lead production came from Canada's only primary lead smelter, a unit of the smelting and refining works of the Consolidated Mining & Smelting Co. of Canada, Ltd., at Trail, British Columbia, which processed concentrates from the company-owned Sullivan, Bluebell, and H. B. mines in British Columbia and some purchased concentrates. Other lead ore and concentrate producers in British Columbia were Canadian Exploration, Ltd., at Salmo; Reeves-McDonald Mines, Ltd., at Remac; and Sheep Creek Mines, Ltd., which operated its Mineral King mine and mill near Invermue, and also began rehabilitation of its Paradise mine, closed since 1955. Highland Hill, Ltd., an important silver producer, also recovered lead and zinc concentrates.

TABLE 31.—World mine production of lead (content of ore), by countries[1 2]

(Short tons)

Country	1951–55 (average)	1956	1957	1958	1959	1960
North America:						
Canada[3]	188,407	188,854	181,484	186,680	186,696	204,907
Cuba	18	120	90	[4] 70	----------	----------
Greenland	----------	5,043	8,212	9,619	11,633	7,300
Guatemala	4,750	8,967	12,535	8,788	6,381	9,433
Honduras	1,038	2,315	[5] 2,955	3,380	4,604	5,913
Mexico	247,024	220,029	236,860	222,582	210,188	210,177
United States[3]	356,883	352,826	338,216	267,377	255,586	246,669
Total	798,120	778,154	780,352	698,496	675,088	684,399
South America:						
Argentina	22,476	31,250	32,100	32,000	33,000	31,500
Bolivia (exports)	26,832	23,777	28,948	25,149	24,293	23,610
Brazil[6]	3,152	3,869	3,878	5,109	6,160	[4] 7,700
Chile	6,001	3,598	3,237	2,815	2,560	[4] 3,300
Colombia (U.S. imports)	[7] 291	1,440	1	851	570	706
Equador	99	128	121	132	118	119
Peru	114,975	142,281	151,184	147,888	127,003	142,111
Total	173,826	206,343	219,469	213,944	193,704	209,046

See footnotes at end of table.

[7] When zinc or copper were coproducts with lead, additional information on mines and countries may be found in the Zinc and Copper chapters of the Minerals Yearbook 1960.

[8] Mineral Resources Division, Department of Mines and Technical Surveys, A Preliminary Survey of the Canadian Mineral Industry in 1960: Mineral Information Bull. MR 49, February 1961, pp. 24–27.

TABLE 31.—World mine production of lead (content of ore), by countries [1] [2]—Continued

(Short tons)

Country	1951–55 (average)	1956	1957	1958	1959	1960
Europe:						
Austria	5,429	5,281	5,969	6,012	5,906	5,758
Bulgaria	46,758	63,600	69,600	[4] 77,900	[4] 88,700	[4] 92,600
Czechoslovakia [4]	2,500	6,600	6,600	6,600	7,000	7,200
Finland	371	1,554	2,623	2,482	2,126	1,755
France	12,371	9,780	13,541	14,727	18,760	19,800
Germany:						
East [4]	4,200	6,600	7,700	7,700	7,700	7,700
West	65,914	72,181	78,395	67,146	57,882	54,999
Greece	3,847	7,200	7,200	11,200	11,000	[4] 12,000
Ireland	1,683	2,560	2,074	412	1,709	1,552
Italy	47,333	53,200	59,300	61,700	54,600	54,200
Norway	611	887	990	2,351	2,487	2,900
Poland	39,700	36,400	33,100	36,500	39,000	[4] 45,000
Portugal	1,865	1,365	1,518	994	35	----------
Rumania [4] [6]	11,000	13,200	13,200	13,200	13,200	13,200
Spain	56,209	66,765	72,224	76,710	77,271	75,079
Sweden	28,149	36,097	40,200	46,595	53,322	60,500
U.S.S.R. [4]	199,400	[6] 290,000	310,000	330,000	340,000	340,000
United Kingdom	7,764	8,139	9,069	4,814	2,632	1,549
Yugoslavia	91,950	96,259	99,305	99,035	101,909	[4] 105,800
Total [4]	627,100	777,700	832,600	866,100	885,200	901,600
Asia:						
Burma	9,777	17,456	16,366	21,180	21,200	19,500
China [4]	10,700	40,000	43,000	52,000	72,000	77,000
Hong Kong	260	110	80	20	----------	----------
India	2,191	3,183	3,666	4,356	5,292	4,991
Iran [4] [8]	15,850	18,700	18,700	18,700	16,500	16,500
Japan	21,610	32,545	39,533	40,448	39,844	43,894
Korea:						
North [4]	3,000	16,000	18,700	18,700	18,700	18,700
Republic of	233	1,600	1,016	1,343	256	1,012
Philippines	2,083	2,360	897	1,415	391	134
Thailand	3,581	4,419	3,346	1,032	1,455	2,028
Turkey	1,698	5,042	4,465	3,250	2,300	827
Total	71,000	141,400	149,800	162,400	177,900	184,600
Africa:						
Algeria	8,100	11,746	11,349	11,095	11,291	11,571
Congo, Republic of the (formerly Belgian Congo)	69	[4] 110	[4] 220	----------	----------	----------
Congo, Republic of	3,812	3,316	2,034	3,611	5,448	4,741
Morocco:						
Northern zone	670	670	897	} 102,712	100,558	104,298
Southern zone	88,927	93,876	101,288			
Nigeria	20	49	504	546	424	[4] 550
Rhodesia and Nyasaland, Federation of: Northern Rhodesia [6]	15,485	17,024	16,800	14,196	16,128	16,160
South-West Africa [9]	68,926	[3] 89,100	[3] 88,763	[3] 83,796	[3] 77,551	71,500
Tanganyika (exports)	2,773	5,730	5,433	5,001	6,917	6,736
Tunisia	26,792	25,848	25,371	25,920	19,997	19,945
Uganda (exports)	37	128	17	256	59	[4] 55
Union of South Africa	584	911	1,223	36	168	136
United Arab Republic (Egypt Region)	149	132	280	[4] 330	770	[4] 770
Total	216,344	248,640	254,179	247,499	239,311	236,462
Oceania: Australia	287,395	335,423	373,256	366,652	354,249	341,095
World total (estimate)	2,170,000	2,490,000	2,610,000	2,560,000	2,530,000	2,560,000

[1] Data derived in part from United Nations Statistical Yearbook, Yearbook of the American Bureau of Metal Statistics, and annual issues of the Statistical Summary of the Mineral Industry (Overseas Geological Surveys, London). and Metal Statistics (Metallgesellschaft) Germany.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Recoverable.
[4] Estimate.
[5] U.S. imports.
[6] Smelter production.
[7] 1952–55 average.
[8] Year ended Mar. 21 of year following that stated.
[9] Includes lead content of lead-vanadium concentrates.

Compiled by Augusta W. Jann, Division of Foreign Activities.

TABLE 32.—World smelter production of lead, by countries [1] [2]

(Short tons)

Country	1951–55 (average)	1956	1957	1958	1959	1960
North America:						
Canada	165,726	149,262	144,017	134,827	140,881	160,079
Guatemala	[3] 250	147				200
Mexico	239,054	213,947	231,745	218,290	206,134	205,263
United States (refined) [4]	464,084	542,272	533,473	469,381	340,886	382,436
Total	869,114	905,628	909,235	822,498	687,901	747,978
South America:						
Argentina	22,163	26,800	28,600	36,200	34,200	28,300
Bolivia (exports) [5]	1,221	1,681	2,482	877	250	119
Brazil	3,152	3,869	3,878	5,109	6,160	[3] 7,700
Chile	[6] 302			321	892	
Peru	60,110	66,546	76,231	71,045	62,619	80,354
Total	86,948	98,896	111,191	113,552	104,121	116,473
Europe:						
Austria [7]	12,563	12,293	13,156	13,756	13,610	13,717
Belgium [7]	84,515	112,715	109,423	105,685	97,489	102,200
Bulgaria	3,683	6,600	21,300	28,800	36,050	44,000
Czechoslovakia [3]	7,900	9,900	9,900	9,900	10,000	10,000
France	62,686	69,809	81,345	77,871	77,082	82,100
Germany:						
East [3] [7]	24,500	27,500	24,800	27,500	27,500	27,500
West	108,982	128,417	151,945	147,985	164,833	162,772
Greece	3,093	3,814	3,987	4,330	4,000	[3] 4,000
Italy	41,501	43,118	43,703	52,912	49,638	48,057
Netherlands [3]	1,900					
Poland	31,900	38,800	39,354	39,488	42,645	43,800
Portugal	1,245	938	829	743	877	1,033
Rumania [3]	11,000	13,200	13,200	13,200	13,200	13,200
Spain	57,966	72,491	64,981	77,729	75,497	78,300
Sweden	17,232	25,553	27,421	36,453	40,619	49,112
U.S.S.R.[3]	199,400	290,000	320,000	340,000	350,000	350,000
United Kingdom	6,353	7,504	8,322	4,156	1,580	1,224
Yugoslavia	75,042	83,509	86,536	92,904	94,132	98,263
Total [3]	752,000	946,200	1,020,200	1,073,400	1,098,800	1,129,300
Asia:						
Burma	10,340	21,889	21,816	19,150	21,768	19,441
China [3]	[8] 15,000	28,000	31,000	40,000	63,000	70,000
India	1,727	2,797	3,556	3,735	4,363	4,112
Iran [9]	[10] 852	1,580	[3] 770	1,047	[3] 1,000	(11)
Japan	21,784	41,151	50,214	42,412	67,152	76,273
Korea: North [3]	2,900	16,000	18,700	18,700	18,700	18,700
Turkey [3]	924	2,000	2,000	3,000	1,808	440
Total [3]	53,500	113,400	128,100	128,000	177,800	189,000
Africa:						
Morocco: Southern zone	29,370	30,991	34,441	36,513	31,361	34,927
Rhodesia and Nyasaland, Federation of: Northern Rhodesia	15,485	17,024	16,800	14,196	16,128	16,160
Tunisia [5]	28,372	26,620	27,068	27,718	24,039	21,894
Total	73,227	74,635	78,309	78,427	71,528	72,981
Oceania: Australia:						
Refined lead	197,660	218,500	215,516	214,451	209,638	212,603
Pb content of lead bullion	40,134	46,657	52,518	64,032	56,745	59,466
Total	237,794	265,157	268,034	278,483	266,383	272,069
World total (estimate)	2,075,000	2,400,000	2,515,000	2,490,000	2,410,000	2,530,000

1 Data derived in part from United Nations Statistical Yearbook, Yearbook of the American Bureau of Metal Statistics, and annual issues of Statistical Summary of the Mineral Industry (Overseas Geological Surveys, London), and Metal Statistics (Metallgesellschaft), Germany.
2 This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
3 Estimate.
4 Figures cover lead refined from domestic and foreign ores; refined lead produced from foreign base bullion not included.
5 Lead bars only; does not include lead contained in antimonial lead or in solders.
6 1954–55 average.
7 Includes scrap.
8 Refined lead production.
9 Year ended Mar. 21 of year following that stated.
10 Average for 1952–55.
11 Data not available; no estimate included in total.

Compiled by Augusta W. Jann, Division of Foreign Activities.

United Keno Hills Mines, Ltd., in the Yukon, recovered lead and zinc concentrates from several mines in the Mayo district. Hudson Bay Mining and Smelting Co. Ltd., in the Saskatchawan-Manitoba area, produced lead concentrates from the Flin Flon, Schist Lake, and Coronation mines.

In Quebec, the Manitou-Barvue Mines, Ltd., and Calumet Mines, Ltd., recovered lead concentrates, and American Smelting and Refining Co. operated the Buchans Mining Co. unit in Newfoundland where additional drilling disclosed an appreciable extension of the ore body.

Mexico.—A new mining law was passed by the Mexican Congress late in December 1960, to become effective 60 working days after its publication in the Official Government Journal on February 6, 1961. The new law may limit future operations by foreign mining companies in Mexico.

American Smelting and Refining Co. operated its lead mines throughout the year. Concentrates were smelted at company plants at San Luis Potosi and Chihuahua, and smelter products were refined at Monterrey.[9]

Compañia Metalurgica Penoles, S.A. (a subsidiary of American Metal Climax, Inc.), produced 62,700 tons of refined and antimonial lead, 17 percent below the 1959 output of 75,600 tons. American Metal Climax was negotiating to bring sufficient Mexican capital into Penoles to provide a basis for expanded activities by a 51-percent-Mexican-owned company in compliance with the new Mexican mining law.[10] The refined lead produced came largely from ore mined in Durango by independent mining operators.[11]

Fresnillo Co. operated the Fresnillo, Plateros, and Naica mines in Mexico throughout the year. The grades of ore recovered at the Fresnillo and Plateros mines were similar to those recovered in 1959; that at Naica was slightly higher. Over 1 million tons of ore was produced and milled during the fiscal year ending June 30, 1960.

The Fresnillo mill, which treated ores from the Fresnillo and Plateros mines, produced 26,530 tons of 53.0 percent lead concentrate, and the Naica mill produced 47,109 tons of 58.9 percent lead concentrate. Relatively small quantities of lead concentrates also were recovered by the 2 subsidiary mining companies, Sombrerete Mining Co. (55 percent owned) in the State of Zacaticas and the Zimapon unit (wholly owned) in the State of Hidalgo.[12]

The San Francisco Mines of Mexico, Ltd., at San Francisco del Oro, Chihuahua, milled a record 902,500 short tons of lead-zinc-copper-silver ore during the year ending September 30, 1960. The grade was approximately the same as that milled in 1959. Sales of refined lead were 27,489 short tons, a decline of 8 percent from the 29,919 tons sold in 1959. Sales were limited not only by U.S.-imposed import quotas, but also by weak markets in the United States and Europe.[13]

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[9] American Smelting and Refining Co., Ann. Rept., 1960, p. 13.
[10] American Metal Climax, Ann. Rept., 1960, p. 18.
[11] American Consulate, Monterrey, Nuevo Leon, Mexico: State Department Dispatch 100, Apr. 21, 1961, p. 13.
[12] The Fresnillo Co., Ann. Rept., Fiscal Year 1960, pp. 10–11.
[13] San Francisco Mines of Mexico, Ltd., Ann. Rept., 1959–60, pp. 6–7.

El Potosi Mining Co. (subsidiary of Howe Sound Co.) operated the El Potosi mine in Chihuahua; Minas de Iquala, S.A. (subsidiary of The Eagle-Picher Co.), operated a mine at Parral Chihuahua.

SOUTH AMERICA

Argentina.—Cia. Minera Aguilar, S.A., in the Province of Jujuy, a wholly owned subsidiary of St. Joseph Lead Co., produced 27,116 short tons of lead concentrate with a metal content of 21,000 tons.[14] Cia. Minera Castano Viejo, S.A., in San Juan Province, a National Lead Co. subsidiary, produced 9,000 short tons of 80 percent lead concentrate. Refined lead production in Argentina of 28,300 tons, all derived from Argentine ores and all consumed domestically, declined 17 percent from the 34,200 tons produced in 1959.

Bolivia.—Mine and smelter production of lead declined in 1960 because of the weak world market and import quotas imposed by the United States. Fundicion Metabol, a Government-owned company, and Asociada a la Compagnia Metalurgica, S.A. la Lima (formerly Fundicion Oruro, reorganized in 1959), with smelters at Oruro, produced metallic lead. The latter company, primarily a tin producer, reported lead output in terms of lead content of solder.

Brazil.—Cia. Plumbum, S.A., Instituta de Pesquisas Technologicas, and Accumalatores Prest-O-Lite were the only producers of lead metal in Brazil. Consumption increased greatly as a result of the expanding automotive industry. Requirements, however, were still being met largely by imports.

Peru.—Cerro de Pasco Corp. produced 79,942 short tons of lead at its Oroya refinery, a new production record and a 29-percent increase over the 62,200 tons recovered in 1959. Modernization of the lead smelter, especially the sinter plant, was largely responsible for the increase. Production from Cerro's San Cristobal copper-lead-zinc mine also increased.[15] Other significant lead producers in Peru were Cia. Minera Atacocha S.A., Northern Peru Mining Corp., Hochschild Mines, Compagnie des Mines de Huaron, Cia. Mineral Milpo, Volcan Mines Co., and Cia. Minerales Santander, Inc., a partially owned subsidiary of St. Joseph Lead Co.

EUROPE

Bulgaria.—Production of lead concentrates and metal remained at a high level. The output of metal in 1960 reached 44,000 tons, an increase of 22 percent over 1959. At Plovdiv, a secondary smelter was being constructed to process residues and scrap from the Pirdop, Kurdiali, and Plovdiv smelters.[16]

Germany, West.—The lead industry in 1960 was characterized by increases in refinery production and imports of refined metals and ores, and declines in mine production and exports of metal.[17] The

[14] St. Joseph Lead Co., Ann. Rept., 1960, p. 10.
[15] Cerro Corp., Ann. Rept., 1960, pp. 10–11.
[16] Metal Bulletin, Bulgarian 1960 Output: No. 4586, Apr. 11, 1961, p. 30.
[17] Mining Journal (London), West Germany's Non-Ferrous Metal Industries in 1960; Vol. 256, No. 6548, Feb. 17, 1961, p. 177.

Rammelsberg mine of the Unterharzer Berg- und Huttenwerke GmbH, at Goslar, was one of the major lead-zinc producers. This mine, which began producing in A.D. 968, produced about 1,000 tons per day of lead-zinc ore in 1960.[18]

Sweden.—A new lead mine estimated to produce 150,000 tons of ore with a 6-percent lead content or 9,000 tons of lead metal annually was opened by the Boliden Mining Co. at Vassbo in central Sweden in 1960. The ore-crushing plant, located in the mine at a depth of 240 feet, used ore blocks and water as crushing media, thus saving expensive high-grade steel used in conventional crushing plants. The crushing plant, based on a U.S. idea, was the first of its type.

United Kingdom.—Mine production of lead continued at a low level. Output from the new plant of National Smelting Co., at Swansea, was below expectations. Consumption of metal increased, however, because of heavy demand for battery oxide by the automobile industry.[19]

Yugoslavia.—Lead-zinc ore production in Yugoslavia reached 2,116,000 short tons containing an average of 6.5 percent lead and 3 percent zinc. Lead concentrate recovered totaled 132,654 tons.

Exploration at the Ajvalija and Kisnica lead-zinc mines near Pristina in 1960 disclosed a considerable tonnage of ore averaging 3.56 percent lead and 1.85 percent zinc, with 51 grams of silver per ton. A plant to manufacture lead batteries was to be built at Kosovoka Mitrovica about 4 miles from the Trepca mines.[20]

ASIA

Burma.—Burma Corp., Ltd., a joint Government venture in which there was a 25-percent U.S. interest, produced for the year ended December 31, 1960, 19,440 short tons of refined lead and 308 short tons of antimonial lead at its refinery at Namtu. This output, a slight decline from the preceding year's total, was attributed largely to reduced lead prices in world markets and to output lost during the rebuilding of a hoist which raised ores from the richer section of the mine. Geological studies failed to disclose an expected rich ore body. Burma, therefore, asked the United Nations Special Fund and West Germany to finance further studies aimed at using existing low-grade ores.

China.—The expansion program for the lead and zinc industry in China continued. Milling equipment purchased from Bulgaria was put into operation at mines at Si-din in the Kwangsi-Chuang Autonomus Region in south China. The flotation plant was reported to be capable of handling 400 tons of ore per day. A second plant was scheduled for early delivery from Bulgaria to a mine in Liaoning Province of northeast China.

India.—Mine production of lead came from the Zawar mine near Udaipor-Rajasthan State, the only lead-zinc mine in India. Lead concentrate was shipped by rail to the smelter in Tundoo, Katarsgarh,

[18] Huttle, J. B., Nearly 1,000 Years of Mining at Rammelsberg: Eng. Min. Jour., vol. 161, No. 10, October 1960, pp. 97–103.

[19] American Metal Market, United Kingdom—Lead Mining Continues at Low Level: Vol. 68, No. 37, Feb. 24, 1961, p. 12.

[20] Mining World, What's Going on in Mining in Europe. Yugoslavia: Vol. 23, No. 1, January 1961, p. 63.

Bihar State. The mine and smelter were owned by the Metals Corporation of India. Measured reserves in mid-1960 were 3.9 million short tons containing 2.2 percent lead and 5.1 percent zinc.

Iran.—In an effort to develop its mineral resources, the Government enacted mining legislation attractive to foreign countries and placed in operation new smelting furnaces at the Chah Kharboozeh lead-zinc mines. A barter agreement for 1960–61 was signed with the U.S.S.R. to deliver 44,092 short tons of lead ore to the U.S.S.R.

Japan.—Production of 85,571 short tons of crude lead and 76,273 tons of refined lead represented increases, respectively, of 28 and 10 percent above the 1959 output of crude and refined lead, as Japan continued its plan to dominate the East and southeast Asian lead and zinc markets.

AFRICA

Morocco.—Production of lead ore and concentrate in 1960 reached 104,298 short tons; that of lead metal was 34,927 tons. The metal, all of which was produced for export, was recovered at the Oued el Hunia smelter near Oujda, the only lead smelter in Morocco.

Rhodesia and Nyasaland, Federation of.—Rhodesian Broken Hill Development Co., Ltd., the only lead and zinc metal producer in the Federation, recovered 16,160 short tons of refined lead of 91.99 percent purity. A total of 183,426 tons of ore averaging 18.0 percent lead and 30.4 percent zinc was treated, from which 23,942 short tons of 78.2 percent lead concentrate was produced. Recovery of refined lead was 85.4 percent. Reserves reported on December 31, 1960, were 2.4 million tons of proven ore containing 16.9 percent lead and 3.7 million tons of indicated ore containing 11.5 percent lead. Plans were completed in 1960 and construction begun on the new Imperial smelting furnace and auxiliary plant.[21]

South-West Africa.—A total of 614,000 short tons of ore, averaging 24 percent combined copper, lead, and zinc, was mined and milled by the Tsumeb Corp., Ltd., during the fiscal year ending June 30, 1960. Sales of lead concentrates were 51,800 tons, a decline of about 35 percent from the 79,600 tons sold in 1959. Reserves above the 30th level in 1960 were estimated at 7.9 million tons averaging 14.85 percent lead, 5.18 percent copper, and 4.47 percent zinc. Based on a diamond drilling program begun in 1959, reserves below the 30th level at the end of fiscal 1960 were estimated at 3 million tons averaging 10.3 percent lead, 4.7 percent copper, and 2.3 percent zinc.[22]

OCEANIA

Australia.—Although the output of lead declined in 1960 because of the weak world market and U.S. import quotas, Australia was the leading free-world producer of lead ore and concentrate. The Broken Hill district in New South Wales, with four companies (New Broken Hill Consolidated, Ltd., Zinc Corp., Ltd., Broken Hill South, Ltd., and North Broken Hill, Ltd.), was the leading Australian lead-producing district. Production of lead concentrate by the North Broken Hill,

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[21] Rhodesian Broken Hill Development Co., Ltd., Ann. Rept., 1960, pp. 4, 10, 12.
[22] American Metal Climax, Ann. Rept., 1960, p. 27.

Ltd., declined from the preceding year's total because the ore treated was lower in grade.

Mount Isa Mines, Ltd., in which American Smelting and Refining Co. had a 53.8-percent interest, produced 56,582 short tons of lead bullion containing 4,283,000 troy ounces of silver during the fiscal year ending June 30, 1960. Exploration during the year resulted in a substantial increase in reserves of copper-silver-lead-zinc ores. Design of a new lead-zinc mill also was well advanced during the year.[23]

Lake George Mines, Pty., Ltd., the operating company of the Lake George Mining Corp. in Australia, recovered 221,036 short tons of copper-lead-zinc ore during the fiscal year ending June 30, 1960. The recovery was made from Elliot's, Keating's, and Central ore bodies in the Captain's Flat district of New South Wales. Exploration failed to reveal any economic extensions of existing ore bodies or any new deposits. The mill recovered 16,241 tons of 61.08-percent lead concentrate. Copper and zinc concentrates and some gold and silver also were recovered. All lead concentrate recovered was exported.[24]

Electrolytic Zinc Co. of Australasia Ltd., for the fiscal year ending June 30, 1960, produced 229,915 tons of copper-lead-zinc ores from the Roseberry and Hercules mines on the west coast of Tasmania. Operations at the Hercules mine were halted on January 8, 1960, by a fire which destroyed many of the surface installations. By the end of June 1960, reconstruction work was well advanced, and production was scheduled to resume early in fiscal 1961.

The ore yielded 85,631 tons of zinc, lead, and copper concentrates. Lead concentrate accounted for 12,021 tons.

TECHNOLOGY

The recent increasing demands for lead in radiation shielding, nuclear work, ultrasonic cleaning of precision parts, products for heavy construction, for imparting special properties to metal products, and in anode systems for cathodic protection of ships and power stations placed additional emphasis on improvements in the processing and manufacturing of lead metal and compounds. Coupled with the increased demand is greater dependence on lower grade and more complex ores because of the exhaustion of many of the higher grade deposits.

Experimental work on the production of a new class of lead alloys produced by stirring powders of low-solubility such as copper, nickel, and cobalt into molten lead showed promise for extending the usefulness of lead.[25] The production of a new leaded manganese bronze alloy suitable for high quality screw machine work also was reported.[26]

A new ultrasonic cleaning system based on a sandwich-type transducer composed of lead-zirconate-titanate, which will reduce cleaning

[23] American Smelting and Refining Co., Ann. Rept., 1960, pp. 14–15.

[24] Lake George Mining Corp., Ltd., Ann. Rept., 1960, pp. 13–15.

[25] Williams, D. N., Houck, J. A., and Jaffee, R. I., A New Class of Lead-Base Alloys: Metal Progress, vol. 77, No. 2, February 1960, pp. 79–81.

[26] American Metal Market, New Leaded Alloy Extruded by Ampco: Vol. 67, No. 230, Dec. 2, 1960, p. 7.

costs for cleaning steel strip, maintenance of street lights, and pickling metal wire, bar, and strip, was perfected.[27]

A lead and plastic puttylike material made of lead powder (94 percent) and resin (6 percent), which can be formed and shaped before curing and can be sawed, drilled, or machined when hard, was developed.[28] This product may be utilized in bonding, sealing, and adhesive applications.

The substitution of tetramethyl lead (TML) for part of the tetraethyl lead (TEL) added to high octane gasoline as an antiknocking agent was reported to be more effective and economical, and raised the octane quality of high premium gasolines one to two octane numbers.[29]

Processes of smelting lead ore containing zinc by removing the zinc as zinc oxide vapor [30] and for refining lead under vacuum to remove zinc [31] were reported. A process for the recovery of separable lead and tin compounds from rich alkaline leach liquor solutions containing copper, ammonia, carbon dioxide, lead, and tin also was reported.[32]

Lead sheets processed to form a lubricating seal at concrete joints of water conduits, and lead-asbestos pads utilized to reduce or eliminate vibration in buildings near railways or heavy traffic were described.[33]

A new group of metallurgically bonded lead-clad metals showed promise as a shielding material in the chemical and nuclear field.[34]

A lubricating film of lead monoxide, fired on rocket-bearing surfaces was developed; it gave promise of a relatively low coefficient of friction at high temperatures and a longer service life for the bearing.[35]

Progress was reported in the U.S.S.R. on an experimental program for the production of lead from lead-sulfide concentrate by electrolysis in fused salts [36] and the electrolytic recovery of lead from factory crudes and bismuth-containing drosses by the use of fusedelectrolytes.[37]

The thermodynamic properties of the system Pb-S-O to 1,100° K., the physical-chemical behavior of which is important to the under-

[27] Lead, Ultrasonic Cleaning: Vol. 24, No. 3, 1960, p. 4.

[28] Engineering and Mining Journal, Metal and Mineral Market, A Lead and Plastic Putty-Like Material: Vol. 31, No. 16, Apr. 21, 1960, p. 7.

[29] Chemical Engineering, Tetramethyl Lead Goes Commercial: Vol. 67, No. 10, May 16, 1960, pp. 69–71.

[30] Schwartz, W. (assigned to Dravo Corp.), Process of Smelting Zinc Containing Lead Ores: U.S. Patent 2,926,081, Feb. 23, 1961.

[31] Curnow, L. T., Randazzo, P. S., Skalak, A. J., and Bosilievac, T. N., Jr. (assigned to American Smelting and Refining Co.), Vacuum Dezincing of Lead: U.S. Patent 2,956,871, Oct. 18, 1960.

[32] Redemann, C. E., and Tschirner, H. J. (assigned to The Fluor Corp., Ltd.), Treatment of Copper Leach Solutions: U.S. Patent 2,923,618, Feb. 2, 1960, and U.S. Patent 2,927,019, Mar. 1, 1960.

[33] Materials in Design Engineering, Lead Sheet Forms Lubricating Seal: Vol. 51, No. 2, February 1960, pp. 125–179.

[34] Iron Age, Composite-Bonded Metals Resist Chemical and Nuclear Attack: Vol. 186, No. 15, Oct. 13, 1960, pp. 90–91.

[35] Lead, Bearings for Rocket Flight: Vol. 24, No. 2, 1960, p. 3.

[36] Gulidin, I. T., Buzhinskaya, A. V., Barsegiyan, V. P., and Ruppul, V. K., Electrolysis of Lead Concentrates in Fused Salts: Zhur. Priklad. Khim., vol. 33, No. 2, February 1960, pp. 373–383. (Trans. by Consultants Bureau, Inc., Jour. Appl. Chem. U.S.S.R., vol. 33, No. 2, February 1960, pp. 374–378.)

[37] Panchenko, I. D., and Delimarskii, Yu K., Electrolytic Recovery of Lead from Factory Crudes and Bismuth-Containing Drosses: Zhur. Priklad. Khim., vol, 33, No. 1, January 1960, pp. 155–157. (Trans. by Consultants Bureau, Inc., Jour. Appl. Chem. U.S.S.R., vol. 33, No. 1, January 1960, pp. 147–150.)

standing of lead-smelting processes [38] and the production of high-purity lead by amine leaching [39], were investigated.

The Federal Bureau of Mines reported several papers on beneficiation of lead-zinc ores in Missouri, Nevada, and California.[40] Reports also were published on mining, drilling, methods, and costs of shaft sinking, and the removal of volatile metals from lead and tin.[41]

Several papers reported research on the lead-zinc mineralization in the Coeur d'Alene district of Idaho by the Federal Geological Survey.[42]

The research program of the Lead Industries Association continued through 1960, and considerable progress was reported in some phases of the program. The relationship between strength and composition was established for 15 binary lead alloy systems, and the vibration attenuating characteristics of lead-asbestos pads were determined over frequencies encountered in industrial equipment and building foundations. A report on the use of lead in sound barriers also was completed.[43] Additional research on lead chemicals and lead in ceramic materials also was in progress.

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[39] Forward, F. A., Veltman, H., and Vizsoli, A., Production of High Purity Lead by Amine Leaching: Mine and Quarry Eng. (London), vol. 26, No. 12, December 1960, pp. 531–536.

[40] Powell, H. E., Beneficiating a Complex Sulfide-Oxide Lead-Zinc Ore From Missouri: Bureau of Mines Rept. of Investigations 5564, 1960, 10 pp.

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[42] Walace, R. E., Griggs, A. B., Campbell, A. B., and Hobbs, S. W., Tectonic Setting of the Coeur d'Alene District, Idaho: Geol. Survey Professional Paper 400–B, 1960, pp. B–25–27.

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Kennedy, V. C., and Hobbs, S. W., Geochemical Studies in the Coeur d'Alene District, Shoshone County, Idaho: Geol. Survey Bull. 1098–A, 1960, 54 pp.

[43] Radtka, S. F., Expanded Research Program: AZI–LIA, Quarterly Rept., No. 6, Oct. 1, 1960, pp. 1–25.

Lime

By C. Meade Patterson [1] and Victoria M. Roman [2]

ALTHOUGH domestic lime production increased slightly during 1960, producing capacity increased even more. Several new lime plants were completed, and others were being built. Modern, larger capacity kilns were installed in some old plants. Increased quicklime consumption was assured in steelmaking by more basic-oxygen-process furnaces.

TABLE 1.—Salient lime statistics in the United States [1]

(Thousand short tons and thousand dollars)

	1951–55 (average)	1956	1957	1958	1959	1960
Active plants	155	153	146	[2] 145	156	158
Sold or used by producers:						
Quicklime	5,042	5,967	5,942	5,538	7,756	8,299
Hydrated lime	2,012	2,186	2,081	2,014	2,766	2,715
Dead-burned dolomite	1,968	2,424	2,251	1,659	1,986	1,949
Total	9,022	10,577	10,274	9,211	12,508	12,963
Value [3]	$106,638	$135,727	$135,323	$121,193	$164,211	$173,067
Average value per ton	$11.81	$12.83	$13.17	$13.16	$13.13	$13.35
Open-market	7,906	9,004	8,516	7,388	8,405	8,189
Captive	[4] 1,116	[4] 1,573	[4] 1,758	[4] 1,823	4,103	4,774
Imports for consumption	34	42	50	26	35	32
Exports	73	83	65	46	53	61

[1] Includes Puerto Rico.
[2] Revised figure.
[3] Selling value f.o.b. plant, excluding cost of containers.
[4] Incomplete figures; before 1959 the coverage of captive plants was only partial.

DOMESTIC PRODUCTION

Lime production rose 4 percent above 1959 to 13 million short tons. Open-market lime output decreased 3 percent, and captive lime increased 16 percent. Thirty-seven percent of the total lime production was captive. Agricultural, construction, and refractory lime decreased, and chemical and industrial lime increased.

Thirty-three States and Puerto Rico manufactured lime in 1960. The three leading lime-producing States, Ohio, Missouri, and Michigan, in descending order, accounted for 43 percent of all the lime.

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.

The next five States were Pennsylvania, New York, Texas, Virginia, and Illinois.

Ray Mines Division, Kennecott Copper Corp., Ray, Ariz., completed a hydrating plant in June and a calcining plant having a daily capacity of 60 to 100 tons of quicklime later in the year. The lime produced became milk of lime conditioning agent in the flotation circuit at the concentrator. Five vertical kilns were planned in order to permit flexibility in quicklime production according to the variable feed conditions of the flotation plant.

Total lime production in California from 1894 through 1958 was reported as 5,742,954 short tons valued at $73,488,000.[3]

Chemical Lime, Inc., Ocala, Fla., was building a $2 million lime plant at Brooksville, Fla. A fluidized-bed calciner was expected to produce up to 200 tons a day of quicklime from Eocene Ocala limestone. Quicklime and hydrated lime production was scheduled to begin in the summer of 1961. Output was intended for the manufacture of phosphates, insecticides, and other chemical products.

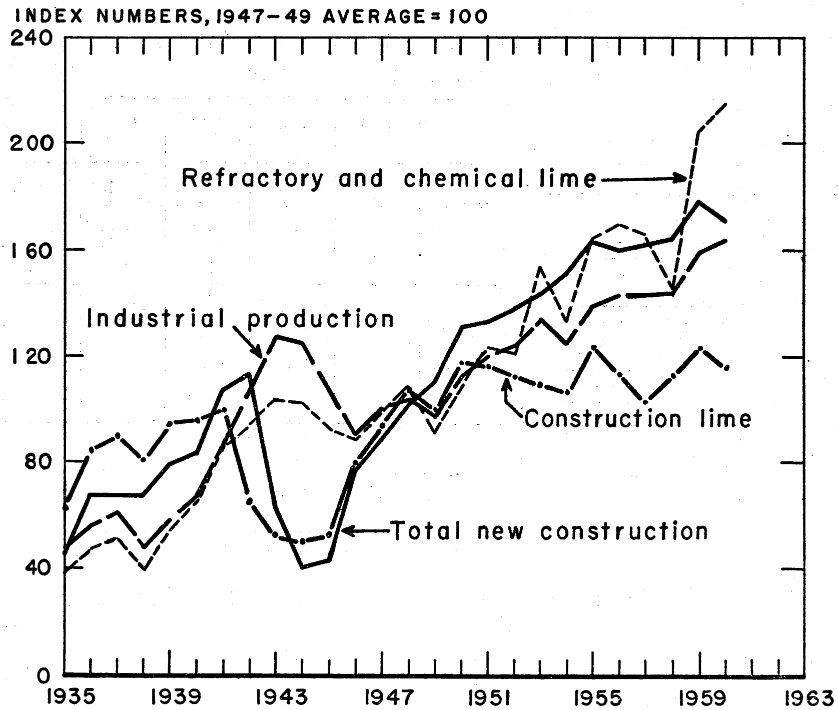

FIGURE 1.—Production of construction lime compared with physical volume of total new construction, and output of refractory and chemical lime compared with industrial production, 1935–60. Units are reduced to percentages of the 1947–49 average. Statistics on new construction from U.S. Department of Commerce and on industrial production from Federal Reserve Board.

[3] Campbell, Ian, 56th Report of the State Mineralogist, Calif. Div. of Mines, San Francisco, Calif., 1960, p. 104.

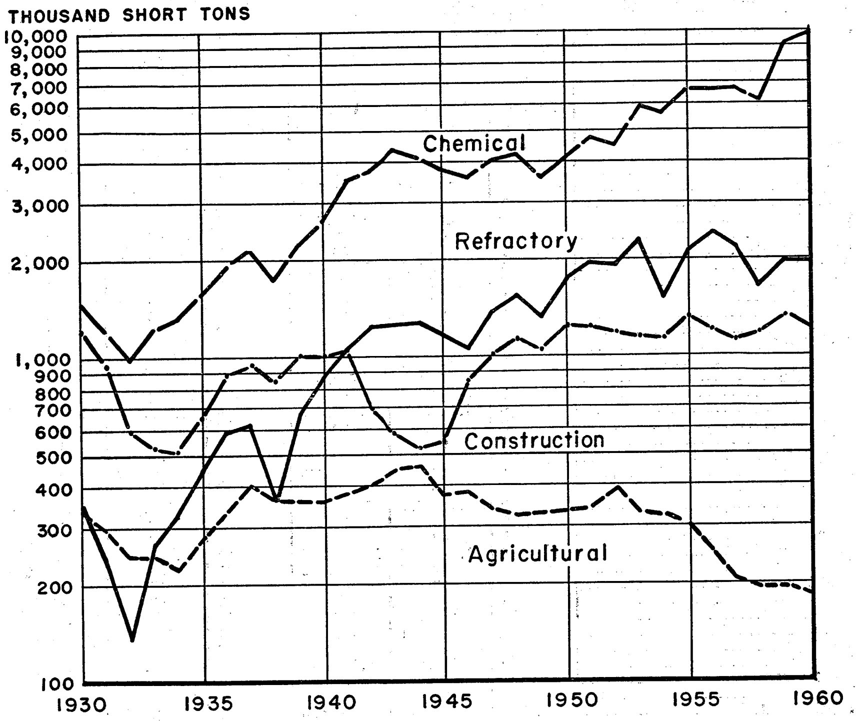

FIGURE 2.—Trends in major uses of lime, 1930–60.

Midwest Lime Co., Inc., completed its new 100-ton-a-day, high-calcium lime plant near Loring Quarries, 4 miles west of Bonner Springs, Kans., in September, but no commercial quicklime had been produced by the end of 1960. Quicklime had not been produced in Kansas since 1920. The unique 57½-foot, natural-gas-fired, vertical kiln with a doughnut-shaped cross section was designed for calcining Upper Farley limestone (97 to 98 percent $CaCO_3$) at about 2,300° F. The Kansas City, Mo., water department contracted with the company for lime for its water-treatment plant.

Pelican State Lime Corp., 4 miles east of Morgan City, La., on Bayou Boeuf of the Intracoastal Waterway, began producing high-calcium quicklime and hydrated lime commercially in March in its new $1.5 million, 200-ton-per-day lime plant. Reef oystershell dredged from a bay connecting with the Gulf of Mexico was delivered by barge to the plant where it was washed, unloaded, and calcined at 2,200° F. in two natural-gas-fired, 7- by 120-foot rotary kilns. Oystershell was selected as the raw material not only because it was nearby but because it was believed to require slightly less heat to calcine than clamshell. Part of the quicklime was hydrated in a continuous hydrator having a capacity of 15 tons per hour. Quicklime and hydrated lime were sold in bulk and in bags for water treatment, sugar refining, chemical plants, papermills, road stabilization, and oil-well drilling.

United States Gypsum Co., Chicago, Ill., completed a $1.5 million

TABLE 2.—Lime sold or used by producers in the United States [1]

State	1959			1960		
	Active plants	Short tons	Value	Active plants	Short tons	Value
Alabama	8	579,082	$6,847,329	7	564,270	$6,912,364
Arizona	5	122,856	1,666,104	5	147,758	2,429,746
Arkansas	2	[2]	[2]	2	[2]	[2]
California	6	357,668	5,817,367	7	345,344	5,628,223
Colorado	2	[2]	[2]	2	[2]	[2]
Connecticut	1	[2]	[2]	1	34,664	615,718
Florida	4	111,287	1,238,234	4	150,958	2,610,505
Hawaii	2	[2]	[2]	2	[2]	[2]
Illinois	5	[2]	[2]	5	[2]	[2]
Iowa	1	[2]	[2]	1	[2]	[2]
Louisiana	1	[2]	[2]	3	[2]	[2]
Maryland	3	[2]	[2]	3	[2]	[2]
Massachusetts	3	143,567	2,289,250	3	153,710	2,370,059
Michigan	6	861,808	11,747,657	7	1,177,431	15,730,384
Minnesota	1	[2]	[2]	1	[2]	[2]
Missouri	6	1,324,458	15,714,479	6	1,254,269	14,701,377
Montana	2	[2]	[2]	2	[2]	[2]
Nevada	4	[2]	[2]	4	[2]	[2]
New Jersey	2	[2]	[2]	1	[2]	[2]
New Mexico	1	16,286	209,275	1	35,707	496,327
New York	4	[2]	[2]	4	[2]	[2]
Ohio	20	3,190,432	45,121,149	20	3,116,891	44,403,404
Oklahoma	1	[2]	[2]	1	[2]	[2]
Oregon	1	[2]	[2]	2	[2]	[2]
Pennsylvania	23	1,263,180	18,260,836	24	1,120,463	16,276,512
Puerto Rico	2	9,816	321,102	1	581	14,985
South Dakota	1	[2]	[2]	1	[2]	[2]
Tennessee	3	[2]	[2]	3	[2]	[2]
Texas	10	808,777	8,529,654	10	821,442	9,087,109
Utah	4	90,151	1,773,037	4	127,210	2,671,923
Vermont	2	[2]	[2]	2	[2]	[2]
Virginia	10	765,240	8,168,412	10	711,039	8,027,986
West Virginia	4	[2]	[2]	3	[2]	[2]
Wisconsin	6	[2]	[2]	6	[2]	[2]
Undistributed	----------	2,863,619	36,506,635	----------	3,201,648	41,090,065
Total	156	12,508,227	164,210,520	158	12,963,385	173,066,687

[1] Includes Puerto Rico.
[2] Included with "Undistributed" to avoid disclosing individual company confidential data.

lime plant on the Industrial or Inner Harbor Navigational Canal at New Orleans, La., in October. The 10- by 250-foot, natural-gas-fired rotary kiln calcined clamshell dredged from Lake Ponchartrain and delivered by barges to the plant. The shell was washed before and after delivery, and then calcined above 2,000° F.; kiln capacity was 200 tons of quicklime daily. Some quicklime was pulverized and some hydrated in a hydrator having a capacity of 10 tons per hour. Pulverized quicklime and hydrated lime were sold in bulk, and hydrated lime was also sold in 50-pound bags. The quicklime and hydrated lime were used in the aluminum, oil, paper, petrochemical, and sugar industries and in water treatment, building, and road stabilization.

The Flintkote Co. purchased M. J. Grove Lime Co., Lime Kiln, Md., in September for about $5 million.

New England Lime Co., Adams, Mass., operated its fluidized-bed calciners almost at capacity and was considering installing another calciner of larger capacity.[4]

National Gypsum Co. conducted market surveys in the Detroit, Mich., Chicago, Ill., and Lorain-Cleveland, Ohio, areas as promising locations for erecting three large lime plants to serve the steel industry.

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[4] Pit and Quarry, Business Prompts Expansions at New England Lime Company: Vol. 53, No. 1, July 1960, p. 138.

TABLE 3.—Lime sold or used by producers in the United States,[1] by types and major uses

(Short tons)

Type and use	1959			1960		
	Sold	Used	Total	Sold	Used	Total
By type:						
Quicklime	6,373,027	3,369,650	9,742,677	6,251,373	3,997,247	10,248,620
Hydrated lime	2,032,482	733,068	2,765,550	1,937,963	776,802	2,714,765
Total lime	8,405,509	4,102,718	12,508,227	8,189,336	4,774,049	12,963,385
By use:						
Agricultural:						
Quicklime	83,325		83,325	76,530		76,530
Hydrated lime	112,229		112,229	110,239		110,239
Total	195,554		195,554	186,769		186,769
Construction:						
Quicklime	111,046	44,321	155,367	92,869	33,838	126,707
Hydrated lime	1,107,962	52,017	1,159,979	1,036,115	73,995	1,110,110
Total	1,219,008	96,338	1,315,346	1,128,984	107,833	1,236,817
Chemical and other industrial:						
Quicklime	4,217,596	3,299,828	7,517,424	4,159,932	3,936,191	8,096,123
Hydrated lime	812,291	681,051	1,493,342	791,609	702,807	1,494,416
Total	5,029,887	3,980,879	9,010,766	4,951,541	4,638,998	9,590,539
Refractory (dead-burned dolomite)	1,961,060	25,501	1,986,561	1,922,042	27,218	1,949,260

[1] Includes Puerto Rico.

TABLE 4.—Number and production of domestic lime plants by size of operation [1]

Annual production (short tons)	1959			1960		
	Plants	Production		Plants	Production	
		Short tons	Percent of total		Short tons	Percent of total
Less than 10,000	43	152,202	1	40	132,610	1
10,000 to less than 25,000	21	395,748	3	18	309,505	2
25,000 to less than 50,000	27	977,319	8	37	1,357,466	11
50,000 to less than 100,000	29	1,941,127	15	26	1,865,399	14
100,000 to less than 200,000	18	2,712,144	22	21	3,197,794	25
200,000 and over	18	6,329,687	51	16	6,100,611	47
Total	156	12,508,227	100	158	12,963,385	100

[1] Includes captive tonnage.

The Dow Chemical Co. plant at Ludington, Mich., began operating a Lepol-type kiln and became the first company to use this traveling-grate system for manufacturing lime. Economical fuel consumption was anticipated. The 11½- by 160-foot kiln was rated at a record capacity of 600 tons of quicklime daily.

Wyandotte Chemicals Co. began to convert its coke-fired kilns at Wyandotte, Mich., to use natural gas. Chemical lime production was expected to increase to 1.5 million tons annually after completion of the conversion in 1961.

Minerals & Chemicals Corp. of America, Menlo Park, N.J., and Neville Lime Co. of Ohio organized the Cuyahoga Lime Co. to build a $1- to $2-million plant at Cleveland, Ohio, to manufacture high-grade metallurgical lime for steelmaking. Vertical kilns for the new lime plant were designed by Chemstone Corp. to calcine Michigan limestone from Presque Isle Corp. Chemstone Corp., a Minerals & Chemicals Corp. of America subsidiary, operated a lime plant at Strasburg, Va.

Argentum Mining Co. built a lime plant at Columbus Flat, Esmeralda County, Nev., to produce 20 tons a day of high-calcium, metallurgical-grade lime for captive use in the mill. Surplus lime was to be sold.

Gibsonburg Lime Products Co., Gibsonburg, Ohio, increased quicklime production 70 percent by replacing a 140-ton-a-day rotary kiln with a 240-ton-a-day rotary kiln. Ohio Lime Co., Woodville, Ohio, acquired controlling interest in United Cement Co., Inc., Montevallo, Ala. Ohio Lime Co., established in 1916, operated a dolomitic limestone quarry, 36 vertical kilns for finishing lime and dolomitic lime, and 4 rotary kilns for dead-burned dolomite. United Cement Co., which started its rotary-kiln lime plant in 1955, produced high-calcium lime from its Montevallo quarry limestone.

G. & W. H. Corson, Inc., Plymouth Meeting, Pa., had licensed 10 lime plants to operate under patents including the company's process for hydrating lime under pressure.

Austin White Lime Co., near McNeil, Tex., calcined Lower Cretaceous Edwards limestone in six 50-ton-a-day vertical kilns and a 225-ton-a-day rotary kiln. The 10- by 150-foot rotary kiln, which began producing in September 1959, operated at a calcining temperature of 2,300° to 2,350° F. Total quicklime capacity was 525 tons a day, and the three hydrators had a combined capacity of 360 tons a day. The hydrated lime was sold primarily for stabilizing roads. Papermills, steel mills, oil refineries, water treatment plants, insecticide manufacturers, and building projects were also supplied with lime. Stone shaft kilns fired with wood and lignite were used from 1870 to 1930, and the first steel shaft kiln was erected in 1925.[5]

Round Rock White Lime Co., Round Rock, Tex., increased productive capacity from 75 tons of lime a day in 1953 to 500 tons a day during 1960. The company had only four stone shaft kilns (used between 1867 and 1950), two 11- by 50-foot steel shaft kilns (erected in 1905), and one hydrator (built in 1953). First, the two steel kilns were converted to natural gas. Then a third shaft kiln (11 by 16 by 110 feet high) fired by natural gas was installed, raising quicklime capacity to 175 tons a day. Calcining temperature in these three shaft kilns varied between 2,100° and 2,400° F., and 5,500 cubic feet of natural gas was consumed in producing a ton of quicklime. Next, two more hydrators were installed. Finally, two natural-gas-fired, 8- by 150-foot Vulcan rotary kilns, each capable of producing 150 tons of quicklime a day by calcining ½- to 1½-inch stone at 2,500° F., were added in 1959. Rotary-kiln consumption of natural gas was 6,500 cubic feet per ton of pebble quicklime. Lime containing 95 to

[5] Herod, Buren C., Small Stone Leads to Big Project: Pit and Quarry, vol. 52, No. 11, May 1960, pp. 104–109.

97 percent calcium oxide was produced by calcining Lower Cretaceous Edwards limestone. The principal market was for soil stabilization, but lime was also sold for chemical and building purposes.[6]

The Utah Lime & Stone Co., Division of The Flintkote Co., Salt Lake City, Utah, started using its new $1.5-million lime plant at Dolomite, Utah, 42 miles west of Salt Lake City. The new plant was an expansion based on five Ellernan kilns, a normal hydrator, and a pulverizing and milling plant of The Utah Lime & Stone Co. acquired in 1958 by The Flintkote Co. The patented Corson process had been installed to produce pressure-hydrated building lime. The Utah Lime & Stone Co. was the 10th lime plant licensed to operate under Corson's patents. Total investment in all three plants at Dolomite was $2.5 million. High-calcium limestone was quarried at Flux, 2 miles east of Dolomite. Hydrated lime was pulverized and shipped in bulk and in bags. Combined output of hydrated lime from the two hydrating plants was approximately 300 tons a day. The Utah Lime & Stone Co. also produced lump and pulverized quicklime, and hydrated lime for masonry.[7]

A survey by the Washington Department of Commerce and Economic Development established the need for a 100-ton-a-day lime plant in the State. There were no lime plants in Washington, but there were ample limestone formations of suitable composition.

Blair Limestone Division, Jones & Laughlin Steel Corp., Martinsburg, W. Va., installed two gas-fired, vertical kilns to double quicklime capacity to 72,000 tons per year and to improve the quality of the quicklime. The captive lime was for steelmaking furnaces at Pittsburgh and Aliquippa, Pa. The new kilns were 12 by 14 by 52 feet high. Average inside diameter was 9 feet, and kiln walls were lined with a 2-foot thickness of refractories. The sulfur content of the quicklime was reduced 75 to 80 percent by the new kilns, thereby increasing the efficiency of the steelmaking furnaces that used the lime. Eleven coke-fired kilns that had produced quicklime since 1911 were replaced. The two new kilns had automatic equipment for charging, shutting off the gas supply when a charging door was opened, moving limestone and lime in the kilns, heating, and continuous discharge of quicklime.

During late 1960 many lime plants operated at full capacity, but others supplying the steel industry operated at only 50 percent capacity.[8]

The National Lime Association, Washington, D.C., serving quicklime and hydrated lime producers through education, research, and promotion of lime uses since 1902, listed 51 domestic member companies, representing 83 operating lime plants, and 6 Canadian member companies.[9] The Association's map of commercial lime plants showed the locations of 104 plants in 32 States, indicated whether high-calcium

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[6] Herod, Buren C., Historic Lime Operation Modernized: Pit and Quarry, vol. 53, No. 2, August 1960, pp. 96–101.

[7] Intermountain Industry and Engineering, vol. 62, No. 5, May 1960, p. 59.
Intermountain Industry and Engineering, Utah Lime Opens New Plant: vol. 62, No. 6 June 1960, p. 32.

[8] Oil, Paint and Drug Reporter, Lime: vol. 178, No. 23, Nov. 28, 1960, p. 31.

[9] National Lime Association, Lime Masonry Mortar, Plaster, Stucco: January 1960, p. 8; Program of the 58th Ann. Conv., Sea Island, Ga., May 23–25, 1960, p. 6.

lime or dolomitic lime was produced, and where vertical and rotary kilns were used. There were 52 vertical-kiln plants, 41 rotary-kiln plants, and 11 plants with both vertical and rotary kilns. Vertical kilns included standard and large-capacity, gas-fired vertical kilns; mixed-feed kilns; Ellernan kilns; fluidized-bed calciners; and pot kilns. Captive lime plants, dead-burned dolomite plants, and small pot-kiln plants, that operated sporadically on a local basis, were excluded from the map. Eighty-one commercial plants produced high-calcium lime; 19 produced dolomitic lime; and 4 produced both kinds. Dolomitic lime was manufactured in central California, Connecticut, eastern Illinois, Massachusetts, southern Nevada, western Ohio, southeastern Pennsylvania, Utah, and southern Wisconsin. High-calcium lime was produced everywhere else.[10]

CONSUMPTION AND USES

Although Washington had no lime production, 102 Washington lime-consuming manufacturers paid $1.7 million for 54,722 tons of lime produced outside the State in 1959. Pulpmills and papermills consumed 44,014 short tons; steel, alloy, and chemical plants, 2,940 tons; agriculture, 7,093 tons; and other industries, 675 tons. This consumer canvass was conducted by the Washington Department of Commerce and Economic Development.[11]

Seventy-four percent of the total United States lime production was used by chemical and industrial plants, 15 percent as refractory material, 10 percent in construction, and 1 percent in agriculture. Quicklime and hydrated lime were used in chemical and industrial products and processing, in construction, and in agriculture. Disregarding refractory lime or dead-burned dolomite, chemical and industrial uses consumed 87 percent, construction 11 percent, and agriculture 2 percent.

There were increases in many principal uses of lime over 1959. Gains were reported in the quantities of lime used in masonry, ore concentration, and in the manufacture of alkalies, calcium carbide and cyanamide, precipitated calcium carbonate, paper and pulp, and steel. Lime consumption remained virtually the same in soil stabilization, water treatment, and in the manufacture of glass and petrochemicals. Less lime was used in agriculture, finishing lime, sewage and trade wastes treatment, and in tanning. Minor chemical and industrial uses of lime, that account for less than 50,000 short tons annually, often do not show any consistency for successive years.

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[10] National Lime Association, Commercial Lime Plants in the United States, 1961.

[11] Pit and Quarry, Washington State Official Outlines Potential Market for New Lime Producers: vol. 53, No. 3, September 1960, p. 137.

TABLE 5.—Lime sold or used by producers in the United States, by uses

(Short tons)

Use	1959 Open-market	1959 Captive	1959 Total	1960 Open-market	1960 Captive	1960 Total
Agriculture	195,554		195,554	186,769		186,769
Construction:						
Finishing lime	548,763	4,122	552,885	470,438	3,875	474,313
Mason's lime	[1] 437,325	[1] 85,510	[1] 522,835	473,585	96,634	570,219
Soil stabilization	167,967	460	168,427	171,248	691	171,939
Other	[1] 64,953	[1] 6,246	[1] 71,199	13,713	6,633	20,346
Total	1,219,008	96,338	1,315,346	1,128,984	107,833	1,236,817
Chemical and other industrial:						
Alkalies (ammonium, potassium, and sodium compounds)	10,326	2,683,409	2,693,735	8,898	3,008,399	3,017,297
Brick, sand-lime and slag	6,749		6,749	9,751		9,751
Brick, silica (refractory)	22,435		22,435	20,356		20,356
Calcium carbide and cyanamide	664,415	358,635	1,023,050	668,899	410,149	1,079,048
Calcium carbonate (precipitated)	(2)	(2)	73,595	(2)	(2)	77,282
Coke and gas (gas purification and plant byproducts)	(2)	(2)	20,519	18,218	3,012	21,230
Food and food byproducts	11,410		11,410	40,782		40,782
Glass	244,373		244,373	247,997		247,997
Insecticides, fungicides, and disinfectants	39,739		39,739	39,236	1,905	41,141
Metallurgy (other) [3]	206,960	51,469	258,429	86,206		86,206
Oil well drilling	6,921		6,921	9,262		9,262
Ore concentration [4]	232,824	398,623	631,447	237,711	540,654	778,365
Paint	(2)	(2)	61,185	(2)	(2)	11,605
Paper and pulp	717,666	45,822	763,488	701,221	136,932	838,153
Petrochemicals (glycol)	(2)	(2)	142,829	(2)	(2)	146,905
Petroleum refining	40,076		40,076	42,755		42,755
Rubber	5,549		5,549	1,272		1,272
Sewage and trade-wastes treatment	128,944	9,611	138,555	128,191	4,142	132,333
Steel (open-hearth, basic oxygen, and electric furnace flux)	1,377,052	60,691	1,437,743	1,510,000	95,864	1,605,864
Sugar and refining	35,298	1,904	37,202	28,470	13,001	41,471
Tanneries	67,972		67,972	62,899		62,899
Water softening and purification	686,492	68,591	755,083	710,407	67,123	777,530
Wire drawing	3,991		3,991	3,751		3,751
Undistributed [5]	[1] 520,695	302,124	524,691	375,259	357,817	497,284
Total	5,029,887	3,980,879	9,010,766	4,951,541	4,638,998	9,590,539
Refractory lime (dead-burned dolomite)	1,961,060	25,501	1,986,561	1,922,042	27,218	1,949,260
Grand total	8,405,509	4,102,718	12,508,227	8,189,336	4,774,049	12,963,385

[1] Revised figure.
[2] Included with "Undistributed" and "Total" columns to avoid disclosing individual company confidential data.
[3] Includes various metallurgical uses.
[4] Includes flotation, cyanidation, bauxite purification, and magnesium manufacture.
[5] Includes alcohol, calcium carbonate (precipitated), medicine and drugs, explosives, paint, petrochemicals, salt, miscellaneous, and unspecified uses.

TABLE 6.—Lime sold or used by producers in the United States,[1] by major uses

	1959			1960		
	Short tons	Value [2]		Short tons	Value [2]	
		Total	Average per ton		Total	Average per ton
Agricultural	195,554	$2,468,465	$12.62	186,769	$2,488,945	$13.33
Construction:						
Finishing lime	552,885	10,981,720	19.86	474,313	9,758,245	20.57
Mason's lime	[3] 522,835	[3] 8,017,748	[3] 15.34	570,219	9,412,405	16.51
Soil stabilization	168,427	1,975,939	11.73	171,939	2,098,669	12.21
Other	[3] 71,199	[3] 1,348,009	[3] 18.93	20,346	331,582	16.30
Total construction	1,315,346	22,323,416	16.97	1,236,817	21,600,901	17.46
Chemical and industrial uses	9,010,766	106,369,570	11.80	9,590,539	116,509,442	12.15
Refractory (dead-burned dolomite)	1,986,561	33,049,069	16.64	1,949,260	32,467,399	16.66
Grand total	12,508,227	164,210,520	13.13	12,963,385	173,066,687	13.35

[1] Includes Puerto Rico.
[2] Selling value, f.o.b. plant, excluding cost of container.
[3] Revised figure.

TABLE 7.—Apparent consumption of lime sold and used in the United States

(Short tons)

State	1959			1960		
	Quicklime	Hydrated lime	Total	Quicklime	Hydrated lime	Total
Alabama	268,485	65,008	333,493	257,262	75,830	333,092
Alaska		821	821		231	231
Arizona	112,477	17,418	129,895	135,570	25,259	160,829
Arkansas	52,449	10,290	62,739	63,027	9,333	72,360
California	389,663	96,590	486,253	409,590	97,941	507,531
Colorado	18,010	9,174	27,184	17,471	11,526	28,997
Connecticut	31,936	29,508	61,444	46,096	25,107	71,203
Delaware	34,783	14,115	48,898	35,783	9,587	45,370
District of Columbia	110	9,546	9,656		8,635	8,635
Florida	198,216	73,188	271,404	248,866	57,096	305,962
Georgia	68,850	23,383	92,233	75,139	22,623	97,762
Hawaii	(1)	(1)	(1)		(1)	(1)
Idaho	2,681	2,030	4,711	2,315	2,649	4,964
Illinois	435,543	143,912	579,455	373,461	108,728	482,189
Indiana	[2] 449,168	[2] 38,333	[2] 487,501	528,847	62,530	591,377
Iowa	[2] 87,669	[2] 20,437	[2] 108,106	80,381	18,130	98,511
Kansas	35,728	16,146	51,874	37,896	15,478	53,374
Kentucky	475,969	20,014	495,983	503,653	18,094	521,747
Louisiana	306,224	58,876	365,100	617,640	35,668	653,308
Maine	35,361	9,737	45,098	48,526	10,404	58,930
Maryland	162,343	30,852	193,195	168,902	26,586	195,488
Massachusetts	66,084	46,345	112,429	35,098	46,731	81,829
Michigan	463,305	560,524	1,023,829	806,390	595,599	1,401,989
Minnesota	88,211	21,961	110,172	95,372	19,910	115,282
Mississippi	41,908	7,880	49,788	39,750	10,578	50,328
Missouri	120,016	65,862	185,878	110,703	53,255	163,958
Montana	53,570	1,783	55,353	78,054	5,989	84,043
Nebraska	12,363	8,582	20,945	10,499	11,556	22,055
Nevada	779	24,979	25,758	356	36,546	36,902
New Hampshire	4,443	7,700	12,143	4,861	5,465	10,326
New Jersey	40,838	100,262	141,100	33,254	71,258	104,512
New Mexico	[2] 263	[2] 22,067	[2] 22,330	4,869	50,886	55,755
New York	[2] 1,152,651	[2] 116,480	[2] 1,269,131	1,271,977	124,103	1,396,080
North Carolina	90,631	34,924	125,555	102,007	27,174	129,181
North Dakota	7,391	1,899	9,290	7,357	1,532	8,889
Ohio	[2] 2,015,901	[2] 175,015	[2] 2,190,916	1,671,747	117,163	1,788,910
Oklahoma	[2] 38,216	[2] 15,770	[2] 53,986	38,397	12,680	51,077
Oregon	38,868	12,641	51,509	49,454	8,975	58,429
Pennsylvania	[2] 1,086,332	208,518	[2] 1,294,850	1,028,769	238,498	1,267,267
Rhode Island	[2] 6,991	5,356	[2] 12,347	8,707	6,342	15,049
South Carolina	10,443	7,414	17,857	12,790	7,711	20,501
South Dakota	7,415	1,205	8,620	8,429	1,058	9,487
Tennessee	[2] 61,840	[2] 25,821	[2] 87,661	47,036	27,019	74,055
Texas	[2] 389,097	[2] 399,566	[2] 788,663	441,058	400,968	842,026
Utah	70,075	24,692	94,767	86,672	23,762	110,434
Vermont	3	1,955	1,958		1,825	1,825
Virginia	302,110	42,943	345,053	272,516	37,199	309,715
Washington	20,932	12,503	33,435	19,007	11,536	30,543
West Virginia	221,018	19,949	240,967	166,218	20,578	186,796
Wisconsin	96,277	53,702	149,979	94,981	55,464	150,445
Wyoming	71	4,073	4,144	502	4,017	4,519
Total	[2] 9,673,707	[2] 2,721,749	[2] 12,395,456	10,197,255	2,676,812	12,874,067

[1] Figures withheld to avoid disclosing individual company confidential data, not included in total.
[2] Revised figure.

PRICES AND SPECIFICATIONS

The average price of open-market and captive quicklime and hydrated lime, f.o.b. plant, excluding the cost of containers, rose to $13.35 per ton from $13.13 in 1959. The Oil, Paint and Drug Reporter quoted the same prices for lime throughout the year.[12] Bulk quicklime was $14.25 a ton; bagged hydrated lime $17.25 a ton; and

[12] Oil, Paint and Drug Reporter, vol. 177, Nos. 1–27; vol. 178, Nos. 1–27; Jan. 4–Dec. 26, 1960.

bagged hydrated spray lime $18.25 a ton. These prices were for 25-ton carlots at Eastern lime plants. Wholesale New York City prices were $6.29 a ton higher when the freight charge from the nearest producing point was included.

Lime Committee C-7 of the American Society for Testing Materials recommended tentative revisions of the ASTM Standard Methods of Testing Quicklime and Hydrated Lime.[13]

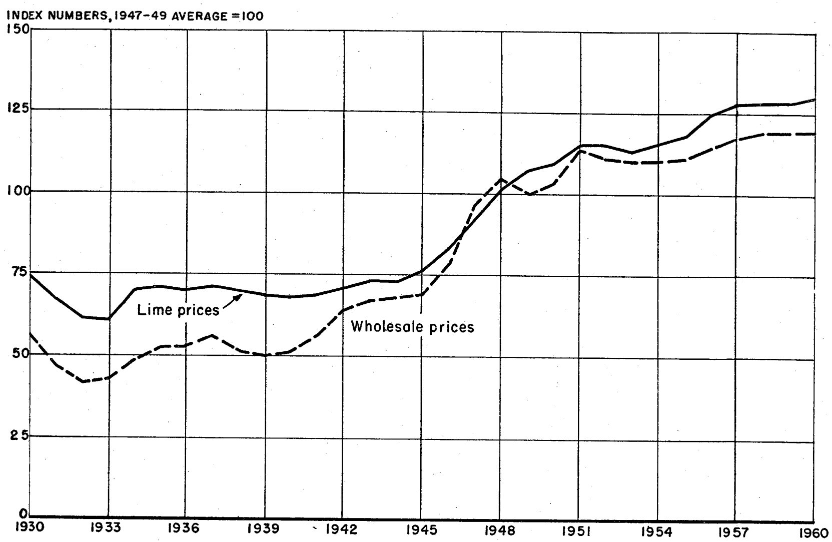

FIGURE 3.—Average price of lime per ton, compared with wholesale prices of all commodities, 1930-60. Units are reduced to percentages of the 1947-49 average. Wholesale prices from U.S. Department of Labor.

FOREIGN TRADE[14]

Imports.—Eight border States from Maine to Washington imported Canadian quicklime, hydrated lime, and dead-burned dolomite. Most of the imported lime entered the United States at the Washington border, with much smaller quantities entering New York, Montana, and Idaho, in descending order. Puerto Rico imported hydrated lime from Colombia.

Exports.—Lime was exported to 32 countries. Canada, Costa Rica, Panama, Mexico, Honduras, and Nicaragua, in decreasing order, received 96 percent of the exported lime. The other 4 percent went to 26 countries in North America, Asia, Europe, South America, Africa, and Oceania, in decreasing order.

[13] Pit and Quarry, Standard Lime Tests: Vol. 53, No. 3, September 1960, p. 109.
[14] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 8.—U.S. imports for consumption of lime[1]

Year	Hydrated lime		Other lime		Dead-burned dolomite[2]		Total	
	Short tons[3]	Value	Short tons[3]	Value	Short tons[3]	Value	Short tons[3]	Value
1951–55 (average)	1,207	$18,379	28,686	$507,177	4,336	$282,690	34,229	$808,246
1956	757	12,312	31,903	549,290	9,031	586,754	41,691	1,148,356
1957	245	4,603	39,002	687,421	10,419	639,741	49,666	1,331,765
1958	1,000	20,646	18,822	318,495	5,686	322,386	25,508	661,527
1959	530	9,346	26,374	442,330	[4] 8,468	[4] 495,952	[4] 35,372	[4] 947,628
1960	672	14,597	18,445	369,051	[5] 12,932	[5] 550,365	32,049	934,013

[1] Revision in 1959 Minerals Yearbook, p. 689, table 9, 1950–54 (average) should read as follows: Other lime, 28,814 short tons; total, 33,163 short tons.
[2] Dead-burned basic refractory material consisting chiefly of magnesia and lime.
[3] Includes weight of immediate container.
[4] Revised figure.
[5] Adjusted by Bureau of Mines.

Source: Bureau of the Census.

TABLE 9.—U.S. exports of lime

Year	Short tons	Value	Year	Short tons	Value
1951–55 (average)	72,778	$1,300,120	1958	45,844	$1,047,310
1956	82,737	1,546,127	1959	52,780	1,000,337
1957	65,195	1,328,575	1960	61,056	991,769

Source: Bureau of the Census.

WORLD REVIEW

NORTH AMERICA

British West Indies.—The Bahama Islands produced 4,120 short tons of lime valued at $87,172 in 1959.[15]

Canada.—Lime production in 1960 was 1,533,673 short tons valued at Can$17,037,970, according to a preliminary report.[16] In 1959, lime production set a record with 1,685,725 short tons valued at Can$21,304,021. Five new vertical kilns were installed in Ontario, and a rotary-kiln plant was under construction in Quebec. Canada was self-sufficient in lime, except for pressure-hydrated lime which was imported from the United States. All of the Provinces except Newfoundland, Nova Scotia, Prince Edward Island, and Saskatchewan produced lime. About 2,826,000 tons of limestone was calcined into lime in 1959. The 38 Canadian lime plants had 130 vertical kilns, 24 rotary kilns, and a total capacity of 7,590 tons of primary quicklime daily. There were also two separate hydrating plants. In addition, 15 plants with 16 rotary kilns in British Columbia, Ontario, Quebec, and New Brunswick reclaimed captive secondary lime from waste carbonate sludges from pulp and paper manufacture.[17]

[15] U.S. Consulate, Nassau, Bahamas, British West Indies, State Department Dispatch 120: May 2, 1960, p. 1.
[16] Dominion Bureau of Statistics (Ottawa), Preliminary Estimate of Canada's Mineral Production, 1960: Jan. 2, 1961, p. 4.
[17] Ross, J. S., Lime, 1959: Canada Dept. of Mines and Tech. Surveys, Ind. Min. Div., Rev. 38, May 1960, 7 pp.

Three vertical kilns fired by producer gas were erected by Chemical Lime, Ltd., at Beachville, Ontario, and two vertical kilns were added at Canadian Gypsum Co., Ltd., Guelph, Ontario.[18] Standard Lime Co., Ltd., doubled its lime-producing capacity at its Joliette, Quebec, plant by installing an 8- by 200-foot rotary kiln. Calcining temperature was 2,300° F. Daily capacity increased to 200 tons of quicklime. Both high-calcium quicklime and hydrated lime were produced.[19] Dominion Lime, Ltd., St. Bruno, Quebec, converted the vertical kilns at its Lime Ridge plant from producer gas to oil.[20] Although a commercial lime plant had not been established in Newfoundland, reserves of high-calcium and dolomitic limestone were widespread. Two sulfite pulpmills and some base-metal concentrators on the island consumed from 29,000 to 34,000 tons of limestone annually.[21]

Chemical and industrial uses of lime accounted for 88 percent and construction 12 percent of all lime consumed in 1958. The principal consumers of lime, in descending order, were: Uranium mills, pulpmills and paper mills, nonferrous smelters, and iron and steel mills. The average value of lime in Ontario was Can$11.81 a ton at the lime plants. Quicklime was sold in bulk as lump, pebble, and pulverized lime; and in bags as pulverized lime only. Hydrated lime was also sold in bulk and in bags as a fine granular material. Lime prices varied according to type, form, tonnage of sale, and location.[22]

Costa Rica.—Lime production in 1959 was 3,307 short tons valued at US$21,116.[23]

Dominican Republic.—Estimated lime production in 1959 was 16,343 short tons.[24]

Netherlands Antilles.—A small lime plant, The Bonaire Lime Factory, N.V., was erected on the island of Bonaire. Although two shaft kilns were purchased from a phosphate rock producer, Curacao Mining Co., only one kiln was used for calcining. Its capacity was rated at 275 to 385 short tons of quicklime monthly. Coral washed ashore on the west coast of the island was the kiln feed. The lime output was for the large Shell Curacao, N.V., oil refinery at Curacao and a water-treatment plant at Aruba.[25]

SOUTH AMERICA

Brazil.—Lime production in 1959 was 1.4 million short tons.[26] A Fabrica Nacionale de Alcalis plant was under construction at Cabo Frio, Rio de Janeiro State. Its annual lime-producing capacity was expected to be 80,000 tons.[27]

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[18] Work cited in footnote 17.
[19] Canadian Mining Journal (Gardenvale, Quebec), Standard Lime Co.'s New Rotary Kiln: Vol. 81, No. 3, March 1960, p. 149.
[20] Pit and Quarry, Vertical Lime Kilns Converted to Bunker C Oil Firing: Vol. 53, No. 5, November 1960, p. 93.
[21] Canadian Mining Journal (Gardenvale, Quebec), Industrial Mineral Exploration in Newfoundland—Limestone: Vol. 81, No. 4, April 1960, pp. 92–93.
[22] Work cited in footnote 17.
[23] U.S. Embassy, San Jose, Costa Rica, State Department Dispatch 556: May 4, 1960, p. 1.
[24] U.S. Embassy, Ciudad Trujillo, Dominican Republic, State Department Dispatch 354: Apr. 22, 1960, p. 1.
[25] U.S. Consulate, Curacao, Netherlands Antilles, State Department Dispatch 11: Aug. 5, 1960, p. 1.
Pit and Quarry, vol. 53, No. 5, November 1960, p. 91.
[26] Bureau of Mines, Mineral Trade Notes: Vol. 51, No. 3, September 1960, p. 33.
[27] Chemical Age (London), Large Alkalis Expansion Underway in Brazil: Vol. 84, No. 2153, Oct. 15, 1960, p. 632.

Paraguay.—Output of lime in 1959 amounted to 10,796 short tons valued at US$196,721.[28]

Peru.—During 1959, 73,850 short tons of lime was produced: 32,000 tons for construction, 24,250 tons for mineral concentration, 13,200 tons for agriculture, and 4,400 tons for chemical and industrial uses.[29]

Venezuela.—Lime production in 1959 was 50,000 short tons.[30]

EUROPE

Denmark.—Estimated quicklime production in 1959 was 121,250 short tons. Lime for industrial use was 55,115 tons, and lime and limestone for agriculture amounted to 264,550 tons.[31]

Finland.—Quicklime production was 231,000 short tons in 1959.[32]

France.—Estimated 1959 production of high-calcium lime was 2,535,000 short tons.[33]

Germany, West.—Sales of agricultural lime, primarily quicklime with some limestone and chalk, amounted to 804,000 short tons in 1959. Some types of lime increased in price in 1959, and three producer groups sought governmental approval for regional price cartels.[34] Several lime plants in the Stolberg district calcined limestone from formations in the Eifel Mountains near Aachen.[35] Total consumption of lump and pulverized quicklime was almost as much as in the United States because of much greater use of lime in metallurgical processes, building, and agriculture. The sand-lime-brick industry consumed on the average 850,000 tons of lime yearly.[36]

Hungary.—Hydrated lime production, 165,000 short tons in 1958, increased to 352,000 short tons in the first 8 months of 1959. A 1-million ton-a-year quicklime and cement plant was announced.[37]

Italy.—Societa Forindus, Milan, manufactured oil-fired limekilns.[38]

Luxembourg.—Quicklime production in 1959 was 47,119 short tons valued at US$7.62 to US$11.61 a short ton.[39]

Malta.—Lime production was approximately 53,400 short tons in 1958.[40]

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[28] U.S. Embassy, Asuncion, Paraguay, State Department Dispatch 392: May 2, 1960, p. 1.

[29] U.S. Embassy, Lima, Peru, State Department Dispatch 615: Apr. 20, 1960, encl. 1, p. 2.

[30] U.S. Embassy, Caracas, Venezuela, State Department Dispatch 942: Apr. 26, 1960, encl. 1, p. 1.

[31] U.S. Embassy, Copenhagen, Denmark, State Department Dispatch 780: May 4, 1960, encl. 1, p. 1.

[32] U.S. Embassy, Helsinki, Finland, State Department Dispatch 676: May 3, 1960, encl. 1, p. 2.

[33] U.S. Embassy, Paris, France, State Department Dispatch 1633: Apr. 22, 1960, p. 2.

[34] U.S. Consulate, Duesseldorf, Germany, State Department Dispatch 312: May 11, 1960, p. 16.

[35] U.S. Consulate, Duesseldorf, Germany, State Department Dispatch 341: June 14, 1960, p. 6.

[36] Rock Products, Lime Industry Probes New Markets: Vol. 63, No. 7, July 1960, pp. 110, 115–116, 122, 132.

[37] Chemical Engineering, Hungary: Vol. 67, No. 4, Feb. 22, 1960, p. 175.
Figyelo (Budapest), [Production and Distribution of Construction Materials], Oct. 6, 1959, p. 4.

[38] Mine and Quarry Engineering (London), Agency for Oil-Fired Lime Kilns: Vol. 26, No. 3, March 1960, p. 132.

[39] U.S. Embassy, Luxembourg, State Department Dispatch 174: Apr. 4, 1960, encl. 1, p. 1.

[40] U.S. Consulate, Valletta, Malta, State Department Dispatch 122: Apr. 26, 1960, encl. 1, p. 2.

Poland.—Lime sales increased 23 percent during the first half of 1959, compared with the first half of 1958.[41] In 1959, shaft kilns produced one-third of the 1.6 million tons of lime produced. Small shaft kilns, designed by the Cement and Lime Industry Designing Bureau at Krakow, to burn small-size limestone, produced 35 tons of lime an hour. New shaft kilns were planned for lime plants at Plaza, Strzelce, and Gorazdze. Rotary kilns were installed in the lime plants in Piechcin-Wapienno.[42]

Rumania.—A completely mechanized vertical kiln began producing lime in Cernele.

United Kingdom.—Imperial Chemical Industries, Ltd., calcined limestone from quarries in Derbyshire and exported some lime to gold producers in Ghana.[43] The Power-Gas Corp., Ltd., Stockton-on-Tees and London, erected mixed-feed and gas-fired shaft kilns.[44] Arden limestone was calcined in vertical kilns near Nitshill, southern Scotland, and the pulverized lime was used in mortars.[45] The subsidy for agricultural liming was set at the flat rate of 65 percent of liming costs for the entire year of 1960–61. Over 80 percent of the spreading was done by contractors.[46] Spreading lime by airplane was demonstrated at Cranfield Aerodrome in 1959.[47]

ASIA

Cambodia.—Kilns in Kampot produced enough lime in 1959 to satisfy national requirements.[48]

India.—A West German firm erected three limekilns and two deadburned dolomite kilns at the Rourkela Steel Project late in 1959.[49] Two gas-fired vertical limekilns, each capable of producing 75 tons of quicklime daily, and a rotary kiln (8½ by 275 feet) for deadburning dolomite began operating at the Durgapur Steelworks, West Bengal.[50]

Israel.—A 180-foot rotary kiln having two diameters of 9 and 10½ feet was built in Sheffield, England, for the Lime and Stone Production Co., Ltd., plant at the Shfeya quarry near Haifa. Limestone was to be calcined at a rate of 13 tons an hour.[51]

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[41] Gospodarka Planowa (Warsaw), [Investment Problems and the Economic Situation]: September 1959, pp. 1–7.
[42] Cement, Wapno, Gips (Krakow), [Data on Lime Industry], May 1960, pp. 124–136.
[43] Mining Journal (London), Imperial Chemical Industries, Ltd.: Vol. 254, No. 6501 supp., Mar. 25, 1960, p. 15.
[44] Chemical Trade Journal and Chemical Engineer (London), Vol. 147, No. 3832, Nov. 11, 1960, p. 1075.
[45] Gallagher, G. J., Arden Lime—A Century Review: Building Ind. and Scotch Architect (Glasgow), vol. 71, No. 838, 1960, pp. 47–49.
[46] Chemical Trade Journal and Chemical Engineer (London), The Lime and Fertiliser Subsidies: Vol. 146, No. 3798, Mar. 18, 1960, p. 625.
Fertiliser and Feeding Stuffs Journal (London), Lime Subsidy Change: Vol. 52, No. 7, Apr. 6, 1960, p. 355; Lime Spreading Conference: Vol. 52, No. 8, Apr. 20, 1960, p. 376.
[47] Pit and Quarry, Aerial Lime Spreading Techniques Demonstrated in Great Britain: Vol. 52, No. 11, May 1960, pp. 152, 156, 159.
[48] U.S. Embassy, Phnom Penh, Cambodia, State Department Dispatch 431: June 17, 1960, encl. 1, p. 1.
[49] Pit and Quarry, vol. 52, No. 10, April 1960, p. 48.
[50] Iron and Coal Trades Review (London), Durgapur Lime and Dolomite Plant Commissioned: Vol. 180, No. 4795, June 10, 1960, p. 1297.
[51] Chemical Age (London), 180-Foot Rotary Kiln for Israel: Vol. 84, No. 2150, Sept. 24, 1960, p. 501.

Philippines.—Lime production in 1959 included 29,674 short tons of quicklime valued at US$538,537 and 21,110 tons of hydrated lime valued at US$374,134.[52]

Ryukyu Islands.—Lime production in 1959 was 1,611 short tons valued at US$24,400.[53]

United Arab Republic (Syria Region).—Lime production in 1959 was 11,023 short tons valued at US$178,082.[54] The average calcium oxide content of the lime was 96.5 percent.

Viet-Nam.—The Long Tho (long-lived dragon) Lime Plant on the Perfume River in Thua Thiên Province near Huê was founded in 1902 and incorporated as the Société des Chaux Hydrauliques du Long Tho in 1915. Lime output was 1,000 tons a month from 1942 through 1944. The plant was largely destroyed by military action in 1945 and 1946. It reopened in 1947 with 2 kilns producing 300 to 350 tons of lime a month, closed again in October 1956, and reopened in October 1959. During the first 8 months of operation through May 1960, quicklime production from a single kiln (with a daily capacity of 12 tons of quicklime) averaged 292 tons a month. The coal-fired vertical kiln calcined limestone feed for 5 days at 1,500° to 1,800° F. Bagged hydrated lime was sold at $43 a ton, only for building purposes. Lime production in 1960 was expected to be less than the 12,000 to 15,000 tons planned.[55]

AFRICA

British East Africa.—Production of lime was 10,306 short tons valued at US $183,400 in 1959.[56]

Cape Verde Islands.—Lime production in 1959 was 3,060 short tons.[57]

Kenya.—Delegates from the United Kingdom, France, Portugal, Belgium, South Africa, Southern Rhodesia, Ghana, and Nigeria met in Nairobi in November to discuss soil stabilization of low-cost roads.[58]

Libya.—Output of lime in 1959 was 15,432 short tons.[59]

Nigeria.—A 3-year, US$700,000 contract was undertaken to stabilize the base of 65 miles of road between Shagamu and Benin with lime, cement, or asphalt.[60]

Rhodesia and Nyasaland, Federation of.—A new lime plant was started by Nchanga Consolidated Copper Mines, Ltd., at Chingola.[61]

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[52] U.S. Embassy, Manila, Philippines, State Department Dispatch 560: Apr. 29, 1960, encl. 1, p. 3.
[53] U.S. Consulate, Naha, Ryukyu Islands, State Department Dispatch 45: Apr. 29, 1960, p. 1.
[54] U.S. Consulate, Damascus, Syria Region, United Arab Republic, State Department Dispatch 559: Apr. 27, 1960, p. 2.
[55] U.S. Consulate, Huê, Viet-Nam, State Department Dispatch 5: Oct. 5, 1960, encl. 1, pp. 1–4.
[56] U.S. Consulate, Kampala, British East Africa, State Department Dispatch 204: Apr. 4, 1960, p. 1.
[57] U.S. Embassy, Lisbon, Portugal, State Department Dispatch 459: May 6, 1960, encl. 1, p. 1.
[58] Cement, Lime and Gravel (London), vol. 35, No. 12, December 1960, p. 348.
[59] U.S. Embassy, Tripoli, Libya, State Department Dispatch 368: Apr. 7, 1960, p. 1.
[60] Cement, Lime and Gravel (London), Soil Stabilization in Nigeria: Vol. 35, No. 12, December 1960, p. 372.
[61] World Mining, vol. 13, No. 11, October 1960, p. 69.

South-West Africa.—In South-West Africa, 3,562 short tons of lime valued at US$62,950 was produced by E. Höring, Usakos, and South-West Africa Co., Ltd., Grootfontein, in 1959.[62]

Tanganyika.—Lime production was 4,067 short tons valued at US$45,486 in 1959.[63]

Tunisia.—Average lime production was 8,282 tons a month in 1959.[64]

Union of South Africa.—Lime and limestone production amounted to 8,027,350 short tons in 1959. Total exports of 6,978 tons of lime and limestone valued at US$79,010 went to the Federation of Rhodesia and Nyasaland, and to Mozambique. Local sales of lump quicklime were 547,568 tons valued at US$4,174,122; ground quicklime, 536 tons, at US$5,233; air-separated hydrated lime, 186,573 tons, at US$1,986,785; "blue" lime, 15,198 tons, at US$102,855; and agricultural burned lime, 58,385 tons, at US$199,522 in 1959.[65] The modern Silver Streams rotary-kiln lime plant of The Northern Lime Co., Ltd., operated beyond its rated capacity during most of 1959, as demand for lime remained high. Quality of lime also remained high because of selective quarrying. The Northern Lime Co., Ltd., increased mechanization at its older lime plant at Taungs.[66] Pentlands Lime Works, Ltd., closed after operating over 66 years.[67]

OCEANIA

Australia.—Imperial Chemical Industries (Australasia), Ltd., at Osborne produced quicklime for alkali manufacture by calcining limestone from quarries at Penrice.[68] A large deposit of calcium carbonate sand near Coffin Bay, Eyre Peninsula, South Australia, attracted interest as possible feed for kilns.[69]

New Zealand.—Lime and limestone production was 1,070,384 short tons in 1959.[70]

TECHNOLOGY

PROCESSING

Calcination.—Rotary kilns were mounted on trunion rollers with swivel bases so that the rollers automatically alined themselves with the kiln axis whenever it shifted. The girth gears and riding rings of the rotary kilns were closely integrated, being mounted together on a subassembly of the shell.[71]

Refractory heat exchangers, having a trefoil cross section and usually a 15- to 25-foot length, were installed in rotary limekilns and

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[62] Bureau of Mines, Mineral Trade Notes: Vol. 52, No. 1, January 1961, p. 29.

[63] U.S. Consulate, Dar es Salaam, Tanganyika, State Department Dispatch 296: May 10, 1960, encl. 1, p. 1.

[64] U.S. Embassy, Tunis, Tunisia, State Department Dispatch 593: May 2, 1960, encl. 1, p. 7.

[65] U.S. Consulate, Johannesburg, Union of South Africa, State Department Dispatch 7: July 18, 1960, encl. 1, p. 13; encl. 3, p. 1; encl. 4, p. 1; encl. 5, p. 1; and encl. 6, p. 1.

[66] Work cited in footnote 58.

[67] Cement, Lime and Gravel (London), Historic Lime Works Shuts Down: Vol. 35, No. 10, October 1960, p. 298.

[68] Chemical Age (London), Australian I. C. I. Alkali Plant to be Expanded: Vol. 83, No. 2120, Feb. 27, 1960, p. 365.

[69] Mining and Chemical Engineering Review (Melbourne), vol. 52, No. 12, Sept. 15, 1960, p. 10.

[70] Bureau of Mines, Mineral Trade Notes: Vol. 52, No. 1, January 1961, p. 28.

[71] Vulcan Iron Works, Inc., A New Concept in Rotary Kiln Design, 1960, 10 pp.

rotary lime-sludge kilns. Passage of the preheated charge through the trefoil heat exchanger moderated the temperature in the hottest zone, thereby inhibiting undesirable accretions with some fuels and extending the refractory-lining life. This design saved fuel and increased quicklime output.[72] "Multivane" internal heat recuperators were also installed in rotary kilns. The six alloy-steel vanes saved fuel and increased the heat-transfer surface and exposure of the charge to hot gases.[73]

A network of chains inside the feed end of a rotary kiln prevented clogging of the kiln by the entering slurries.[74] Another chain system (45 feet long) inside a rotary kiln accelerated heat transfer from the gas stream to the lime slurry.[75] An auxiliary ring inside a rotary kiln delayed the charge in a soaking bed on the upslope side of the ring. Sloping down from the ring interior toward the kiln shell, a groove (diagonal across the ring and at an angle with the kiln axis) dispensed material in the soaking bed toward the discharge end of the kiln.[76]

Improved vertical kilns maintained and controlled their calcining temperature by even distribution of fuel and air throughout the calcining zone.[77] Horizontal, hollow beams across the calcining zone had oppositely disposed lateral ports along their lengths for delivering a mixture of fuel and air for primary combustion. An indirectly fired vertical kiln also controlled the calcining temperature within narrow limits. The hot gases were conducted into the kiln from external combustion chambers.[78] A closed-circuit, cross-stream, vertical kiln calcined limestone in an upper and lower zone.[79] Hot gases flowed through the upper half of the charge, were mixed with waste gases, reheated, and passed through the lower half of the charge in the opposite direction.

Lime production was increased and fuel consumption reduced by new systems of selective charging. Feed was evenly distributed by two bells moving vertically in the top of the vertical kiln. Lowering the large bell on top shut off the feed, and raising it allowed the feed to flow into the kiln. Lowering the small bell directed the feed against the kiln walls, and raising it inside the large bell caused the feed to fall into the center of the kiln. Alternate lowering and raising of the small bell assured even distribution of limestone. Ordinary charging concentrated feed at the center of the kiln, causing the hot gases to rise along the walls at greatest velocity with maximum heating effect. Overheating kiln walls, reactions between lining and charge, overburning of peripheral lime, and underburning of central lime were

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[72] Pit and Quarry, vol. 52, No. 11, May 1960, pp. 52, 103.
[73] Rock Products, vol. 63, No. 1, January 1960, p. 161.
[74] Chemical and Engineering News, Chains Prevent Clogging in Rotary Kiln: Vol. 38, No. 24, June 13, 1960, p. 71.
[75] Stout, R. C., and Mertz, E. C., Lime Recovery Transforms Waste to Income: American City, vol. 74, No. 5, May 1959, pp. 101–103.
[76] Spence, Gerald M. (assigned to Monolith Portland Midwest Co., Los Angeles, Calif.), Rotary Kilns: U.S. Patent 2,921,779, Jan. 19, 1960.
[77] Erasmus, Hendrik de W., and Leuenberger, Hans (assigned to Union Carbide Corp., New York, N.Y.), Lime Kiln: U.S. Patent 2,933,297, Apr. 19, 1960.
[78] Ludin, Werner (assigned to L. von Roll A. G. Zurich, Switzerland), Shaft Kiln: U.S. Patent 2,960,323, Nov. 15, 1960.
[79] Heiligenstaedt, Hans E. W. (assigned to Röchling'sche Eisen- und Stahlwerke G.m.b.H., Volklingen, Germany), Process and Apparatus for Heating a Cross Stream Shaft Furnace in View of Heating Solid Materials, Particularly for the Calcination of Limestone: U.S. Patent 2,948,521, Aug. 9, 1960.

counteracted.[80] Another selective-charging device also maintained horizontal layering of feed in vertical kilns.[81]

Uniformly burned quicklime less liable to contamination by ash was produced by downdraft sintering. Limestone was spread in two layers on a traveling sintering band. The lower layer of fine limestone particles was mixed with coke or anthracite, and the upper layer consisted only of coarse limestone fragments. Heat was supplied to the upper layer exclusively at first by the descending hot oxygen-containing gases. When the top layer of coarse limestone fragments was partly calcined, the solid fuel in the bottom layer began to burn and the delayed calcination of the fine limestone particles began. Consequently, the calcination of both layers was completed about the same time.[82]

Hydration.—Quicklime was hydrated at 140° C. by superheated steam. Hard lumps, that formed and would not break down on watering, impaired the quality of the steam-hydrated lime, which had low plasticity.[83] A slurry that could be pumped, containing 30 to 50 percent lime, was formed by continuously flowing dry, finely-divided hydrated lime into a mixing zone where water or dilute slurry was injected under pressure.[84] This lime slurry could be delivered directly to the consumer.

USES

Agriculture.—Only a small fraction of the lime and agricultural limestone needed was spread. The application of fertilizers had increased more than that of liming materials in recent years. It was not generally understood that the full benefit of some fertilizers could not be realized without commensurate liming.[85]

Lime counteracts soil acidity and raises the pH of soils. It makes available greater quantities of calcium, magnesium, potash, and phosphate. It increases forage yields, promotes thicker legume growth, and increases the efficiency of fertilizer applied to nonlegume crops. The solubility of some harmful chemicals is reduced by lime. Lime improves the feed value and quality of crops, stimulates the growth of beneficial soil bacteria and the decay of organic matter, promotes root development and the release of nitrogen to the soil for plant use, improves soil structure and tilth, and provides better aeration of the soil. Lime increases the absorption of moisture by the soil and decreases runoff and loss of water and topsoil. Lime should be applied in accordance with soil-test data. It can be spread in any season and at any time in the cropping sequence.[86] Liming several months before

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[80] Tesch, T. An., Here's an Idea for Shaft-Kiln Charging: Rock Products, vol. 63, No. 8, August 1960, pp. 129, 138, 141.
[81] Beckenbach, Karl, Apparatus for Charging Kilns: U.S. Patent 2,950,019, Aug. 23, 1960.
[82] Meyer, Kurt (assigned to Dravo Corp., Pittsburgh, Pa.), Calcining or Like Process: U.S. Patent 2,923,539, Feb. 2, 1960.
[83] Kreutz, M., and Schimmel, G. [Slaking Tests on Quicklime with Steam]: Zement, Kalk, Gips (Wiesbaden), vol. 12, No. 10, 1959, pp. 471–477.
[84] Minnick, Leonard J., and Danforth, Clifton A. (assigned to G & W. H. Corson, Inc., Plymouth Meeting, Pa.), Method of Handling Lime: U.S. Patent 2,920,922, Jan. 12, 1960.
[85] Trauffer, Walter E., Liming Needs Public Support: Pit and Quarry, vol. 52, No. 12, June 1960, p. 79.
[86] Way, Winston A., Let's Look at Lime: Pit and Quarry, vol. 52, No. 11, May 1960. pp. 119–122, 134–135.
Commercial Fertilizer, Data Growing on Lime Use: Vol. 101, No. 1, July 1960, p. 59.

planting, however, allows time for neutralizing acid soil. After spreading, lime must be thoroughly mixed with the soil by plowing or disking.[87] Calcium ions derived from spread lime occupy the base-exchange positions of the clay minerals and the organic matter in the soil[88] which should be maintained at pH 6.5 to 7.0 by liming. The quantity of lime required depends upon the pH of the soil, the clay and organic content of the soil, and the quality of the lime used. Raising the pH of fertilized farmland from 5.4 to 7.0 in an Ohio experiment, by liming, increased corn yields 7 bushels an acre.[89]

Lime made soil conditions more favorable for alfalfa.[90] Applying lime and fertilizer in the spring and fall made lawn grass grow so thick that weeds were crowded out.[91] Weed growth in earthen reservoirs and ditches was reduced to a minimum by liming the soil.[92] A pulverized dolomitic quicklime capable of producing a pH as high as 10 in a solution was offered by The Moores Lime Co., Springfield, Ohio, for neutralizing acid fertilizer mixes.[93] Crops contaminated by radioactive fallout from a nuclear explosion should be cut and removed, or plowed under to a depth of 2 to 3 feet. Then liming followed by seeding can produce safe crops. Applying lime to acid soil reduces the absorption of toxic strontium 90 by a factor of 3, and alkaline soil absorbs very little strontium 90.[94]

Building.—When stored in metal drums, an all-purpose lime-putty mortar retained its moisture indefinitely, was delivered to the job by tank truck, and pumped from the tank to construction sites 100 feet high.[95] Patented finishing mortars contained powdered, dry hydrated lime as a binder.[96] A coating of lime and white cement was recommended for painting roofs to reduce air-conditioning costs.[97] Lime-diatomite slurries coated composition sheets, and hydrous calcium silicate formed in the coating during autoclaving.[98]

Plaster was produced when byproduct anhydrous calcium sulfate sludge was treated with enough quicklime to neutralize sulfuric acid.[99] Double hydrated lime constituted the base and 39 to 46 percent of a one-coat plaster mix.[1] Acoustical plaster contained 89.5 percent hydrated lime, 10 percent asbestos, and 0.5 percent foaming agent. Agitation in water up to 3 minutes yielded plaster with a density of 40

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[87] Better Crops With Plant Food, When to Lime: Vol. 44, No. 3, May–June 1960, p. 23.
[88] Aldrich, Samuel R., Random Thoughts on Limestone: Pit and Quarry, vol. 52, No. 11, May 1960, pp. 143–144.
[89] Better Crops With Plant Food, Lime: Vol. 44, No. 1, January–February 1960, p. 10.
[90] Better Crops With Plant Food, Importance of Lime: Vol. 44, No. 3, May–June 1960, p. 22.
[91] Science Newsletter, Use of Lime, Fertilizer Crowds Out Red Sorrel: Vol. 77, No. 18, Apr. 30, 1960, p. 275.
[92] Industrial and Engineering Chemistry, vol. 52, No. 6, June 1960, p. 26A.
[93] Agricultural Chemicals, Doloxide, a Mg-Ca Oxide: Vol. 15, No. 6, June 1960, p. 54.
[94] Pit and Quarry, Reducing Effects of Fallout: Vol. 52, No. 9, March 1960, p. 98.
[95] Pit and Quarry, All-Purpose Lime Putty Delivered by Tank Truck: Vol. 53, No. 3, September 1960, p. 145.
[96] Östergren, Jarl O. B. (assigned to Nya Murbruksfabrikens i Stockholm Aktiebolag, Stockholm, Sweden), Finishing Mortars: U.S. Patent 2,950,206, Aug. 23, 1960.
[97] Rock Products, Whitewashing a Roof Can Lower its Temperature: Vol. 63, No. 9, September 1960, p. 11.
[98] Seipt, Willard R. (assigned to Keasbey & Mattison Co., Ambler, Pa.), Composite Building Unit: U.S. Patent 2,946,158, July 26, 1960.
[99] Hanusch, Hellmut (assigned to Rofusa N.V., Willemstad, Curacao, Netherlands Antilles), Method of Preparing Synthetic Anhydrite: U.S. Patent 2,937,926, May 24, 1960.
[1] Covert, Kenneth B., Park, Robert W., and Brist, Uriah M. (assigned to Pabcor, Inc., Fredericksburg, Va.), Plastering Material: U.S. Patent 2,931,733, Apr. 5, 1960.

pounds per cubic foot, but after 10 minutes of agitation, plaster density was reduced 50 percent.[2]

The plasticity of pressure-hydrated dolomitic lime was increased and its workability and soaking properties improved by subjecting the dry hydrate first to high-velocity impact milling and then to localized compression milling.[3] A temperature-stabilized, atmospherically hydrated dolomitic lime having improved plasticity when soaked and used at low temperature was prepared by tube-milling part, hammermilling the rest, and then mixing.[4]

Chemical and Industrial.—Quicklime and hydrated lime were used as low-cost alkalies in neutralizing acidic industrial wastes. Lime sludge from water-treatment plants and calcium carbide-acetylene plants was inexpensive. Waste lime slurries were most effective when collected, concentrated, and used while wet. Yet even after several years of drying, accompanied by atmospheric recarbonation, waste lime beneath the exposed layer still retained neutralizing capacity.[5] Lime was substituted for sodium hydroxide to lower costs $5 to $6 per ton of pulp produced.[6]

Radioactive liquid was incorporated into molten glass composed of 15 percent lime and 85 percent nepheline syenite at 1,350° C. by Atomic Energy of Canada Ltd., Chalk River, Ontario, for safe underground disposal. Tests showed that the solid glass, containing up to 10 percent by weight of fission-product oxides, resisted leaching by water.[7]

Hydrated lime mixed with acid-activated kaolin was added to smoking tobacco to remove tars produced in burning and to improve aroma.[8] A new hydrated calcium silicate was manufactured from an aqueous lime diatomite solution.[9] Sodium aluminate was produced from an alumina material contaminated with silica, vanadium, and chromium by adding lime in a ratio of at least 20:1 for silica and up to 80:1 for vanadium.[10]

A refractory composition consisted of 65 to 85 percent high-calcium quicklime and 15 to 35 percent alumina plus silica, as clay. An amorphous material that formed on heating enveloped the unaltered quicklime particles and shielded them against hydration.[11] A new high-temperature insulation contained lime, asbestos, and diatomite.[12]

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[2] Stewart, Basil O., and Schneiter, Henry J. (assigned to National Gypsum Co., Buffalo, N.Y.), Sound Absorptive Structure: U.S. Patent 2,933,147, Apr. 19, 1960.

[3] Volk, Joseph, and Kinsinger, Frank E. (assigned to National Gypsum Co., Buffalo, N.Y.), Building Lime: U.S. Patent 2,956,867, Oct. 18, 1960.

[4] Volk, Joseph (assigned to National Gypsum Co., Buffalo, N.Y.), Hydrated Lime: U.S. Patent 2,957,776, Oct. 25, 1960.

[5] Jacobs, H. L., In Waste Treatment, Know Your Chemicals, Save Money: Chem. Eng., vol. 67, No. 11, May 30, 1960, pp. 87–92.

[6] Chemical Engineering, Lower Pulping Costs: Vol. 67, No. 7, Apr. 4, 1960, p. 68.

[7] Chemical Engineering, vol. 67, No. 9, May 2, 1960, p. 113.
Bancroft, A. R., Incorporation of Fission Products into Glass for Disposal: Canadian Jour. Chem. Eng., vol. 38, 1960, pp. 19–24.
Watson, L. C., Glass for Disposing of Fission Products: Glass Industry, vol. 41, No. 5, May 1960, pp. 264–267, 292–296.

[8] Specht, Charles A. (assigned to Minerals & Chemicals Corp. of America, Menlo Park, N.J.), Tobacco Composition and Smoking Unit Containing Material for Eliminating Deleterious Matter: U.S. Patent 2,938,818, May 31, 1960.

[9] Vander Linden, Carl R., and Blair, Laurence R. (assigned to Johns-Manville Corp., New York, N.Y.), Low Solubility Hydrated Calcium Silicate: U.S. Patent 2,966,441, Dec. 27, 1960.

[10] Perrin, Tom S., Banner, Robert G., and Smith, Robert C. (assigned to Diamond Alkali Co., Cleveland, Ohio), Alkali Metal Aluminates: U.S. Patent 2,926,069, Feb. 23, 1960.

[11] McAllister, Robert W., Refractory Lime: U.S. Patent 2,948,631, Aug. 9, 1960.

[12] Rock Products, Insulating Product Uses Rock Products: Vol. 63, No. 1, January 1960 p. 58.

The Miami, Fla., Department of Water and Sewers recalcining plant, that cost $1.25 million to build in the late 1940's, returned its cost in 5 years by producing quicklime used in water treatment. Precipitation and removal of lime in water softening reduced the water hardness from 260 to 85 parts per million.[13]

Metallurgy.—Basic oxygen processes for making steel offered the best prospect for increased lime consumption in the United States. From 100 to 175 pounds of quicklime was required as flux for each ton of ingot produced by oxygen steelmaking methods, the most popular being the Austrian L.D. process. An 82-ton heat at a Jones & Laughlin Steel Corp. plant consumed quicklime at rates of 5½ to 9¼ tons an hour.[14]

Pig iron was converted to steel at Société Usinor, Denain, France, by blowing powdered quicklime in an oxygen jet onto the molten surface. A dispenser injected commercial-grade quicklime accurately and uniformly into the stream of oxygen. High-phosphorous iron was refined by blowing lime and oxygen continually. The blown lime reacted instantaneously with the molten metal, and 240 pounds was injected into each ton of iron.[15] A jet of oxygen containing powdered quicklime was directed downward against the surface of molten, phosphorous-bearing pig iron under such pressure that the stream penetrated to the bottom of the bath where the most efficient reaction with the iron occurred. Constant jet diameter kept turbulence in the bath to a minimum.[16]

Lime and aluminum suspended in air or nitrogen desulfurized molten pig iron in ladles.[17] Powdered magnesium diluted with lime was injected into molten steel in electric furnaces at The Dow Chemical Co., Midland, Mich., to remove sulfur.[18]

Quicklime replaced limestone in an improved process of the Ford Motor Co., Detroit, Mich., that more than tripled output of open-hearth steel. Heat that had been formerly used to dissociate limestone to lime now contributed to melting the charge. Some steelmakers questioned the economy of substituting quicklime at $20 a ton for limestone at $2.50 to $3 a ton, despite this increased production.[19]

The Steel and Tube Division of the Timken Roller Bearing Co., Canton, Ohio, used 50 tons of quicklime daily in operating nine electric steelmaking furnaces at full capacity. Lime was hauled, stored, and delivered to the charging floor in waterproof metal containers holding 1.7 tons each, or enough for three charging boxes. These new con-

[13] Engineering News-Record, Keeping Water in the Black: Vol. 164, No. 19, May 12, 1960, pp. 75, 78, 80.
[14] Work cited in footnote 36.
[15] Steel, French Converter Process Produces Quality Steel: Vol. 146, No. 5, Feb. 1, 1960, pp. 92, 94.
Iron and Coal Trades Review (London), French Converter Process: Vol. 180, No. 4789, Apr. 29, 1960, p. 979.
[16] Allard, Marc, Trentini, Bernard, and Wahl, Lucien (assigned to Institut de Recherches de la Siderurgie, Saint Germain en Laye, France), Method for Top Blowing Pulverulent Burnt Lime and Oxygen into Cast Iron for Refining Same: U.S. Patent 2,950,186, Aug. 23, 1960.
[17] Iron and Steel Engineer, vol. 37, No. 3, March 1960, p. 43.
[18] Iron and Coal Trades Review (London), Steel Desulphurization with Magnesium: Vol. 180, No. 4784, Mar. 25, 1960, p. 711.
[19] Chemical Week, vol. 86, No. 22, May 28, 1960, p. 77.
Metal Progress, Burnt Lime and Oxygen Increase Steel Output: Vol. 78, No. 1, July 1960, pp. 66–67.

tainers reduced hydration of the quicklime, and consequently the hydrogen in the steel; insured fresh, uniform quality because the lime was used within 3 days of arrival; lowered handling costs; saved storage space; reduced dust; and simplified the lime-inventory control at any level of steelmaking operations. Each truck hauled 10 full containers, or 17 tons of quicklime, from the supplier directly to the plant.[20]

Scale formation on the backing steel of clad plates was reduced during annealing. The plate was coated with an aqueous mixture of magnesium chromate and quicklime, dried, and annealed at 1,950° F.[21] Pulverized taconite and low-grade iron ore were mixed with hydrated lime and smaller amounts of sodium hydroxide and magnesium hydroxide in the presence of water to form strong pellets, briquets, and molded blocks.[22]

In the Ray-Hayden, Ariz., district, the lime consumption rate for pH control in the flotation plant varied from 6 to 10 pounds for each ton of copper ore, depending upon the degree of oxidation of the ore. The lime necessary to control pH was expected to decrease to 4 to 6 pounds per ton for ore mined in the open pits below the oxidation zone.[23]

Greater importance was attached to lime in Australian nonferrous ore dressing. More lime than formerly was added to zinc roughing concentrate to raise the pH from 8.6 to 8.8 at the Electrolytic Zinc Co. of Australasia Ltd. mill at Rosebery. The Zinc Corp. Ltd. and New Broken Hill Consolidated Ltd. found that adding lime to the flotation circuit improved the grade of the zinc concentrate. Mount Isa Mines Ltd. experimented with lime as a pyrite depressant in its copper plant.[24]

Magnesium hydroxide was precipitated continuously by reacting milk of lime with the magnesium chloride and magnesium sulfate dissolved in sea water and other brines.[25]

Soil Stabilization.—About 160,000 short tons of hydrated lime was used in stabilizing Texas highways during 1960. In 1959, the Texas Highway Department had used 121,000 tons of hydrated lime. By 1960, 30 States employed lime stabilization of highways and subgrades (including lime-fly ash and lime-asphalt), and 12 of these States had adopted lime stabilization specifications. Colorado was a leader in using lime as a filler in asphalt mix for highway construction. Lime stabilization had also been used in railroad subgrades, haul road embankments, tennis courts, and building foundation subgrades. To counteract swelling-clay soils, a clay subgrade was soaked with water, or ponded, for at least 30 days to allow the clay to swell to its maximum. Then the clay was drained, and the upper 6-inch layer was mixed with

[20] Iron Age, Keep Lime Flux Moisture Free: Vol. 185, No. 5, Feb. 4, 1960, p. 89.
Cement, Lime and Gravel (London), New Lime-Handling System Improves Quality of Steel: Vol. 35, No. 8, August 1960, p. 218.

[21] Ma, James L. (assigned to Lukens Steel Co., Coatesville, Pa.), Prevention of Irregular Scaling of Ferrous Metals: U.S. Patent 2,943,961, July 5, 1960.

[22] Lee, John M. (assigned to The Dow Chemical Co., Midland, Mich.), Treatment of Particulate Iron Ore: U.S. Patent 2,931,717, Apr. 5, 1960.

[23] Mining World, vol. 22, No. 10, September 1960, p. 61.

[24] Woodcock, J. T., Ore Dressing Developments in Australia, 1959: Chem. Eng. Min. Rev. (Melbourne), vol. 52, No. 6, Mar. 15, 1960, pp. 62, 69.

[25] Nossardi, Gerolamo, and Marengo, Mario, Method of and Installation for the Continuous Extraction of Magnesium with Milk of Lime from Sea Waters and the Like: U.S. Patent 2,940,831, June 14, 1960.

lime, which sealed off the moisture and retained it below the stabilized layer in order to prevent shrinkage of the clay. Lime also dried out the water-soaked top layer and made it into a firm working table for construction.[26]

Philadelphia Electric Co., Philadelphia, Pa., planned to dispose of 200,000 tons of waste fly ash a year by mixing it with lime and with sand or other aggregates to produce a roadbuilding compound that could support traffic immediately.[27] Stabilized road bases having higher compressive strengths than obtained by normal stabilization methods were built in two stages. Mixtures of hydrated lime (2 to 9 percent by weight), fly ash (10 to 30 percent by weight), and soil were compacted, aged for a week to a year, then disrupted, and recompacted.[28] Dry sodium carbonate powder (0.3 to 2 percent by weight) was mixed with soil, fly ash, and hydrated lime (1 to 10 percent by weight) to accelerate setting.[29]

A 7,000-foot highway section was built across a marsh between Florence, La., and Weeks Island, using hydrated lime. A 1-foot layer of sand replaced the top foot of muck, next a 1-foot clay layer stabilized with hydrated lime was laid in two 6-inch lifts; and then a 1-foot soil layer on top completed the subgrade. Hydrated lime (12 percent by volume but 4 percent by weight of dry clay) was spread and mixed with each lift of the clay layer. When bagged hydrated lime proved too slow and expensive, bulk hydrated lime was used instead. Lime reacted chemically with clay, reduced its plasticity and excess water, and rendered it friable and compactible. Lime increased the rigidity of the subgrade, permitted uniform compaction along the roadway, and prevented equipment from breaking through the subgrade into the marsh.[30]

The first lime stabilization by a railroad was reported. The Southern Railway System used hydrated lime (3 percent by weight of clay) to stabilize 5 miles of wet subgrade clay to a depth of 6 to 8 inches at a new track location near New Orleans, La.[31] By stabilizing the soil of earthen reservoirs and ditches with lime, it was possible to walk or drive vehicles on the bottom of the pond or ditch when it was drained.[32]

National Lime Association research on lime-clay mineral reactions conducted at the University of Illinois, Urbana, Ill., demonstrated favorable results using lime on eight different clays. Data were compiled on the permanency of lime-silicate reactions and the resistance of stabilized soils to leaching. Investigation of the reactions of hydrated lime with major types of soil in the United States was continued to show State highway departments what effect lime stabilization would have on their particular soils. All soils treated with lime so far had been improved, but some soils needed more lime than others to stabilize

[26] Work cited in footnote 36.
[27] Skillings' Mining Review, New Utilization of Fly Ash: Vol. 49, No. 12, June 18, 1960, p. 12.
[28] Havelin, Jules E., and Kahn, Frank, Road Building Method: U.S. Patent 2,937,581, May 24, 1960.
[29] Handy, Richard L., and Davidson, Donald T., Method of Accelerating the Setting of Lime-Fly Ash-Soil Mixes: U.S. Patent 2,942,993, June 28, 1960.
[30] Vincent, W. C., Road-on-a-Raft Crosses Swamp: Roads and Streets, vol. 103, No. 4, April 1960, pp. 110–112, 117, 189.
[31] Rock Products, Lime Stabilization Reported by Railroad: Vol. 63, No. 1, January 1960, p. 65.
[32] Work cited in footnote 92.

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them.[33] Lehigh University, Bethlehem, Pa., received a National Science Foundation grant to investigate the reaction between lime and the common soil minerals. This 2-year program expected to determine how specific soils stabilized with lime would react under varying loads and temperatures, to investigate the mechanism of the lime reactions with soil minerals, and to study the nature of the lime-soil mineral reaction products.[34]

[33] Trauffer, Walter E., New Market Possibilities Stressed at N.L.A. Convention: Pit and Quarry, vol. 53, No. 1, July 1960, pp. 228–230, 232–233.
Work cited in footnote 36.

[34] Pit and Quarry, Lehigh University Gets Grant for Lime-Soil Reaction Study: Vol. 52, No. 8, February 1960, p. 26.
Rock Products, Lime-Stabilized Soils Are Subject of Research Project: Vol. 63, No. 2, February 1960, pp. 76, 78.

Lithium

By Albert E. Schreck[1]

ALTHOUGH 1960 witnessed no major changes in production or consumption of lithium, the domestic industry continued to be hopeful of the future. Output of the major mineral producers in 1960 was slightly below 1959, and the famous Etta mine in South Dakota was closed.

DOMESTIC PRODUCTION

Domestic production of lithium raw materials was slightly less in 1960 than in 1959 and again centered largely in North Carolina, where Foote Mineral Co., produced spodumene primarily for conversion to lithium chemicals at its Sunbright, Va., plant. American Potash & Chemical Corp. recovered dilithium sodium phosphate from Searles Lake brines in California. Maywood Chemical Works, Division of Stepan Chemical Co., recovered spodumene from the Etta mine in South Dakota. The Etta mine, operated by Maywood for more than 50 years, was closed in the spring of 1960. This operation, famous for its large spodumene crystals, had produced lithium minerals almost continuously since 1898.

The following firms also produced or shipped lithium minerals in South Dakota: Black Hills-Keystone Corp., from the Ingersoll mine (lepidolite and amblygonite), and Lawrence Judson, from the Hunter mine (spodumene).

TABLE 1.—Shipments of lithium ores and compounds from mines in the United States

Year	Ore		Li_2O, Short tons	Year	Ore		Li_2O, Short tons
	Short tons	Value			Short tons	Value	
1950	9,306	$579,922	747	1953	27,240	$2,134,000	1,767
1951	12,897	896,000	956	1954	37,830	3,126,000	2,459
1952	15,611	1,052,000	1,088	1955–60	(1)	(1)	(1)

1 Figures withheld to avoid disclosing individual company confidential data.

American Lithium Chemicals, Inc., completed its contract to supply the Atomic Energy Commission (AEC) with lithium hydroxide. This was the last of three contracts between the AEC and the lithium industry to expire.

1 Commodity specialist, Division of Minerals.

The Dow Chemical Co. relinquished its option on 400 acres of a lithium pegmatite deposit in Warren Township, Knox County, Maine.

Late in the year, Foote Mineral Co. began building, at New Johnsonville, Tenn., a butyl lithium plant designed for an annual capacity of 100,000 pounds of n-butyl lithium.[2] This firm also redefined its ore reserves in the Kings Mountain, N.C., area. Measured reserves were estimated at 20,746,000 tons averaging 1.53 percent Li_2O. Additional reserves of 15,769,000 tons were indicated on adjoining properties.[3]

The $4 million breach-of-contract action against Lithium Corp. of America by Quebec Lithium Corp. was settled out of court early in the year, when Lithium Corporation of America agreed to pay Quebec $1.9 million over a 4-year period.[4]

Lithium Corporation of America designated U.S. Borax & Chemical Corp. as sales agent for lithium compounds used in the ceramics and glass industries in the United States and certain adjacent foreign countries. The agreement also called for development and joint promotion of other industrial uses for lithium. The transfer of Lithium Corp. of America facilities from Minneapolis, Minn., was completed in midyear when the home office was moved to New York City. Production facilities had been moved to Bessemer City, N.C., in 1959.

CONSUMPTION AND USES

Most of the domestically produced lithium minerals were consumed in manufacturing various lithium chemicals. The rest were used in the ceramics and glass industries.

Lithium hydroxide was used in manufacturing multipurpose greases and in the electrolyte of alkaline storage batteries. Lithium carbonate was used in ceramics and glasses as a flux to decrease the coefficient of expansion and increase acid resistance. Because of their hygroscopicity, lithium chloride and lithium bromide solutions were utilized in air-conditioning systems for cooling and dehumidification. Other lithium compounds were used in welding and brazing fluxes and as catalysts in various organic reactions.

Lithium metal dispersions and n-butyl lithium served as catalysts in making a synthetic rubber that closely resembles natural rubber. The metal also was used to degasify and deoxidize certain coppers and stainless steels and to make certain aluminum alloys.

PRICES

E&MJ Metal and Mineral Markets quoted lithium metal, 99.5 percent pure, at $9 to $11 per pound throughout 1960.

Russian prices for lithium metal were reported to be about $75 per pound.[5]

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[2] Chemical Engineering News, vol. 38, No. 47, Nov. 21, 1960, p. 21.
[3] Mining World, vol. 22, No. 7, June 1960, p. 68.
[4] Wall Street Journal, Lithium Corp. To Pay $1,900,000 to Quebec Lithium in Legal Action: Vol. 155, Jan. 4, 1960, p. 5.
[5] Kowalewski, Jan, Soviet Metal Prices: Min. Jour. (London), vol. 255, No. 6533, Nov. 4, 1960, pp. 500–503.

TABLE 2.—Range of prices on selected lithium compounds, in 1960

(Per pound)

Compound	January	December
Lithium bromide, NF, gran. bags, works, freight equalized	$2.60	$2.60
Lithium carbonate, technical, drums, carlots, truckloads, freight allowed [1]	.67	.67
Drums, tonlots, same basis	.73	[2].76
Drums, smaller lots, same basis [3]	.79	[2].81
Lithium chloride, technical, anhydrous, drums, carlots, truckloads, delivered or works, freight allowed	.87	.87
Less than carlots, same basis	.88–.92	.88–.92
Lithium hydride, powder, drums, 500-pound lots or more, works	9.50	9.50
Lithium hydroxide monohydrate, drums, carlots, truckloads, freight allowed	.72	.72
Less than carlots, same basis	.73	.73
Lithium nitrate, technical, drums, 100-pound lots	1.15–1.25	1.15–1.25
Lithium stearate, drums, carlots, works	.47½	.47½
Tonlots, works	.48½	.48½
Less than tonlots, works	.53½	.53½

[1] Quotation changed July 4 to read: "Technical, drums, carlots, freight allowed."
[2] Price changed July 4.
[3] Quotation changed July 4 to read: "Technical, drums, smaller lots, f.o.b. plant."

Source: Oil, Paint and Drug Reporter.

FOREIGN TRADE [6]

Imports of lithium minerals—spodumene, amblygonite, lepidolite, and petalite—continued to provide part of the Nation's raw material requirements. The Federation of Rhodesia and Nyasaland was the major supplier.

TABLE 3.—U.S. imports for consumption of lithium, by countries, and customs districts, in 1960

Country and customs district	Short tons	Value
Lithium ores: [1]		
North America: Canada:		
Michigan	1,347	$66,671
Ohio	62	4,920
Total	1,409	71,591
South America:		
Argentina: New York	110	5,150
Brazil: New York	33	1,331
Total	143	6,481
Africa: Rhodesia and Nyasaland, Federation of:		
Galveston	18,166	$330,168
Maryland	20,202	618,090
Massachusetts	5,622	120,616
Philadelphia	5,557	211,627
Total	49,547	1,280,501
Grand total	51,099	1,358,573

[1] In addition, 14 pounds ($395) of metallic lithium was imported from Canada through the Vermont customs district.

Source: Bureau of the Census.

Lithium minerals from Argentina and Brazil, together with part of the material from Rhodesia were converted to lithium chemicals. Canadian imports and the remainder of the Rhodesian imports were for use in ceramics and glass. Quantities received from Rhodesia and Canada were considerably smaller than in previous years. Imports from Canada decreased noticeably, because Lithium Corporation of America terminated its contract with Quebec Lithium Corp. The reduced requirement of American Lithium Chemicals, Inc., for

[6] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

lepidolite was the primary reason for the decline in imports from Rhodesia.

WORLD REVIEW

Canada.—Quebec Lithium Corp. began trial runs at its new lithium carbonate plant in the last half of the year.[7] No sales of lithium carbonate were made. Plans called for resuming mining operations, which had been suspended late in 1959, to replenish the stockpile of ceramic-grade spodumene.

France.—The French Geological and Mining Survey Bureau began surveying about 6,500 acres in the Creuse and Allier Departments for lithium.[8]

South-West Africa.—The following firms produced lithium minerals in 1959:[9] P. J. Human, Omaruru; S.W.A. Lithium Mines, Windhoek; and Tantalite Valley Minerals (Pty.), Ltd., Karasburg.

United Kingdom.—Associated Lead Manufacturers, Ltd., began producing lithium chloride. The company also manufactured ground petalite, lithium hydroxide, and lithium carbonate.[10]

TABLE 4.—World production of lithium minerals, by countries

(Short tons)

Country	Mineral produced	1956	1957	1958	1959	1960
North America:						
Canada [1]	Spodumene	2,395	2,570	1,927	1,378	103
United States	Lithium minerals	(2)	(2)	(2)	(2)	(2)
South America:						
Argentina	do	165	22	186	(3)	(3)
Brazil	Spodumene (exports)	----	----	160	468	(3)
	Amblygonite (exports)	----	552	----	590	(3)
Europe: Spain	Amblygonite	57	7	----	----	----
Africa:						
Congo, Republic of the (formerly Belgian Congo) and Ruanda-Urundi.	do	1,996	2,317	11	2,965	(3)
	Spodumene (exports)	72	1	----	----	----
Mozambique	Lepidolite	1,105	379	96	99	1
	Amblygonite	39	----	----	----	----
Rhodesia and Nyasaland, Federation of: Southern Rhodesia.	Eucryptite	----	56	398	[4] 57,901	[4] 61,648
	Amblygonite	646	122	1,835		
	Lepidolite	84,599	93,545	64,699		
	Petalite	13,524	9,934	13,166		
	Spodumene	4,445	5,599	5,238		
South-West Africa	Amblygonite	831	535	534	242	160
	Lepidolite	1,139	882	1,043	2,168	973
	Petalite	3,675	5,325	7,405	2,787	3,908
Uganda	Amblygonite	----	6	----	----	----
Union of South Africa	do	713	30	----	10	[5] 160
Oceania: Australia	Spodumene	----	----	----	----	----
	Petalite	----	----	76	----	----
Total		115,401	121,882	96,774	68,608	(3)

[1] Tons of lithia in spodumene concentrates.
[2] Figure withheld to avoid disclosing individual company confidential data.
[3] Data not available.
[4] Exports.
[5] Estimate.

Compiled by Helen L. Hunt, Division of Foreign Activities.

[7] Northern Miner, Quebec Lithium Mill to Resume: Vol. 46, No. 34, Nov. 17, 1960, pp. 1, 5.
[8] Bureau of Mines, Mineral Trade Notes: Vol. 50, May 1960, p. 18.
[9] Bureau of Mines, Mineral Trade Notes: Vol. 52, January 1961, pp. 29, 30.
[10] Chemical Age (London), Lithium Chloride: Vol. 83, No. 2122, Mar. 12, 1960, p. 462.

TABLE 5.—Federation of Rhodesia and Nyasaland: Exports of lithium ores, by countries

Destination	1959		1960 [1]	
	Short tons	Value [2]	Short tons	Value [2]
France	454	$4,328		
Germany, West	2,116	55,494	2,069	$40,270
Japan	1,108	22,176	1,042	31,271
Netherlands	6,185	114,492	1,274	18,078
Union of South Africa	45	1,258		
United Kingdom	4,866	81,834	2,662	45,275
United States	43,127	689,673	54,601	1,359,712
Total	57,901	969,255	61,648	1,494,606

[1] January through June, inclusive.
[2] Converted to U.S. currency at the rate of £1 equals U.S. $2.8088 (1959) and U.S. $2.8076 (1960).

Compiled from Customs Returns of the Federation of Rhodesia and Nyasaland by Corra A. Barry, Division of Foreign Activities.

TABLE 6.—South-West Africa: Exports of lithium ores, by countries

Year and destination	Amblygonite		Lepidolite		Petalite	
	Short tons	Value [1]	Short tons	Value [1]	Short tons	Value [1]
1959:						
Belgium			467	$10,234		
Germany, West	108	$5,238	208	4,155		
Japan	23	84	417	8,969	23	$879
Netherlands			502	10,147	462	9,794
Union of South Africa			208	4,298	122	1,847
United Kingdom					805	19,421
Total	131	5,322	1,802	37,803	1,412	31,941
1960: [2]						
Germany, West			2	56		
Netherlands					821	12,089
United Kingdom					62	1,127
Total			2	56	883	13,216

[1] Converted to U.S. currency at the rate of SA £1 equals U.S. $2.7983 (1959) and U.S. $2.7971 (1960).
[2] January through June, inclusive.

Compiled from Customs Returns of South-West Africa by Corra A. Barry, Division of Foreign Activities.

TECHNOLOGY

A flame spectrophotometric method for rapidly determining the lithium content of lithium minerals was discussed.[11] In this method, the ions that affect the lithium spectrum are eliminated by adding a citric acid-ammonium citrate buffer. Precision of the method is considered good.

An article describing Foote Mineral Co. mining and milling operations at Kings Mountain, N.C., was published.[12]

The physical properties and fabrication of Aluminum Company of America's lithium-containing alloy were described.[13] This alloy,

[11] Kassner, J. L., Benson, V. M., and Creitz, E. E., Flame Spectrophotometric Determination of Lithium in Lithium Minerals: Anal. Chem., vol. 32, No. 9, August 1960, p. 1151–1153.
[12] Johnson Neil O., Mining Lithium at Kings Mountain in North Carolina: Explosives Eng., vol. 38, No. 5, September-October 1960, pp. 148–155.
[13] Spuhler, E. H., Knoll, A. H., and Kaufman, J. G., Lithium in Aluminum-X2020: Metal Progress, vol. 77, June 1960, pp. 80–82.

for use in aircraft construction, contained 1.1 percent lithium and had a density of 0.098 pound per cubic inch, high mechanical strength, and a high modulus of elasticity.

Several patents were issued for recovering lithium from its various ores. In one process, lithium sulfate was produced by passing a gaseous mixture of sulfur trioxide, air, and water vapor over ground beta spodumene.[14] Enough gas should be used to provide 1 mole of water for each mole of spodumene and under conditions to maintain the gaseous phase. The material was leached with water to recover the lithium and leave an insoluble residue.

Another process recovered lithium hydroxide from a complex lithium phosphate by calcining the phosphate with alumina and lime in equal molar ratios. The calcined material was then digested with water in the presence of lime, forming a solution of lithium hydroxide.[15]

In still another patented process, beta spodumene was mixed with a sodium or potassium salt or formic or acetic acid and sodium or potassium carbonate and heated.[16] Lithium values in the spodumene were converted to the water-soluble form and recovered by leaching.

Research to furnish basic information on lithia in ceramics and glass continued, and the results were published.[17]

Experiments in partially replacing the soda in opal and alabaster glasses with lithium indicated that faster melting, lower operating temperatures, whiter color, lower coefficient of expansion, and improved light transmission could be obtained.[18]

The use of lithium hydride for producing hydrogen for various space uses was investigated.[19] Experimental generators, producing hydrogen at pressures from 500 to 1,500 pounds per square inch, were developed. One generator produced hydrogen at a rate of 12 pounds per hour. In addition to particle size, the research included configuration of the chamber, response times, control techniques, and methods of restricting temperatures within the generator.

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[14] Archambault M., MacEwan, J. U., and Olivier, C. A. (assigned to Department of Mines, Province of Quebec, a department of the Provincial Government of Quebec, Quebec, Canada), Method of Producing Lithium Sulfate from Beta Spodumene: U.S. Patent 2,923,600, Feb. 2, 1960.

[15] Reader, L. J. (assigned to Foote Mineral Co., Philadelphia, Pa.), Process for Recovery of Lithium Hydroxide from Lithium Phosphates: U.S. Patent 2,931,703, Apr. 5, 1960.

[16] Peterson, J. A. (assigned to International Minerals & Chemical Corp.), Process for Recovering Lithium Values: U.S. Patent 2,924,507, Feb. 9, 1960.

[17] Sastry, B. S. R., and Hummel, F. A., Studies in Lithium Oxide Systems: VII, $Li_2O-B_2O_3-SiO_2$: Jour. Am. Ceram. Soc., vol. 43, No. 1, January 1960, pp. 23–33.

Hummel, F. A., Tien, T. Y., and Kim, K. H., Studies in Lithium Oxide Systems: VIII, Application of Silicate Liquid Immiscibility to Development of Opaque Glazes: Jour. Am. Ceram. Soc., vol. 43, No. 4, April 1960, pp. 192–197.

[18] Rauch, H. W., Commons, C. H., Jr., and Silverman, A., Effect of Partial Replacements of Soda by Lithia in Opal and Alabaster Glass: Glass Industry, vol. 41, No. 5, May 1960, pp. 261–263, 292.

[19] Missiles and Rockets, LiH Studied as Hydrogen Generator: Vol. 7, No. 11, Sept. 12, 1960, p. 25.

Magnesium

By H. B. Comstock[1] and Jeannette I. Baker[2]

PRODUCTION of primary magnesium in the United States rose 29 percent in 1960 to 38 percent of world output. Increases in primary production capacity were reported in Japan and Norway.

Although U.S. consumption of primary metal was 10 percent below 1959, shipments by producers rose 14 percent. Greater requirements for magnesium structural products in the latter half of 1960 were due mainly to increasing demands for die castings.

Progress in research included development of new magnesium alloys, better surface treatments and finishes, and improved techniques in casting, extruding, and rolling.

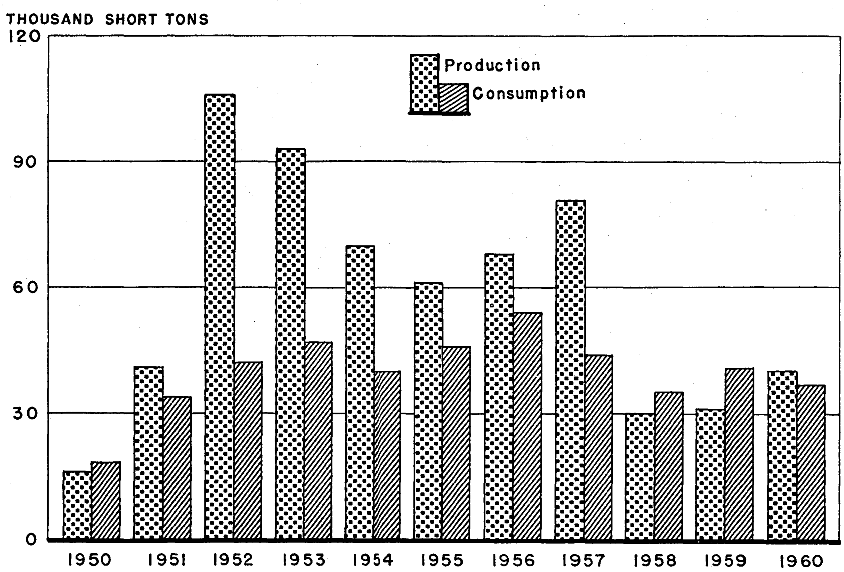

FIGURE 1.—Domestic production and consumption of primary magnesium, 1950–60.

[1] Commodity specialist, Division of Minerals.
[2] Research assistant, Division of Minerals.

TABLE 1.—Salient magnesium statistics

	1951-55 (average)	1956	1957	1958	1959	1960
United States:						
Production:						
Primary ..... short tons	74,128	68,346	81,263	30,096	31,033	40,070
Secondary ..... do	10,686	10,529	10,658	8,707	10,090	10,348
Imports for consumption ..... do	1,829	630	982	537	593	401
Exports ..... do	3,138	3,388	1,219	207	1,601	4,467
Consumption ..... do	41,733	53,610	44,442	35,352	[1] 41,551	37,100
Price per pound ..... cents	26.4	33.9	35.25	35.25	35.25	35.25
World: Primary production ..... short tons	104,300	[1] 114,300	[1] 128,700	[1] 78,500	[1] 82,500	104,100

[1] Revised figure.

DOMESTIC PRODUCTION

Primary.—Commercial production of primary magnesium in the United States increased 29 percent in 1960. The Dow Chemical Co. electrolytic plant at Freeport, Tex., Alabama Metallurgical Corp. silicothermic plant at Selma, Ala., and the Government-owned silicothermic plant at Canaan, Conn., operated throughout the year. Titanium Metals Corp. of America continued to recycle magnesium as an integrated operation of its production of titanium at Henderson, Nev.

TABLE 2.—Production and shipments of primary magnesium in the United States, by months

(Short tons)

Month	1951–55 (average)		1956		1957	
	Production	Shipments	Production	Shipments	Production	Shipments
January	6,150	6,015	6,337	6,052	7,391	7,529
February	5,817	5,748	5,908	4,932	6,617	7,776
March	6,523	5,922	6,347	6,329	7,383	5,318
April	5,731	5,911	6,081	6,564	7,222	4,251
May	6,228	5,452	6,359	5,400	7,227	3,870
June	5,883	6,315	6,098	3,846	6,718	4,668
July	5,979	5,443	1,136	4,127	6,777	2,596
August	6,222	5,779	3,314	4,736	7,152	3,097
September	5,982	5,657	6,128	5,760	6,486	5,130
October	6,383	5,631	6,735	6,726	6,468	3,147
November	6,486	7,157	6,818	5,382	5,995	2,114
December	6,744	5,893	7,085	3,408	5,827	2,074
Total	74,128	70,923	68,346	63,262	81,263	51,570

Month	1958		1959		1960	
	Production	Shipments	Production	Shipments	Production	Shipments
January	5,272	3,367	1,877	2,976	3,355	3,775
February	3,526	2,060	1,725	3,671	3,180	3,675
March	3,235	2,260	1,925	3,681	3,600	5,625
April	2,772	3,043	1,808	4,176	3,290	4,105
May	2,469	2,415	2,668	3,995	3,240	4,465
June	1,784	2,844	2,778	4,271	3,075	4,335
July	1,799	2,645	2,850	4,559	3,120	2,435
August	1,845	2,610	2,967	4,367	3,200	5,310
September	1,791	2,942	2,846	3,026	3,290	4,785
October	1,927	3,151	3,018	3,556	3,535	4,925
November	1,814	2,911	3,042	4,718	3,200	4,470
December	1,862	3,908	3,529	4,536	3,985	6,445
Total	30,096	34,156	31,033	47,532	40,070	54,350

Secondary.—There was little change from 1959 in recovery of magnesium from scrap. The largest increase was in the use of secondary magnesium for cathodic protection.

TABLE 3.—Magnesium recovered from scrap processed in the United States [1]

(Short tons)

	1951–55 (average)	1956	1957	1958	1959	1960
Kind of scrap:						
New scrap:						
Magnesium-base	3,444	3,099	3,360	2,280	3,073	3,179
Aluminum-base	1,794	2,071	2,237	1,653	[2] 2,105	2,825
Total	5,238	5,170	5,597	3,933	[2] 5,178	6,004
Old scrap:						
Magnesium-base	4,777	4,662	4,350	4,156	4,133	3,560
Aluminum-base	671	697	711	618	[2] 779	784
Total	5,448	5,359	5,061	4,774	[2] 4,912	4,344
Grand total	10,686	10,529	10,658	8,707	10,090	10,348
Form of recovery:						
Magnesium alloy ingot [1]	5,142	4,072	4,200	2,976	3,881	3,828
Magnesium alloy castings (gross weight)	674	206	75	78	219	103
Magnesium alloy shapes	7	5		3	2	3
Aluminum alloys	3,021	3,188	3,383	2,701	3,507	3,208
Zinc and other alloys	31	85	22	30	21	54
Chemical and other dissipative uses	41	11	29	53	600	255
Cathodic protection	1,770	2,962	2,949	2,866	1,860	2,897
Total	10,686	10,529	10,658	8,707	10,090	10,348

[1] Figures include secondary magnesium content of both secondary and primary magnesium alloy ingot.
[2] Revised figure.

TABLE 4.—Stocks and consumption of new and old magnesium scrap in the United States in 1960

(Short tons, gross weight)

Scrap item	Stocks, beginning of year	Receipts	Consumption			Stocks, end of year
			New scrap	Old scrap	Total	
Cast scrap	957	5,234	808	4,560	5,368	823
Solid wrought scrap	120	1,466	1,424		1,424	162
Borings, turnings, drosses, etc	145	1,912	1,836		1,836	221
Total	1,222	8,612	4,068	4,560	8,628	1,206

CONSUMPTION AND USES

The 6,219-ton decrease in use of primary magnesium for structural products was due primarily to cuts in requirements for defense materials; however, use of magnesium alloys was increased in each unit of some military equipment.[3] Some of this increase was attributed to

[3] American Metal Market, Wide Magnesium Use in Missile: Vol. 68, No. 19, Jan. 27, 1961, p. 11.
Holmes, Roger E., Rugged Magnesium Case Protects Airborne Tape Recorder: Modern Metals, vol. 16, No. 1, February 1960, pp. 64, 66.

the new missile sheet produced in volume quantities for the first time by The Dow Metal Products Co.[4]

New and increased structural uses of magnesium were noted during the latter half of 1960, particularly for die castings in automotive equipment.[5]

TABLE 5.—Domestic consumption of primary magnesium (ingot equivalent and magnesium content of magnesium-base alloys), by uses

(Short tons)

Use	1951–55 (average)	1956	1957	1958	1959	1960
For structural products:						
Castings:						
Sand	11,083	6,478	6,076	5,698	[1] 4,770	2,561
Die	2,107	1,875	1,649	1,553	[2] 1,772	[2] 1,528
Permanent mold	905	1,034	571	889	981	745
Wrought products:						
Sheet and plate	5,008	5,496	4,916	4,061	6,128	4,112
Extrusions (structural shapes, tubing)	3,617	6,223	5,081	2,624	3,074	2,580
Forgings	238	473	7	141	1,913	893
Total	22,958	21,579	18,300	14,966	[1] 18,638	12,419
For distributive or sacrificial purposes:						
Powder	903	918	386	352	456	430
Aluminum alloys	8,821	13,323	11,236	10,746	[1] 14,780	12,511
Other alloys	449	98	587	446	840	421
Scavenger and deoxidizer	743	865	867	708	292	788
Chemical	313	63	325	148	351	276
Cathodic protection (anodes)	3,285	3,036	2,997	2,028	3,005	3,264
Reducing agent for titanium, zirconium, hafnium, uranium, and beryllium	[3] 2,888	13,303	9,695	5,953	[1] 3,175	6,978
Other [4]	1,373	425	49	5	14	13
Total	18,775	32,031	26,142	20,386	[1] 22,913	24,681
Grand total	41,733	53,610	44,442	35,352	[1] 41,551	37,100

[1] Revised figure.
[2] Includes primary metal to produce small quantities of investment castings.
[3] Before 1954, included with other. 1954, 6,386 tons; 1955, 8,056 tons.
[4] Includes primary metal consumed for experimental purposes, debismuthizing lead and producing nodular iron and secondary magnesium alloys.

Fabricators used the high strength-to-weight ratio of magnesium alloys to produce industrial gratings, portable platforms, and bridges.[6]

The increase of 1,768 tons of magnesium used for distributive or sacrificial purposes left total consumption just 4,451 tons below 1959. Greater use of magnesium for cathodic protection was due largely to expanded installation of magnesium anodes with ground pipe in the oil industry. The growing production and use of the newer metals—zirconium, hafnium, uranium, and beryllium, accounted for increased use of magnesium as a reducing agent.

[4] Modern Metals, Special Aircraft, Missile Sheet Introduced by Dow: Vol. 16, No. 5, June 1960, p. 83.
[5] American Metal Market, Magnesium to Get Auto Industry Test: Vol. 67, No. 126, July 1, 1960, pp. 1, 6.
Metal Progress, Auto Makers Trim Costs With Magnesium Die Castings: Vol. 78, No. 6, December 1960, pp. 67.
[6] Van Dyke, Milton, Magnesium Grating: Modern Metals, vol. 16, No. 1, February 1960, pp. 43–44, 46.
E&MJ Metal and Mineral Markets, A 27-Foot Magnesium Portable Platform: Vol. 31, No. 25, June 23, 1960, p. 7.
Modern Metals, Magnesium Bridges Span Split Industrial Areas: Vol. 16, No. 12, January 1961, p. 99.

STOCKS

On December 31, 1960, producer and consumer stocks were 22,420 tons of primary magnesium and 4,475 tons of primary magnesium alloy ingot—a decrease of 14,345 tons of primary magnesium below stocks at the beginning of the year and an increase of 375 tons of primary magnesium alloy ingot above stocks at the beginning of the year. Government agencies continued to retain quantities of primary magnesium ingot, as provided by the Strategic and Critical Materials Stockpiling Act.

PRICES

The base price of primary magnesium ingot in standard 42-pound pig form remained at 35.25 cents per pound, f.o.b. plant.[7]

The Dow Metal Products Co. offered magnesium alloy ingot for castings at prices below list to large consumers such as manufacturers of automotive equipment. These reductions represented allowances to consumers for expenditures necessary to convert their facilities to the use of magnesium instead of other metals.[8]

FOREIGN TRADE[9]

Imports of magnesium in 1960 were only two-thirds of the quantity imported in 1959. About 65 percent of the total 433 tons was scrap metal. These imports came from five countries: 138 tons, from Canada; 4 tons, from the Dominican Republic; less than 1 ton, from West Germany; 80 tons, from Taiwan; and 211 tons, from the United Kingdom. Throughout 1960, the duty on magnesium metal remained at 50 percent ad valorem. For magnesium powder, ribbon, sheets, tubing, manufactures, and so forth, the duty remained at 17 cents per

[7] E&MJ Metal and Mineral Markets, Magnesium: Vol. 32, No. 1, Jan. 5, 1961, p. 4.
[8] American Metal Market, Dow Giving Magnesium Price Concessions to Woo Autos: Vol. 67, No. 20, Jan. 29, 1960, pp. 1–2.
[9] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

pound on metallic content plus 8.5 percent ad valorem. Suspension of duty on magnesium scrap was extended to June 30, 1961.

Exports of magnesium from the United States were more than double those of the preceding year. Table 7 shows that almost half of the metal went to West Germany and that deliveries to the United Kingdom increased considerably.

TABLE 6.—U.S. imports for consumption and exports of magnesium

Year	Imports					
	Metallic and scrap		Alloys (magnesium content)		Sheets, tubing, ribbons, wire, and other forms (magnesium content)	
	Short tons	Value	Short tons	Value	Short tons	Value
1951–55 (average)	1,829	$665,799	7	$25,805	30	[1] $67,344
1956	630	303,586	24	202,675	2	8,715
1957	982	479,855	35	283,099	8	16,952
1958	537	280,316	9	38,096	16	97,194
1959	593	303,307	26	154,775	26	120,630
1960	401	202,087	28	287,916	4	60,623
	Exports					
	Metal and alloys in crude form, and scrap		Semifabricated forms, n.e.c.		Powder	
	Short tons	Value	Short tons	Value	Short tons	Value
1951–55 (average)	3,138	$1,793,596	[2] 181	[2] $472,981	(3)	(3)
1956	3,388	2,239,577	[2] 487	[2] 901,924	56	$98,635
1957	1,219	1,122,164	[2] 355	[2] 767,656	22	39,469
1958	[4] 207	[4] 225,522	[4] 834	[4] 1,053,844	11	16,147
1959	[4] 1,601	[4] 881,514	[4] 776	[4] 1,146,180	12	31,536
1960	[4] 4,467	[4] 2,658,480	[4] 658	[4] 1,037,325	7	23,048

[1] Owing to changes in tabulating procedures by the Bureau of the Census, data known to be not comparable with other years.
[2] Owing to changes in items included in each classification 1954–57, data are not strictly comparable to earlier years.
[3] Not separately classified before 1952; 1952–43 tons, $59,843; 1953–21 tons, $41,591; 1954–34 tons, $44,605; 1955–14 tons, $33,911.
[4] Effective Jan. 1, 1958, some material formerly included with metals and alloys in crude form, and scrap included with "semifabricated forms, not elsewhere classified."

Source: Bureau of the Census.

TABLE 7.—U.S. exports of magnesium, by classes and countries

(Short tons)

Destination	1959			1960		
	Primary metal, alloys, and scrap	Semifabricated forms, n.e.c.	Powder	Primary metal, alloys, and scrap	Semifabricated forms, n.e.c.	Powder
North America:						
Canada	100	231	(1)	177	205	2
Mexico	216	132		358	32	
Other North America	8	9		(1)	51	
Total	324	372	(1)	535	288	2
South America:						
Colombia	1	3			2	
Venezuela	11	82	1	9	29	
Other South America		2		13	24	
Total	12	87	1	22	55	
Europe:						
Belgium-Luxembourg	3	8	2	36	8	(1)
Denmark	11					
France	23	35		66	11	
Germany, West	980	5		2,049	29	
Italy		8	1	(1)	8	
Netherlands	(1)	4		214	17	(1)
Norway		1	1	437	10	1
Spain	50			13	3	
Sweden	40	27		33	36	
Switzerland	(1)	7		152	67	
United Kingdom	150	9		393	17	(1)
Other Europe				321	5	1
Total	1,257	104	4	3,714	211	2
Asia:						
India	1	1		67		
Indonesia		48			3	
Israel	5	13	1	4	9	3
Japan		133		6	46	
Other Asia		10	6	(1)	45	
Total	6	205	7	77	103	3
Africa	2	7		20	(1)	
Oceania		1		99	1	
Grand total	1,601	776	12	4,467	658	7

[1] Less than 1 ton.

Source: Bureau of the Census.

WORLD REVIEW

World production of magnesium in 1960 increased 26 percent over 1959. The rise in U.S. output furnished 43 percent of the world increase.

Canada.—Dominion Magnesium, Ltd., in its plant at Haley, Ontario, was the sole producer. Canadian exports of magnesium declined, owing mainly to decreased deliveries to West Germany.[10] The United Kingdom received the major portion. Some increase was reported in deliveries of the metal to the United States.[11]

[10] American Metal Market, Canadian Exports Show Dollar Decline: Vol. 68, No. 33, Feb. 17, 1961, p. 10.
[11] Modern Metals, Looking Ahead: Vol. 17, No. 1, February 1961, p. 102.

Germany, West.—West Germany continued to depend upon imports of primary magnesium to meet the rising demand for the metal, particularly for automotive equipment. Per capita consumption of the metal was unusually high.

TABLE 8.—World production of primary magnesium, by countries [1]

(Short tons)

Country	1951-55 (average)	1956	1957	1958	1959	1960
Canada	[2] 6,200	9,606	8,385	6,796	6,102	7,373
China	(3)	(3)	(3)	[2] 1,100	[2] 1,100	[4] 1,100
France	1,233	1,660	1,753	1,897	1,938	[2] 2,300
Germany, West [5]	[6] 220	110	330	660	550	330
Italy	1,561	4,116	4,170	4,607	4,960	[2] 5,500
Japan	[6] 85	[7] 86	[7] 472	[7] 1,106	[7] 1,724	[2] 2,400
Norway	3,429	8,185	9,504	10,132	10,633	[2] 13,200
Switzerland	176	----	----	----	----	----
U.S.S.R. [8]	11,400	17,900	18,800	19,400	22,000	27,600
United Kingdom [5]	5,623	4,064	3,831	2,691	2,458	[2] 4,200
United States	74,128	68,346	81,263	30,096	31,033	40,070
World total (estimate) [1]	104,300	114,300	128,700	78,500	82,500	104,100

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] Estimate.
[3] Data not available; estimates by senior author of chapter included in total.
[4] Data represents estimated 1959 production; 1960 production was probably greater.
[5] Primary metal and remelt alloys.
[6] Average for 1954–55.
[7] In addition, the following quantities of remelted magnesium were produced: 1956, 897 tons; 1957, 1,906 tons; 1958, 2,567 tons; and 1959, 2,694 tons.
[8] Revised estimates based on more recent information.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

Japan.—Furukawa Magnesium Co., Ltd., began expanding its silicothermic plant at Oyama to increase annual magnesium capacity from 2,000 to 4,500 tons.[12]

Norway.—In September, Norsk-Hydro Elektrisk completed the expansion, begun in 1959, of its primary magnesium plant at Herøya. This brought the annual production capacity to 14,000 tons. Output in 1960 went mostly to West Germany.[13]

U.S.S.R.—No statistical data on production of magnesium have been published in the U.S.S.R. since the start of the industry in 1935. Previous Bureau of Mines estimates have been calculated from various statements appearing in Russian technical publications concerning planned increases in production. The data appearing in table 8 represent revisions of the former Bureau estimates of production of magnesium in the U.S.S.R., based upon a historical study in 1960 of Russian literature relating to the magnesium industry.

United Kingdom.—Conditions of the magnesium industry in the United Kingdom were similar to those in the United States. Requirements for the metal in aircraft and missiles decreased, and its uses in automotive equipment, farm machinery, and consumer products remained about the same as in 1959. The cut in price on primary magnesium ingot by Alcan (U.K.) Ltd., effective in November 1959,

[12] Bureau of Mines, Mineral Trade Notes: Vol. 50, January 1960, pp. 34–35.
[13] American Metal Market, Norway to Double Capacity: Vol. 68, No. 14, Jan. 20, 1961, p. 18.

was rescinded on January 1, 1960.[14] In May, the Magnesium Industry Council was host to the Magnesium Association of the United States at a joint meeting in London.[15]

TECHNOLOGY

International exchange of information on progress in developing technology and improved facilities for producing and using magnesium was emphasized at the first joint meeting of the Magnesium Association of the United States and the Magnesium Industry Council of the United Kingdom, held in London and Manchester in May 1960.[16] Representatives of the industry from Canada, France, Norway, West Germany, Switzerland, the United Kingdom, and the United States were present. One discussion described current work in West Germany to develop a continuous thermal process for producing primary magnesium and plans to build a plant there, that would use the process.

Improved surface treatments and finishes for magnesium alloys were described and given credit for many new structural applications of the metal since World War II.[17]

Studies in metal loss of magnesium alloys in foundries resulted in developing equipment for recovering the metal from flux.[18] The metal was separated from the flux fraction of the residue while it was molten.

The Federal Bureau of Mines continued fundamental studies on the properties of magnesium-base alloys at its Rolla Metallurgy Research Center, Rolla, Mo., to determine the effects of composition, fabrication practices, and thermal treatment on their vibration-damping capacity and other characteristics.

The Dow Chemical Co. announced plans to construct a laboratory at Midland, Mich., to assist consumers of magnesium in solving their problems concerning melting and casting the metal.[19]

Tests were conducted on magnesium alloys to determine the effects of temperature on their mechanical properties.[20] The work emphasized the phase of investigation concerning the effect of low temperature exposure on welded magnesium alloys.[21] Increases in strength were noticeable; elongation decreased slightly as temperature decreased.

The creep properties at 450°–500° C. of magnesium alloys suitable for cladding nuclear fuel elements were investigated.[22] Adding zir-

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[14] Metallurgia (London), Magnesium Price Rise: Vol. 61, No. 363, January 1960, p. 33.

[15] Metallurgia (London) Magnesium Association in the U.K.: Vol. 61, No. 368, June 1960, pp. 272–273.

[16] Light Metals (London), Magnesium Meeting: Vol. 23, No. 266, July 1960, pp. 182–183.

[17] Kirkpatrick, James S., Surface Treatments and Finishes for Magnesium: Modern Metals, vol. 16, No. 4, May 1960, pp. 64, 66, 68, 70, 72.

[18] Simcox, H. J., Hirst, S. B., and Young, A., Recovery of Metal From Magnesium Alloy Foundry Residues by Centrifuging: Jour. Inst. Metals (London), vol. 88, No. 9, May 1960, pp. 394–397.

[19] American Metal Market, Dow to Set up Magnesium Lab for Customers: Vol. 67, No. 93, May 16, 1960, p. 5.

[20] Fox, D. K., Mechanical Properties of Some Magnesium Sand Casting Alloys From −65 Degrees F to +600 Degrees F: Light Metal Age, vol. 18, Nos. 18, 19, August 1960, pp. 15–18.

[21] Fenn, R. W., Jr., and Lockwood, L. F., Low Temperature Properties of Welded Magnesium Alloys: Welding Jour., vol. 39, August 1960, pp. 352s–356s.

[22] Olds, G. C. E., and Michie, G. M., Creep-Resistant Magnesium Alloys for Nuclear Fuel Elements: Jour. Inst. Metals (London), vol. 88, No. 12, August 1960, pp. 493–499.

conium to binary magnesium-manganese alloys decreased the solubility of the manganese and reduced the quantity of manganese required to obtain precipitation-hardening effects.

Fundamental research reported during 1960 included work on magnesium alloys containing silver and platinum. Tests showed that the addition of 2 to 3 percent silver to a series of magnesium-rare earth alloys improved their resistance to age hardening, whether they were cast or wrought.[23] Although in the past it was believed that inclusion of silver seriously impaired the corrosion resistance of magnesium, tests in 1960 showed that these magnesium-rare earth-silver alloys had as good resistance to corrosion as standard magnesium-rare earth and magnesium-thorium alloys. A report on laboratory tests of the properties of 20 magnesium-platinum binary alloys ranging from 1- to 78-percent platinum content showed that the alloys were compact, usually brittle, and stable toward atmospheric oxidation.[24]

Inspection and test procedures for various magnesium alloy castings were discussed, and more comprehensive metallographic inspection than was customarily followed was recommended for critical sections of each unit.[25] Improvements in casting, extrusion, and rolling techniques were employed to form magnesium alloys, and finishing procedures were simplified.[26]

Preparation and testing of new magnesium alloy castings for missiles were described.[27] New design-allowables were established for the magnesium alloys used in vehicles carrying maximum loads at high temperatures on short, one-mission flights.

A study of the effect of chills on sand-cast magnesium alloys containing aluminum and zinc developed data on thermal and mechanical properties of the alloys and conditions under which porosity-free castings could be produced.[28]

Progress was reported on research begun in 1959 to develop techniques for cold-forming magnesium alloys to improve their physical properties.[29] Preliminary work was encouraging and indicated that the techniques might be used industrially for producing such items as magnesium alloy cans to contain fuel elements in nuclear reactors. The magnesium cans used thus far were prepared by hot-forming processes.

Improved techniques and equipment were developed for forging magnesium-thorium alloys into parts for missiles.[30]

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[23] Payne, R. J. M., and Bailey, N., Improvement of the Age-Hardening Properties of Magnesium-Rare-Earth Alloys by Addition of Silver: Jour. Inst. Metals (London), vol. 88, No. 10, June 1960, pp. 417–427.

[24] Ferro, Riccardo, and Rambaldi, Gabriella, Micrographic and X-Ray Examination of Some Magnesium-Platinum Alloys: Jour. Less-Common Metals (Amsterdam), vol. 2, No. 5, October 1960, pp. 383–391.

[25] Meier, J. W., How Can Foundrymen Reduce the Time and Cost of Evaluating the Quality of Their Magnesium Castings?: Modern Castings, vol. 37, February 1960, pp. 44–50.

[26] Winkler, James V., Progress in Magnesium Alloys: Metal Progress, vol. 78, No. 4, October 1960, pp. 146–148, 158, 160.

[27] Gronwold, Walter, Short-Time Elevated Temperature Properties of Premium Quality Magnesium Castings: Modern Castings, vol. 37, March 1960, pp. 97–106.

[28] Green, R. D., Porosity-Free Magnesium Alloy Castings: Modern Castings, vol. 37, May 1960, pp. 131–138.

[29] Metal Industry, Metal-Forming Research: Vol. 96, No. 25, June 17, 1960, p. 17.

[30] Steel, Heated Mandrel Expands, Hot Forms Magnesium Alloy: Vol. 146, No. 7, Feb. 15, 1960, p. 138.

New methods and equipment were devised for joining magnesium alloys to aluminum alloys and to each other.[31]

Improvements in finishing systems and protective coatings for magnesium alloys were reported. These included a simpler method of porcelain enameling.[32] Investigations at the National Bureau of Standards, U.S. Department of Commerce, on effects of organic compounds on metal fatigue showed that certain polar organic compounds caused an increase of over 600 percent in the fatigue life of a magnesium alloy stressed at 12,500 pounds per square inch.[33]

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[31] Patton, T. L., New Ways to Join Magnesium: Modern Metals, vol. 16, No. 3, April 1960, pp. 46, 48.

[32] Materials in Design Engineering, Enameled Magnesium for Engine Parts, Signs: Vol. 51, March 1960, pp. 189–190.

[33] Frankel, H. E., Bennett, J. A., and Holshouser, W. L., Effect of Oleophobic Films on Metal Fatigue: Jour. Res., Nat. Bureau of Standards, vol. 64C, No. 2, April–June 1960, pp. 147–150.

Magnesium Compounds

By H. B. Comstock[1] and Jeannette I. Baker[2]

PRODUCTION and use of magnesia obtained from sea water and brines in the United States continued to increase in 1960. The greatest increase in world output of magnesite was in Greece. Improved basic refractories were developed, and new and improved techniques were adopted for forming and installing large basic refractory sections in steel furnaces.

DOMESTIC PRODUCTION

Production of crude magnesite decreased 16 percent below 1959. Northwest Magnesite Co. suspended mining at Chewelah, Wash., during part of the year.

Basic, Inc., completed expansion of facilities begun in 1958 at Gabbs, Nev., to enable the plant to manufacture a more complete range

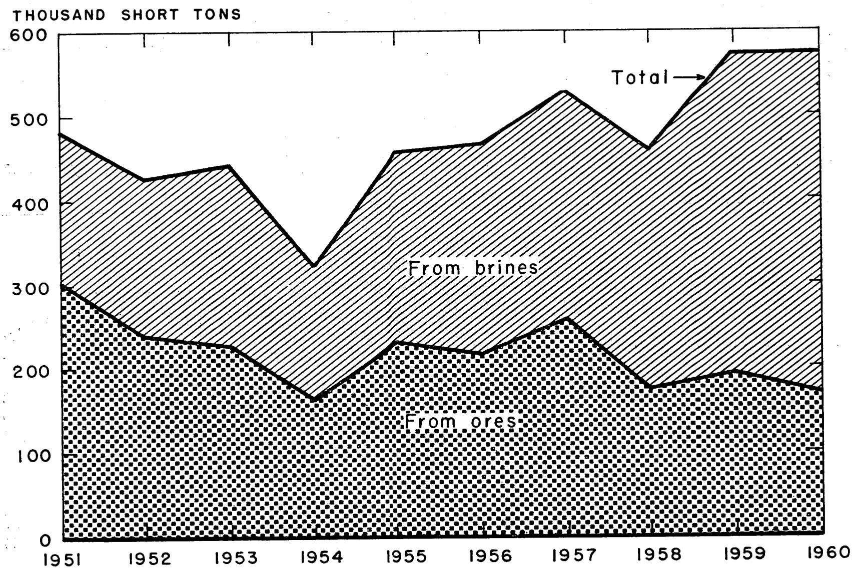

FIGURE 1.—Domestic production of magnesia from ores and brines, 1951–60.

[1] Commodity specialist, Division of Minerals.
[2] Research assistant, Division of Minerals.

of magnesium compounds from magnesite.[3] Installation of an additional rotary kiln increased annual productive capacity of dead-burned magnesite to 120,000 tons.

Kaiser Refractories & Chemical Division of Kaiser Aluminum & Chemical Corp. began producing periclase and refractory-grade magnesias from magnesium hydroxide at its new plant at Midland, Mich. Annual productive capacity of the plant was 45,000 tons.[4]

TABLE 1.—Salient magnesium compounds statistics

(Thousand short tons and thousand dollars)

	1951–55 (average)	1956	1957	1958	1959	1960
United States:						
Production:						
Crude magnesite:						
Quantity	[1] 501	[2] 687	[2] 678	[2] 493	[2] 594	[2] 499
Value [3]	$2,941	$2,502	$3,258	$2,409	$2,401	$2,051
Sold or used by producers:						
Caustic-calcined magnesia:						
Quantity	40	36	61	45	54	66
Value [4]	$3,393	$2,426	$3,161	$2,648	$3,533	$4,292
Imports for consumption (value)	$117	$350	$265	$115	$264	$213
Exports (value)	(5)	$1,501	$4,033	$844	$667	$686
Refractory magnesia:						
Quantity	385	431	468	415	518	506
Value	$18,975	$22,663	$26,319	$23,375	$31,458	$30,863
Imports (value)	$3,183	$6,093	$4,033	$5,095	$9,606	$7,575
Exports (value)	(5)	$451	$1,436	$2,838	[6] $5,160	$5,988
Dead-burned dolomite:						
Quantity	1,968	2,424	2,251	1,659	1,988	1,949
Value	$27,463	$37,745	$35,871	$27,378	$33,069	$32,522
Imports (value)	$283	$587	$640	$322	[6] $496	[7] $550
World: Production, crude magnesite:						
Quantity	4,420	5,400	5,650	6,100	6,600	7,100

[1] Includes crude ore, heavy-medium concentrate and flotation concentrate.
[2] All run-of-mine material.
[3] Partly estimated: most of the crude is processed by mining companies, and very little enters the open market.
[4] Includes specialty magnesia of high unit value.
[5] Not available.
[6] Revised figure.
[7] Adjusted by Bureau of Mines.

TABLE 2.—Magnesia sold or used by producers in the United States, by kinds and sources

Year and kind	From magnesite, brucite, and dolomite		From well brines, raw sea water, and sea water bitterns [1]		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1959:						
Caustic-calcined	16,039	$719	38,054	$2,814	54,093	$3,533
Refractory	176,055	8,134	341,886	23,324	517,941	31,458
Total	192,094	8,853	379,940	26,138	572,034	34,991
1960:						
Caustic-calcined	20,076	902	45,979	3,390	66,055	4,292
Refractory	148,404	7,054	357,507	23,809	505,911	30,863
Total	168,480	7,956	403,486	27,199	571,966	35,155

[1] Magnesia made from a combination of dolomite and sea water is included with that from sea water.

[3] Mining World, Basic Incorporated Increases Magnesite Production at Gabbs, Nevada: Vol. 22, No. 12, November 1960, pp. 30–32.
[4] American Metal Market, Kaiser's Magnesia Plant at Midland Now in Operation: Vol. 67, No. 76, Apr. 21, 1960, p. 9.

TABLE 3.—Dead-burned dolomite sold in and imported into the United States

Year	Sales of domestic product		Imports [1]	
	Short tons	Value (thousands)	Short tons [2]	Value (thousands)
1951–55 (average)	1,967,823	$27,463	4,271	$283
1956	2,423,909	37,745	9,031	587
1957	2,251,428	35,871	10,419	640
1958	1,659,184	27,378	5,686	322
1959	1,987,767	33,069	[3] 8,468	[3] 496
1960	1,949,260	32,522	[4] 12,932	[4] 550

[1] Dead-burned basic refractory material comprising chiefly magnesium and lime.
[2] Includes weight of immediate container.
[3] Revised figure.
[4] Adjusted by Bureau of Mines.

E. J. Lavino & Co. began producing refractory-grade periclase early in the year at its new plant at Freeport, Tex. The raw material was magnesium hydroxide obtained from sea water by The Dow Chemical Co.[5]

Production of dead-burned dolomite remained approximately the same as in 1959. Olivine production increased slightly due mainly to greater demands for crushed olivine to use as molding sand in foundries. No brucite was mined in 1960.

Production of caustic calcined magnesia increased about 22 percent above 1959, and production of magnesium chloride increased about 20 percent. Output of both magnesium carbonate and magnesium trisilicate decreased.

CONSUMPTION AND USES

Consumption of magnesite, brucite, and dead-burned dolomite decreased below 1959, and consumption of magnesium compounds from sea water and brines rose. Use of periclase in basic refractories reflected a continued increase in demands for stronger basic brick to line steel furnaces.

PRICES

The only price change for magnesium compounds was that of magnesium chloride, which increased from $55 to $60 a ton.[6]

FOREIGN TRADE [7]

Imports.—Imports of both refractory-grade and caustic-calcined magnesia were less than 80 percent of the quantities imported in 1959. The major suppliers of refractory magnesia were Austria and Yugoslavia, and imports from Greece increased 32 percent above 1959. Imports from Austria fell 29 percent. Total imports of other magnesium compounds decreased 6 percent below 1959.

[5] Steel, New Plants: Vol. 147, No. 20, Nov. 14, 1960, p. 108.
[6] Oil, Paint, and Drug Reporter, Magnesium Chloride: Vol. 178, No. 15, Oct. 3, 1960, p. 32.
[7] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 4.—Specified magnesium compounds produced, sold, and used by producers in the United States

Year and product [1]	Plants	Produced (short tons)	Sold: Short tons	Sold: Value (thousands)	Used (short tons)
1959:					
Specified magnesias (basis, 100 percent MgO), U.S.P. and technical:					
Extra-light and light	5	2,558	2,403	$1,373	----------
Heavy	3	21,750	21,491	2,660	300
Total	[2] 6	24,308	23,894	4,033	300
Precipitated magnesium carbonate	5	22,278	6,850	1,449	15,479
Magnesium hydroxide, U.S.P. and technical (basis, 100 percent $Mg(OH)_2$)	5	298,406	111,101	2,886	166,444
Magnesium chloride	7	133,289	17,478	941	[3] 117,000
1960:					
Specified magnesias (basis, 100 percent MgO), U.S.P. and technical:					
Extra-light and light	5	2,429	2,486	1,426	----------
Heavy	3	21,765	17,899	2,348	----------
Total	[2] 6	24,194	20,385	3,774	----------
Precipitated magnesium carbonate	5	17,524	5,666	1,192	11,988
Magnesium hydroxide, U.S.P. and technical (basis, 100 percent $Mg(OH)_2$)	5	319,935	146,710	3,756	167,473
Magnesium chloride	7	160,123	17,629	964	[3] 144,917

[1] In addition, magnesium phosphate, nitrate, sulphate, and trisilicate were produced.
[2] A plant producing more than 1 grade is counted only once in arriving at total.
[3] Greater part used for magnesium metal.

TABLE 5.—Domestic consumption of caustic-calcined magnesia by uses

(Percent)

Use	1956	1957	1958	1959	1960
Oxychloride and oxysulphate cement	32	30	50	49	47
Rayon	3	1	2	2	3
Fertilizer	2	(1)	(1)	(1)	1
85-percent-MgO insulation	10	6	10	4	3
Rubber	8	2	4	1	4
Fluxes	(1)	(1)	(1)	(1)	(1)
Refractories	--------	29	(1)	1	9
Chemical processing	--------	--------	2	2	3
Uranium processing	--------	--------	6	9	7
Miscellaneous (including chemicals and paper industry)	45	32	26	32	23
Total	100	100	100	100	100

[1] Less than 1 percent.

TABLE 6.—Domestic consumption of U.S.P. and technical-grade magnesias by uses

(Percent)

Use	1956	1957	1958	1959	1960
Rayon	8	17	18	17	21
Rubber (filler and catalyst)	9	18	12	11	9
Refractories	42	11	11	14	14
Medicinal	1	3	(1)	(1)	(1)
Uranium processing	3	4	5	1	(1)
Fertilizer	--------	(1)	1	1	1
Electrical	--------	--------	21	14	16
Neoprene compounds	--------	--------	2	--------	--------
Oxychloride and oxysulphate cement	--------	--------	--------	7	2
Miscellaneous	37	47	30	35	37
Total	100	100	100	100	100

[1] Less than 1 percent.

Exports.—Exports of magnesite, magnesia, and manufactures (except refractories) were valued at $6,674,000, a 15-percent increase above 1959.

Tariff.—The tariff on crude magnesite, based on the Geneva Agreement of 1947, remained at $^{15}/_{64}$ cent per pound, an ad valorem equivalent of 18.3 percent. Duty on dead-burned and grain magnesite and periclase was $^{23}/_{60}$ cent per pound, an ad valorem equivalent of 11.6

TABLE 7.—U.S. imports for consumption of crude and processed magnesite, by countries

Country	1959		1960	
	Short tons	Value	Short tons	Value
Crude magnesite:				
Europe: Netherlands	34	$1,482		
Oceania: Australia			21	$538
Total	34	1,482	21	538
Lump or ground caustic-calcined magnesia:				
Europe:				
Austria	267	9,813	282	11,451
Greece	5	255		
Netherlands	661	35,458	1,251	71,534
United Kingdom	62	8,146	22	5,660
Yugoslavia	1,323	46,723	656	23,494
Total	2,318	100,395	2,211	112,139
Asia: India	2,980	163,343	1,920	100,955
Grand total	5,298	263,738	4,131	213,094
Dead-burned and grain magnesia and periclase:				
North America: Canada	1,052	245,023	678	108,098
South America: Brazil			55	2,100
Europe:				
Austria	68,847	4,380,511	48,670	3,339,345
Czechoslovakia			17	773
Germany, West			2,800	161,214
Greece	20,254	1,576,835	26,834	2,106,941
Italy	4,479	329,184		
Switzerland	11,244	753,329	6,633	428,908
United Kingdom	15,829	968,842		
U.S.S.R.			1	476
Yugoslavia	28,597	1,352,496	28,939	1,427,420
Total	149,250	9,361,197	113,894	7,465,077
Grand total	150,302	9,606,220	114,627	7,575,275

Source: Bureau of the Census.

TABLE 8.—U.S. imports for consumption of magnesium compounds

Year	Oxide or calcined magnesia		Magnesium carbonate precipitated		Magnesium chloride (anhydrous and n.s.p.f.)		Magnesium sulfate (epsom salt)		Magnesium salts and compounds, n.s.p.f.[1]		Manufactures of carbonate of magnesia	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1951–55 (average)	24	[2] $9,886	222	[2] $61,016	159	$4,885	7,031	[2] $165,467	300	[2] $65,547	27	$7,797
1956	197	[2] 58,507	264	63,771	350	9,421	11,101	256,455	1,508	107,435	3	1,730
1957	412	152,395	307	59,638	431	11,778	10,570	248,948	839	33,867	23	3,769
1958	355	119,012	326	66,174	685	28,038	9,908	238,236	1,202	52,814	1	660
1959	273	71,498	351	93,721	949	28,114	12,350	302,036	1,925	66,096	1	830
1960	266	65,973	346	83,737	1,174	53,920	10,121	240,661	3,036	94,267	28	6,986

[1] Includes magnesium silicofluoride or fluosilicate and calcined magnesia.
[2] Data known to be not comparable with other years.

Source: Bureau of the Census.

TABLE 9.—U.S. exports of magnesite and magnesia, by countries

Destination	Magnesite and magnesia, dead-burned				Magnesite and magnesia (except dead-burned) and manufactures, n.e.c.	
	1959		1960		1959	1960
	Short tons	Value	Short tons	Value	Value	Value
North America:						
Canada	7,053	$605,425	11,638	$985,257	$293,178	$247,242
Cuba	10	1,630	2	1,505	16,315	6,749
Honduras					4,300	4,300
Mexico	[1] 8,732	[1] 646,920	7,090	566,865	20,071	24,453
Other			10	1,225	50,538	20,317
Total	[1] 15,795	[1] 1,253,975	18,740	1,554,852	384,402	303,061
South America:						
Argentina	3	1,996	139	12,959		17,303
Brazil			1	732	21,135	25,510
Chile	459	31,029	158	10,901	4,839	3,871
Venezuela					39,630	30,595
Other	597	43,365	10	1,434	17,731	12,233
Total	1,059	76,390	308	26,026	83,335	89,512
Europe:						
Denmark	58	38,629	56	38,950		5,582
France	30	4,041	83	24,943	17,651	17,240
Germany, West	248	56,777	1,318	179,835		7,083
Hungary			1,727	120,939		
Italy	12	4,549	87	19,604	1,500	
Spain	3	2,096				650
Sweden	16	10,496	25	16,618	6,262	19,927
Switzerland	6	4,087	6	4,507	778	1,947
United Kingdom	99	59,722	5,707	399,547	10,189	72,327
Other	5	3,257	36	12,165	7,576	17,392
Total	477	183,654	9,045	817,108	43,956	142,148
Asia:						
Iran			50	5,500		516
Japan	68,160	3,545,001	63,676	3,430,074	47,802	5,412
Korea, Republic of	665	36,760	2	836	1,015	2,115
Kuwait			149	21,350		
Philippines			30	2,089	17,088	8,309
Other					30,360	19,445
Total	68,825	3,581,761	63,907	3,459,849	96,265	35,797
Africa:						
Congo, Republic of the,[2] and Ruanda-Urundi					35,068	39,452
Mozambique					19,018	57,168
Rhodesia and Nyasaland, Federation of						9,509
Union of South Africa	6	4,256	18	11,425	5,421	7,284
Total	6	4,256	18	11,425	59,507	113,413
Oceania:						
Australia	72	49,517	149	103,837		1,843
New Zealand	15	10,645	20	14,749		434
Total	87	60,162	169	118,586		2,277
Grand total	[1] 86,249	[1] 5,160,198	92,187	5,987,846	667,465	686,208

[1] Revised figure.
[2] Belgian Congo prior to July 1, 1960.

Source: Bureau of the Census.

percent; duty on caustic-calcined magnesia was $^{15}/_{32}$ cent per pound, an ad valorem equivalent of 18.2 percent. Duty on magnesium oxide was 2½ cents per pound, an ad valorem equivalent of 20.16 percent. Duty on dead-burned dolomite was 15 percent ad valorem.

WORLD REVIEW

World production of crude magnesite increased 8 percent above 1959. Austria was the leading producer. The United States was second, and Czechoslovakia was third.

Australia.—A company sponsored by Australian and United States interests began mining magnesite from deposits near Ravensthorpe in Western Australia. Reserves were estimated at 2 to 4 million tons. An American firm contracted to purchase 50,000 tons of the ore.[8]

TABLE 10.—World production of magnesite of countries[1 2]

(Short tons)

Country [1]	1951–55 (average)	1956	1957	1958	1959	1960
North America: United States	500,833	686,569	678,489	492,982	593,307	498,528
Total [1 3]	830,000	990,000	970,000	740,000	890,000	820,000
South America:						
Brazil	[3] 11,000	[3] 11,000	[3] 11,000	6,526	8,714	[3] 8,800
Venezuela	353					
Total	[3] 11,353	[3] 11,000	[3] 11,000	6,526	8,714	[3] 8,800
Europe:						
Austria	892,922	1,194,502	1,292,567	1,346,133	1,324,106	1,791,701
Bulgaria	81,813	155,536	[3] 155,000	[3] 165,000	[3] 165,000	[3] 165,000
Czechoslovakia	(4)	(4)	(4)	(4)	[3] 440,000	[3] 470,000
Greece	90,777	68,350	52,392	97,742	121,254	[3] 193,000
Italy	2,482	5,448	8,512	6,500	7,562	6,584
Norway	1,413	1,124				
Poland	24,720	18,673	18,850	15,432	[3] 15,000	[3] 14,000
Spain	21,616	26,891	40,455	38,442	44,569	[3] 55,000
Yugoslavia	118,313	214,260	233,983	246,032	269,851	277,613
Total [1 3]	3,110,000	3,550,000	3,750,000	3,900,000	4,050,000	4,600,000
Asia						
India	95,709	102,717	99,552	114,900	174,129	171,960
Korea, Republic of	73					
Pakistan			24		443	743
Turkey	619	937	1,439	717		17
Total [1 3]	385,000	730,000	780,000	1,270,000	1,550,000	1,550,000
Africa:						
Kenya			117	551	3,145	33
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	11,725	8,611	2,910			8,031
Tanganyika (exports)	702	272	284	337	118	127
Union of South Africa	23,891	33,485	35,414	80,200	58,883	66,793
United Arab Republic (Egypt Region)	192					
Total	36,510	42,368	38,725	81,088	62,146	74,984
Oceania:						
Australia	51,182	72,447	93,490	77,718	67,856	[3] 66,000
New Zealand	624	818	675	1,344		
Total	51,806	73,265	94,165	79,062	67,856	[3] 66,000
World total (estimate) [1 2]	4,420,000	5,400,000	5,650,000	6,100,000	6,600,000	7,100,000

[1] Quantities in this table represent crude magnesite mined. Magnesite is also produced in Canada, China, Mexico, North Korea and U.S.S.R., but data on tonnage of output are not available; estimates by senior author of chapter included in total.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Data not available; estimate by senior author of chapter included in total.

Compiled by Liela S. Price, Division of Foreign Activities.

[8] Mining World and Engineering Record (London), Bush Telegraph Digest: Vol. 176, No. 4544, November 1960, p. 395.
Mining Journal (London), Mining Miscellany: Vol. 254, No. 6512, June 10, 1960, p. 681.

TABLE 11.—Austria: Exports of magnesia and magnesite brick by countries [1]

(Short tons)

Destination	Magnesia				Magnesite brick	
	Caustic-calcined		Refractory			
	1959	1960	1959	1960	1959	1960
North America: United States	274	326	87,229	57,034	----------	83
South America:						
Argentina	----------	11	1,594	2,082	2,670	2,359
Brazil	13	13	10	----------	495	549
Chile	----------	----------	347	389	825	660
Peru	----------	----------	1,216	19	218	152
Venezuela	55	73	17	34	1,009	130
Europe:						
Belgium-Luxembourg	205	174	1,209	1,542	5,979	8,432
Bulgaria	----------	----------	154	30	658	131
Czechoslovakia	4,895	5,526	228	----------	104	1,351
Denmark	126	133	1,108	461	1,875	2,808
Finland	1	----------	322	459	1,346	2,010
France	2,864	2,875	9,644	10,072	17,151	20,657
Germany, West	81,903	89,055	48,046	66,010	29,125	35,833
Greece	----------	----------	149	168	577	1,462
Hungary	1,314	1,533	5,784	6,583	----------	22
Italy	3,364	4,427	12,354	22,615	7,368	10,351
Netherlands	1	37	116	174	1,071	2,190
Norway	----------	----------	153	387	1,051	1,847
Poland	----------	----------	----------	5,512	780	2,076
Rumania	----------	----------	33	168	390	1,968
Spain	----------	----------	157	265	1,979	3,724
Sweden	122	117	887	1,328	7,173	10,018
Switzerland	2,183	2,254	712	489	1,761	1,395
United Kingdom	2	3	2,594	54,813	4,436	10,980
Asia:						
India	----------	----------	597	20	545	198
Japan	19	----------	13,013	202	----------	----------
Korea, Republic of	----------	----------	367	712	628	122
Turkey	----------	----------	483	143	3,943	2,055
Africa:						
Union of South Africa	----------	----------	2	610	244	607
United Arab Republic (Egypt Region)	39	----------	74	216	871	594
Oceania: Australia	----------	----------	80	4,074	2,267	6,016
Other countries	108	100	1,146	988	8,744	9,106
Total	97,488	106,657	189,825	237,599	105,283	139,886

[1] This table incorporates some revisions.

Compiled from Customs Returns of Austria by Corra A. Barry, Division of Foreign Activities.

TABLE 12.—Greece: Exports of magnesite and calcined magnesia, by countries

(Short tons)

Destination	Crude magnesite		Calcined magnesia	
	1959	1960	1959	1960
Canada	----------	----------	----------	24,109
France	3,858	5,423	1,123	1,824
Germany:				
East	5,921	1,158	----------	----------
West	----------	----------	9,975	11,667
Italy	4,795	8,223	----------	----------
Netherlands	1,942	2,261	17,806	23,469
United Kingdom	----------	----------	4,398	6,522
Other countries	1,453	3,471	474	4,396
Total	17,969	20,536	33,776	71,987

Compiled from Customs Returns of Greece by Corra A. Barry, Division of Foreign Activities.

Austria.—Exports of magnesite from Austria increased considerably above 1959. The principal markets were in Europe.[9]

Greece.—Greek exports of calcined magnesia were more than double those of 1959, and exports of crude magnesite increased 14 percent.

Yugoslavia.—Exploration of a large deposit of magnesite near Jablanica in Bosnia and Hercegovina began during 1960. Ore reserves in this area were estimated at 50 million tons.[10]

TECHNOLOGY

Fundamental research was continued in 1960 to determine the properties of magnesium oxide crystals.[11] Tests of single crystals containing small quantities of impurity showed that a decrease in iron content and high-temperature heating with rapid cooling resulted in decreased strength and increased ductility.[12]

Transparent crucibles with capacities ranging from 0.1 to 1.0 cubic centimeter were made from magnesium oxide single crystals to use as containers for observing reactions in melts or solutions at high temperatures.[13] Several of the halides and compounds tested could be held in the crucibles for extended periods with negligible attack on the crucibles.

Improved basic refractories were developed from tar-bonded magnesia materials for use in lining oxygen steel furnaces.[14]

Techniques for forming and installing large basic refractory sections were described.[15] Methods and rates of heating furnaces to obtain best working conditions and longest life of the refractories were outlined.

New basic refractory roof designs for steel furnaces were described, and analyses of performance results of various types of basic roofs were given.[16]

Increased requirements for high-purity periclase (dead-burned magnesia) in basic refractories encouraged investigations to determine the properties of periclase. Nine samples of commercial periclase were studied, and the chemical and physical properties of each were described.[17] The samples were taken from periclase produced from magnesite, brucite, sea water, and brines.

Two new basic refractory brick materials were developed for use in checker settings of glass-melting furnaces.[18] Each of the products contained more than 95 percent magnesia.

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[9] Mining Journal (London), Mining Miscellany: Vol. 255, No. 6516, July 8, 1960, p. 49.

[10] Chemical Trade Journal and Chemical Engineer (London), New Jugoslavian Magnesite Mine: Vol. 147, No. 3833, Nov. 18, 1960, p. 1177.

[11] May, J. E., and Kronberg, M. L., Temperature Dependence of Plastic Yield Stress of Single Crystals of Magnesium Oxide: Jour. Am. Ceram. Soc., vol. 43, No. 10, Oct. 1, 1960, pp. 525–530.

[12] Gorum, A. E., Luhman, W. J., and Pask, J. A., Effect of Impurities and Heat Treatment on Ductility of MgO: Jour. Am. Ceram. Soc., vol. 43, No. 5, May 1960, pp. 241–245.

[13] De Vries, R. C., and Moehle, C. F., Transparent Crucible Material for High Temperatures: Bull. Am. Ceram. Soc., vol. 39, No. 5, May 15, 1960, pp. 270–271.

[14] Brick & Clay Record, Basic Refractories: Vol. 138, No. 1, January 1961, pp. 70–71, 96. Steel, Tar Bonded Refractories Promise Longer Campaigns: Vol. 147, No. 11, Sept. 12, 1960, pp. 132, 135.

[15] Kraner, Hobart M., Padfield, Ralph C., and Hauser, Richard E., Casting Large Sections of Basic Refractories: Bull. Am. Ceram. Soc., vol. 39, No. 9, Sept. 15, 1960, pp. 456–459.

[16] Fay, Mervin A., Basic Roof Performance in American Open Hearth Furnaces: Blast Furnace and Steel Plant, vol. 48, No. 4, April 1960, pp. 372–376, 386–387.

[17] Hubble, D. H., and Dodge, N. B., A Study of Commercial Periclases: Jour. Am. Ceram. Soc., vol. 43, No. 7, July 1960, pp. 343–347.

[18] Ceramic Age, Basic Refractory Brick: Vol. 75, No. 6, June 1960, p. 6.

An improved type of magnesium carbonate material was developed for insulating boilers and pipe.[19] Tests showed that it was harder, stronger, and more resistant to water than standard magnesium oxide insulation materials.

[19] Chemical Age (London), New Type Magnesium Carbonate Thermal Insulating Material Introduced: Vol. 84, No. 2138, July 2, 1960, p. 22.

Manganese

By Gilbert L. DeHuff [1] and Teresa Fratta [2]

DOMESTIC production of 80,000 short tons of ore, concentrate, and nodules containing 35 percent or more manganese, was considerably lower in 1960 than in preceding years. Annual consumption of ore increased to 1.9 million short tons, yet industrial ore stocks at the end of the year were still more than 2.5 million tons, reflecting continued high imports. Barter of foreign manganese ore and ferromanganese for surplus U.S. agricultural commodities was featured in the trade news of the year.

LEGISLATION AND GOVERNMENT PROGRAMS

The Office of Mineral Exploration (OME) continued to offer financial assistance in exploration for domestic manganese deposits, not exceeding 50 percent of approved exploration costs.

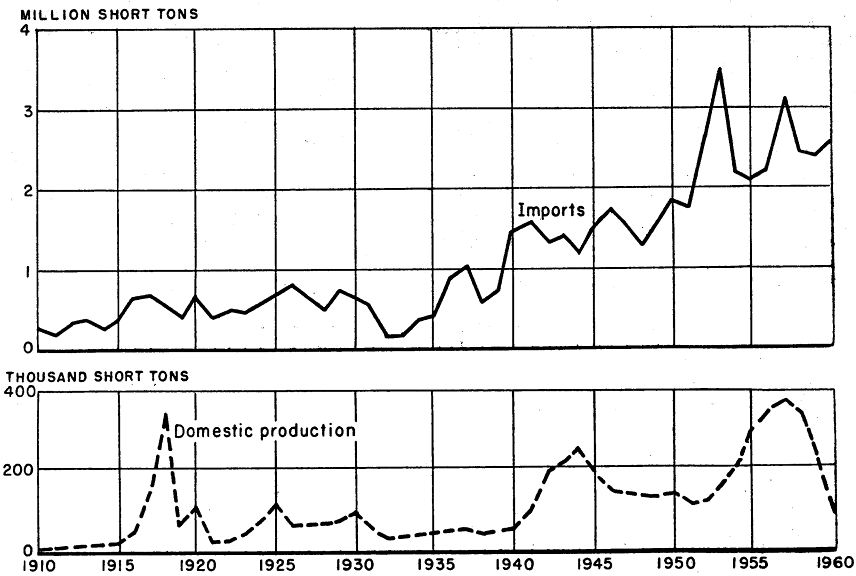

FIGURE 1.—General imports and domestic production (shipments) of manganese ore, 1910–60.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

Manganese ore and ferromanganese both continued to be important among the strategic materials exchanged for surplus U.S. agricultural products in the barter program of the U.S. Department of Agriculture, Commodity Credit Corporation (CCC), (Agricultural Trade Development and Assistance Act of 1954, Public Law 480, 83d Cong.). On December 31, 1960, the Government supplemental stockpile was inventoried as 35,000 short dry tons of natural battery-grade manganese ore, 18,000 tons of Type B chemical-grade manganese ore, and 1,071,000 tons of metallurgical-grade manganese ore. The last figure was made up of actual ore on hand plus the calculated ore equivalent for 462,000 short tons of ferromanganese and 4,040 tons of electrolytic manganese metal in stock. On the same date, the CCC also held stocks of manganese items acquired by barter and not yet transferred to the supplemental stockpile. Materials in the supplemental stockpile had been obtained in large part but not exclusively through the agricultural barter program.

TABLE 1.—Salient manganese statistics in the United States

	1951–55 (average)	1956	1957	1958	1959	1960
Manganese ore (35 percent or more Mn):						
Production (shipments):[1]						
Metallurgical ore..short tons..	160,627	341,291	364,227	327,309	[2] 223,164	70,905
Battery ore..........do....	13,622	3,444	2,107	([3])	6,011	9,116
Miscellaneous ore.....do....	12	----------	----------	----------	24	----------
Total[1] ....do....	174,261	344,735	366,334	327,309	[2] 229,199	80,021
Value..........thousands..	$12,721	$26,990	$29,363	$23,637	[2] $17,904	$5,352
Imports, general.....short tons..	2,436,249	2,238,568	3,105,172	2,452,578	2,397,804	2,543,576
Consumption..............do....	1,949,562	2,264,159	2,361,460	1,497,574	[2] 1,605,507	1,946,389
Manganiferous ore (5 to 35 percent Mn):						
Production (shipments)[1]..do....	978,073	680,651	865,127	520,601	[2] 470,600	658,455
Value..............thousands..	$5,102	$3,984	$5,413	$3,532	[2] $3,153	$4,466
Ferromanganese:						
Production..........short tons..	809,242	923,012	963,814	636,736	629,307	842,818
Imports for consumption..do....	86,454	160,203	338,079	63,932	90,062	120,222
Exports...................do....	1,344	2,248	7,395	1,406	947	751
Consumption............do....	852,686	945,210	935,725	674,495	[2] 755,229	800,430

[1] Shipments are used as the measure of manganese production for compiling U.S. mineral-production value. They are taken at the point that the material is considered to be in marketable form from the consumer's standpoint.
[2] Revised figure.
[3] Battery ore included in metallurgical.

DOMESTIC PRODUCTION

Nevada, with purchases by the Government under special contracts for its metallurgical nodules, provided more than half the 1960 domestic production of manganese ore, containing 35 percent or more manganese. These nodules, containing 44 percent manganese and produced by Manganese, Inc., from Three Kids oxide ore, made the State the leading manganese ore producer. The Anaconda Company shipped metallurgical nodules, containing approximately 57 percent manganese, from Montana. Taylor-Knapp Co. and Trout Mining Co. (formerly Trout Mining Division, American Machine and Metals, Inc.) both in the Philipsburg district of Montana, continued to be the only producers of natural battery-grade ore or concentrate in the Nation. Manganese Chemicals Corp., Riverton, Minn., continued to use the ammonium carbamate leach process to produce synthetic battery ore and synthetic miscellaneous ore from low-grade Cuyuna Range material.

Low-grade manganese ores, containing 10 to 35 percent manganese, were shipped commercially from Arizona, California, Georgia, Minnesota, Montana, Nevada, New Mexico, and Tennessee. Manganiferous iron ore, containing 5 to 10 percent manganese, was shipped by Michigan and Minnesota.

TABLE 2.—Metallurgical manganese ore,[1] ferruginous manganese ore,[2] and manganiferous iron ore,[3] shipped in the United States, by States

(Short tons, gross weight)

State	1959			1960		
	Metallurgical manganese ore	Ferruginous manganese ore	Manganiferous iron ore	Metallurgical manganese ore	Ferruginous manganese ore	Manganiferous iron ore
Arizona	68,183	10,693	------------	1,626	8,677	------------
Arkansas	17,742	------------	------------	------------	------------	------------
California	19,354	[4] 129	------------	------------	96	------------
Colorado	1,218	------------	------------	------------	------------	------------
Georgia	1,547	(5)	------------	------------	(5 6)	------------
Michigan	------------	------------	------------	------------	------------	180,460
Minnesota	------------	122,736	306,366	------------	54,151	386,877
Montana	15,569	2,415	------------	19,920	676	------------
Nevada	[4] 56,611	[4] 200	------------	49,076	(5)	------------
New Mexico	27,528	(5)	------------	------------	(5)	------------
Tennessee	7,586	[6] 56	------------	283	(5 6)	------------
Utah	1,511	------------	------------	------------	------------	------------
Virginia	6,232	(5 6)	------------	------------	------------	------------
Washington	83	------------	------------	------------	------------	------------
Undistributed	------------	28,005	------------	------------	27,518	------------
Total	[4] 223,164	[4] 164,234	306,366	70,905	91,118	567,337

[1] Containing 35 percent or more manganese (natural).
[2] Containing 10 to 35 percent manganese (natural).
[3] Containing 5 to 10 percent manganese (natural).
[4] Revised figure.
[5] Figure withheld to avoid disclosing individual company confidential data, included with "Undistributed."
[6] All miscellaneous ore.

CONSUMPTION, USES, AND STOCKS

Consumption of manganese ore increased 21 percent over 1959; domestic sources supplied 1 percent. Industrial ore stocks at yearend were down somewhat from the beginning of the year but still exceeded 2.5 million short tons.

In the production of steel ingots, consumption of manganese as ferroalloys, metal and direct-charged ore per short ton of open-hearth, bessemer, basic oxygen process, and electric steel produced was 13.3 pounds, compared with 13.1 pounds in 1959. Of these 13.3 pounds, 11.8 pounds was ferromanganese, 1.1 pound silicomanganese, 0.1 pound spiegeleisen, and 0.3 pound manganese metal.

Electrolytic Manganese and Manganese Metal.—Virtually all manganese metal consumed in 1960 was electrolytic manganese. Total metal consumption was 16,000 short tons compared with 14,000 tons (revised) in 1959. Foote Mineral Co. and Union Carbide Metals Co. continued to be the only domestic producers of electrolytic metal. Both companies expanded existing plants to bring total U.S. productive capacity to approximately 23,000 short tons per year. Plans for new electrolytic manganese metal plants were announced by both Foote Mineral Co. and American Potash & Chemical Corp.: The former for a 10,000-ton-per-year plant at New Johnsonville, Tenn., and the latter for a 5,000-ton-per-year plant at Aberdeen, Miss.

TABLE 3.—Manganese and manganiferous ores shipped[1] in the United States in 1960, by States

Type and State	Short tons		Value (thousands)
	Gross weight	Manganese content	
Manganese ore: [2]			
Arizona	1,626	588	$40
Montana	29,036	16,604	1,996
Nevada	49,076	21,726	3,301
Tennessee	283	133	15
Total	80,021	39,051	5,352
Manganiferous ore:			
Ferruginous manganese ore: [3]			
Arizona	8,677	2,126	190
California	96	25	(4)
Minnesota	54,151	6,901	(4)
Montana	676	147	11
Georgia, Nevada, New Mexico, and Tennessee [5]	27,518	3,741	171
Total	91,118	12,940	(4)
Manganiferous iron ore: [6]			
Michigan	180,460	9,185	(4)
Minnesota	386,877	27,648	(4)
Total	567,337	36,833	(4)
Total manganiferous ore	658,455	49,773	4,466

[1] Shipments are used as the measure of manganese production for compiling U.S. mineral-production value. They are taken at the point where the material is considered to be in marketable form from the consumer's standpoint. Besides direct-shipping ore, they include, without duplication, concentrate and nodules made from domestic ores.
[2] Containing 35 percent or more manganese (natural). All metallurgical ore except that shipped from Montana, which includes 9,116 short tons of battery ore, containing 5,408 tons of manganese. Does not include Minnesota's production of synthetic battery ore and synthetic miscellaneous ore. Instead, the low-grade Minnesota ore used to make these items is included under ferruginous manganese ore and manganiferous iron ore.
[3] Containing 10 to 35 percent manganese (natural).
[4] Included in total.
[5] All Georgia and Tennessee manganiferous ore was miscellaneous ore.
[6] Containing 5 to 10 percent manganese (natural).

Ferromanganese.—Production of ferromanganese in the United States employed 20 plants of 10 companies, compared with 21 plants of 11 companies in 1959. Pittsburgh Coke & Chemical Co., Neville Island (Pittsburgh), Pa., a 1959 producer, did not produce in 1960. The quantity of ferromanganese made in blast furnaces was twice that made in electric furnaces. Shipments of ferromanganese totaled 782,000 short tons, valued at $166 million, compared with 710,000 tons, valued at $169 million in 1959, an increase of 10 percent in quantity but a decrease of 2 percent in value.

TABLE 4.—Consumption and stocks of manganese ore[1] in the United States
(Short tons, gross weight)

Use and ore source	Consumption 1959	Consumption 1960	Stocks Dec. 31, 1960[2] (including bonded warehouses)
Manganese alloys and manganese metal:			
Domestic ore	3,841	17,844	462
Foreign ore	1,512,013	1,828,728	2,528,412
Total	1,515,854	1,846,572	2,528,874
Steel ingots:			
Domestic ore	----------	----------	----------
Foreign ore	[3] 463	697	137
Total	[3] 463	697	137
Steel castings:			
Domestic ore	----------	----------	----------
Foreign ore	[3] 245	180	206
Total	[3] 245	180	206
Pig iron:			
Domestic ore	222	----------	----------
Foreign ore	8,430	5,805	4,190
Total	8,652	5,805	4,190
Dry cells:			
Domestic ore	4,097	4,285	670
Foreign ore	24,637	22,930	19,509
Total	28,734	27,215	20,179
Chemicals and miscellaneous:			
Domestic ore	388	6,951	1,193
Foreign ore	[3] 51,171	58,969	32,757
Total	[3] 51,559	65,920	33,950
Grand total:			
Domestic ore	8,548	29,080	2,325
Foreign ore	[3] 1,596,959	1,917,309	2,585,211
Total	[3] 1,605,507	1,946,389	[4] 2,587,536

[1] Containing 35 percent or more manganese (natural).
[2] Excluding Government stocks.
[3] Revised figure.
[4] Excludes small tonnages of dealers' stocks.

Silicomanganese.—Production of silicomanganese in the United States was 101,000 short tons, compared with 106,000 tons in 1959. Shipments from furnaces totaled 104,000 tons valued at $23,983,000, compared with 107,000 tons valued at $27,930,000 in 1959. All plants producing silicomanganese in 1959 were active producers in 1960. Consumption of silicomanganese was 12.3 percent that of ferromanganese, compared with 13.1 percent (revised) in 1959.

Spiegeleisen.—New Jersey Zinc Co., Palmerton, Pa., and Pittsburgh Coke & Chemical Co., Neville Island (Pittsburgh), Pa., were the only two plants producing spiegeleisen in 1960.

Manganiferous Pig Iron.—Pig-iron furnaces used 998,000 short tons of manganese-bearing ores containing (natural) over 5 percent manganese. Of this amount, 461,000 tons was of domestic and 537,000 tons of foreign origin. Of the domestic ore, 413,000 tons contained 5 to 10 percent manganese (natural) and 48,000 tons contained 10 to 35 percent manganese. Of the foreign ore, 531,000 tons contained

5 to 10 percent manganese (natural) and 5,800 tons contained 35 percent or more manganese. The entire foreign manganiferous iron ore came from Canada.

TABLE 5.—Consumption, by end uses, and stocks of manganese ferroalloys and metal in the United States in 1960

(Short tons, gross weight)

Use	Ferromanganese		Silicomanganese	Spiegeleisen	Manganese metal [1]	Briquets
	High carbon	Medium and low carbon				
Steel ingots:						
Stainless steel	487	1,282	3,244	17	6,536	----------
Other alloy steel	124,522	8,591	22,840	9,319	1,107	----------
Carbon steel	571,430	48,943	58,978	15,199	4,798	----------
Other	479	130	737	17	16	----------
Total	696,918	58,946	85,799	24,552	12,457	----------
Steel castings:						
Stainless steel	175	287	143	2	82	----------
Other alloy steel	7,361	1,270	3,344	298	97	32
Carbon steel	7,395	1,252	5,483	1,181	18	159
Other	2,496	179	648	132	69	3
Total	17,427	2,988	9,618	1,613	266	194
Steel mill rolls	859	168	552	583	----------	3
Gray and malleable castings	11,374	3,989	1,628	11,324	3	8,081
Alloys (includes welding rods)	6,747	801	792	56	2,910	10
Other	211	2	245	----------	97	18
Grand total	733,536	66,894	98,634	38,128	15,733	8,306
Stocks, Dec. 31: [2]						
Consumer	111,824	9,311	11,053	9,672	1,362	1,314
Producer	(3)	(3)	(3)	23,984	(3)	----------

[1] Mostly electrolytic.
[2] Including bonded warehouses. Excluding Government stocks.
[3] Producer stocks of ferromanganese, silicomanganese, and manganese metal totaled 172,801 short tons

TABLE 6.—Ferromanganese imported into and made from domestic and imported ores in the United States

(Short tons)

	1959		1960	
	Gross weight	Mn content	Gross weight	Mn content
Ferromanganese: [1]				
Made in United States:				
From domestic ore [2]	2,501	2,013	11,016	8,857
From imported ore [2]	626,806	484,536	831,802	645,968
Total domestic production	629,307	486,549	842,818	654,825
Imported	90,062	70,232	120,222	92,594
Total	719,369	556,781	963,040	747,419
Open hearth, bessemer, basic oxygen process, and electric-furnace [3] steel produced	93,446,132	--------------	99,281,601	--------------

[1] Number of domestic plants making ferromanganese: 1959, 21; 1960, 20.
[2] Estimate.
[3] Includes crucible.

TABLE 7.—Ferromanganese produced in the United States and metalliferous materials consumed in its manufacture[1]

Year	Ferromanganese produced: Gross weight (short tons)	Manganese content: Percent	Manganese content: Short tons	Manganese ore (35 percent or more Mn natural): Foreign (short tons)	Manganese ore (35 percent or more Mn natural): Domestic (short tons)	Iron and manganiferous iron ores (short tons)	Manganese ore used per ton of ferromanganese[1] made (short tons)
1951–55 (average)	809,242	76.4	618,291	[1] 1,589,497	[1] 69,620	14,291	[1] 2.1
1956	923,012	76.9	709,895	2,025,678	63,561	283	2.3
1957	963,814	77.2	743,634	2,066,693	36,692	503	2.2
1958	636,736	77.7	494,761	1,228,769	42,061	1,091	2.0
1959	629,307	77.3	486,549	1,275,138	3,829	3,935	2.0
1960	842,818	77.7	654,825	[1] 1,801,038	17,819	1,821	[1] 2.2

[1] For 1955 and 1960, includes ore used in manufacturing silicomanganese.

TABLE 8.—Manganese ore used in manufacturing ferromanganese[1] in the United States, by source of ore

Source	1959: Gross weight (short tons)	1959: Mn content natural (percent)	1960[1]: Gross weight (short tons)	1960[1]: Mn content natural (percent)
Domestic	3,829	57.1	17,819	56.2
Foreign:				
Africa	456,780	46.8	570,576	46.2
Brazil	257,975	46.5	509,201	45.7
Chile	12,457	44.6	15,635	43.9
Cuba	57,377	36.5	39,216	40.0
India	335,243	45.1	440,988	43.8
Mexico	130,841	43.9	206,845	40.5
Philippines	6,851	41.1	3,133	43.6
Turkey	4,418	39.8	2,588	48.5
Other	13,196	46.2	12,856	46.6
Total	1,278,967	45.5	1,818,857	44.8

[1] For 1960, includes ore used in manufacturing silicomanganese.

Battery and Miscellaneous Industries.—Manufacturers of dry-cell batteries used 27,000 short tons of manganese ore, containing more than 35 percent manganese (natural); 4,300 tons was of domestic origin. Chemical plants and miscellaneous industries used 66,000 tons of manganese ore, containing 35 percent or more manganese. Of this quantity, 7,000 tons came from domestic sources. The domestic ore and an appreciable part of the imported ore was not of chemical grade.

PRICES

Manganese Ore.—Commercial prices for spot purchases of Indian and South African manganese ore containing 46 to 48 percent manganese, as quoted by E&MJ Metal and Mineral Markets, were nominal throughout the year at $0.87 to $0.90 per long-ton unit of manganese, c.i.f. U.S. ports, import duty extra. Prices for Brazilian ore containing 48 to 50 percent manganese were quoted by the same source throughout the year at $0.91, nominal, per long-ton unit of manganese on the same terms.

TABLE 9.—U.S. imports of manganese ore (35 percent or more Mn), by countries

Country	General imports [1] (short tons)				Imports for consumption [2]					
					Short tons				Value	
	Gross weight		Mn content		Gross weight		Mn content			
	1959	1960	1959	1960	1959	1960	1959	1960	1959	1960
North America:										
Canada	57	---	27	---	57	---	27	---	$2,074	---
Cuba	50,067	17,644	22,532	9,073	50,067	17,644	22,532	9,073	1,336,620	$688,983
Mexico	180,855	174,659	83,388	79,944	176,190	200,663	80,821	92,347	6,466,469	6,740,797
Total	230,979	192,303	105,947	89,017	226,314	218,307	103,380	101,420	7,805,163	7,429,780
South America:										
Argentina	15	---	6	---	15	---	6	---	490	---
Brazil	991,385	874,809	477,503	421,331	472,249	682,183	224,597	323,468	19,252,473	24,383,092
British Guiana	---	21,720	---	8,797	---	---	---	---	---	---
Chile	25,446	19,498	11,291	8,606	28,871	22,559	12,968	10,093	1,063,415	812,623
Peru	1,137	---	643	---	1,137	---	643	---	51,853	---
Venezuela	---	---	---	---	---	2,798	---	1,085	---	118,517
Total	1,017,983	916,027	489,443	438,734	502,272	707,540	238,214	334,646	20,368,231	25,314,232
Europe: Greece	18,162	28,501	8,774	13,780	10,195	6,756	4,857	3,255	560,349	412,834
Asia:										
India	373,408	479,279	172,758	222,066	419,415	475,178	195,693	216,880	14,036,117	14,356,995
Philippines	18,937	11,370	9,236	5,418	18,937	14,063	9,236	6,662	584,404	433,559
Portuguese Asia, n.e.c.	6,043	---	2,780	---	6,043	---	2,780	---	172,490	---
Turkey	3,736	2,909	1,665	1,271	3,736	2,909	1,665	1,271	71,618	97,921
Total	402,124	493,558	186,439	228,755	448,131	492,150	209,374	224,813	14,864,629	14,888,475
Africa:										
Angola	28,028	30,353	13,679	15,242	32,827	24,237	16,370	12,090	1,252,387	909,637
Congo,[3] Republic of the, and Ruanda-Urundi	97,874	164,679	47,875	80,756	93,973	141,221	46,583	69,610	3,726,357	4,940,001
Ghana	278,238	318,656	137,370	162,819	269,446	341,043	131,342	173,364	14,036,353	15,785,817
Morocco	79,689	75,033	42,405	40,306	74,229	76,064	39,348	40,712	4,914,967	4,172,549
Rhodesia and Nayasaland, Federation of	32,062	24,354	15,322	12,114	31,396	22,122	15,030	10,861	1,168,410	877,929
Sudan	---	---	---	---	1,793	---	656	---	98,186	---
Union of South Africa	177,037	277,358	78,444	121,029	172,493	226,288	75,292	101,104	5,306,397	6,696,344

United Arab Republic (Egypt region)	17,675	20,562	8,352	10,181	3,274	9,956	1,725	5,221	107,129	408,786
Western Africa, n.e.c.[4]		2,128		1,021		2,128		1,021		[4] 76,800
Total	710,603	913,123	343,447	443,468	679,431	843,059	326,346	413,983	30,610,186	33,867,863
Oceania:										
Australia	8,326	64	4,163	32	4,436	64	2,218	32	167,213	2,884
British Western Pacific Islands	9,627		4,621		7,286	8,829	3,292	4,069	272,023	373,025
Total	17,953	64	8,784	32	11,722	8,893	5,510	4,101	439,236	375,909
Grand total [5]	2,397,804	2,543,576	1,142,834	1,213,786	1,878,065	2,276,705	887,681	1,082,218	74,647,794	82,289,093

[1] Comprises ore received in the United States; part went into consumption during the year, and the remainder entered bonded warehouses.

[2] Comprises ore received during the year for immediate consumption plus material withdrawn from bonded warehouses; excludes imports for manufacture in bond and export.

[3] Effective July 1960; formerly Belgian Congo.

[4] Adjusted by Bureau of Mines, believed to be Ivory Coast.

[5] In 1960, general imports of ore classified as battery and chemical grades totaled 162,768 short tons averaging 51 percent manganese. Of this quantity 47,861 short tons from Morrocco, 45,519 short tons from Ghana, 28,501 short tons from Greece, 18,432 short tons from India, 7,408 short tons from Cuba, 5,415 short tons from Union of South Africa, 4,322 short tons from Republic of the Congo and Ruanda-Urundi, 2,238 short tons from Federation of Rhodesia and Nyasaland, 2,161 short tons from Angola, 760 short tons from Chile, and 151 short tons from Philippines. Imports for consumption of battery and chemical grades in 1960 totaled 133,629 short tons valued at $7,239,142 or $54.17 per short tons f.o.b. foreign ports. Of this total Morrocco supplied 47,861 short tons ($2,906,888); Ghana, 38,125 short tons ($2,338,913); India, 18,432 short tons ($563,-975); Cuba, 7,408 short tons ($414,680); Greece, 6,756 short tons ($412,834); Union of South Africa, 5,415 short tons ($225,927); Republic of the Congo and Ruanda-Urundi, 4,322 short tons ($159,150); Federation of Rhodesia and Nyasaland, 2,238 short tons ($118,742); Angola, 2,161 short tons ($61,720); Chile, 760 short tons ($30,678); and Philippines, 151 short tons ($5,635).

Source: Bureau of the Census.

Manganese Alloys.—The average value, f.o.b. producers' furnaces, for ferromanganese shipped in 1960 was $212.10 per short ton, compared with $238.54 in 1959. The price of standard ferromanganese, 74 to 76 percent manganese, at eastern furnaces, carlots, opened the year at 12.25 cents per pound of alloy. On January 19 the price was cut to 11 cents per pound of alloy and remained there until the end of the year. Spiegeleisen containing 19 to 21 percent manganese opened the year at $102.50 per long ton, carlots, f.o.b. Palmerton, Pa., decreasing in January to $100.00 per long ton at which price it remained for the remainder of the year.

Manganese Metal.—The price of electrolytic manganese metal remained unchanged throughout the year at 35 cents per pound for carlots and 37 cents per pound for ton lots. These prices have continuity with previous Yearbook quotations and continued from a 1-cent-per-pound price rise effected November 1959. Hydrogen-removed metal continued to command a premium of 0.75 cent per pound throughout the year, and the premium for nitrided electrolytic manganese metal containing a minimum of 5.5 percent nitrogen was 3.5 cents per pound.

FOREIGN TRADE[3]

Imports.—The average grade of imported manganese ore was 47.7 percent manganese, the same as in 1959. Brazil, providing 34 percent of the total ore received in 1960, continued to be the leading supplier; India delivered 19 percent; Ghana, 13 percent; Union of South Africa, 11 percent; Mexico, 7 percent; and Republic of the Congo, 6 percent. General imports of ore containing more than 10 percent and less than 35 percent manganese totaled 28,842 short tons, of which 26,154 tons came from Ghana and 2,688 tons from Mexico; imports for consumption consisted only of the Mexican tonnage.

Ferromanganese imports for consumption, increasing 33 percent over 1959, included Government acquisitions. The total manganese content of imports for consumption classified as "manganese silicon (includes silicon manganese)" was 10,046 short tons. This was broken down as follows: Norway, 3,198 tons; Japan, 2,141 tons; Italy, 1,443 tons; Belgium-Luxembourg, 1,086 tons; Chile, 825 tons; Spain, 618 tons; Yugoslavia, 598 tons; West Germany, 98 tons; and Canada, 39 tons. Imports for consumption of manganese metal were 243 tons, all from Japan except for 8 pounds of high-purity metal from United Kingdom valued at $230. There were no spiegeleisen imports.

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 10.—U.S. imports for consumption of ferromanganese, by countries

Country	1959			1960		
	Gross weight (short tons)	Mn content (short tons)	Value	Gross weight (short tons)	Mn content (short tons)	Value
North America: Canada	127	101	$40,821	710	615	$296,670
South America: Chile	1,540	1,233	244,297	573	448	72,967
Europe:						
Belgium-Luxembourg	6,782	5,297	787,733	3,676	2,757	492,265
France	22,288	17,198	3,245,611	23,187	18,041	2,771,736
Germany, West	4,711	3,594	618,892	804	634	196,247
Italy	3,031	2,285	412,532	1,995	1,611	412,745
Norway	16,137	12,780	2,626,543	2,879	2,232	432,949
Spain	------	------	------	1,837	1,422	231,262
Sweden	1,323	1,005	175,911	------	------	------
United Kingdom	------	------	------	1,121	852	168,080
Yugoslavia	5,997	4,726	877,201	4,998	3,950	627,785
Total	60,269	46,885	8,744,423	40,497	31,499	5,333,069
Asia:						
India	5,547	4,143	721,075	37,105	27,850	6,374,379
Japan	22,579	17,870	4,316,563	30,017	23,328	5,523,179
Total	28,126	22,013	5,037,638	67,122	51,178	11,897,558
Africa: Union of South Africa	------	------	------	11,320	8,854	1,408,059
Grand total	90,062	70,232	14,067,179	120,222	92,594	19,008,323

Source: Bureau of the Census.

Exports.—Ferromanganese exports totaled 751 short tons valued at $202,000, compared with 947 tons in 1959 valued at $388,000. This export classification includes silicomanganese. Exports classified as "manganese metal and alloys in crude form and scrap", believed to be almost entirely electrolytic manganese metal, were 2,430 tons valued at $1,501,000, compared with 1,260 tons valued at $752,000 in 1959, and 586 tons valued at $300,000 in 1958. Exports of spiegeleisen in 1960 were 148 tons valued at $15,000, all going to Canada. Exports classified as "manganese ores and concentrates, containing 10 percent or more manganese" totaled 5,139 tons valued at $719,000, compared with 5,702 tons valued at $819,000 in 1959. This export classification includes "manganese dioxide ore, chemical, for manufacture of dry cells," "manganite," and "silicon manganese ore." These reported ore exports are believed to consist almost entirely of imported manganese ore, in large part of battery-grade, which was exported from the United States after grinding, blending, or otherwise classifying.

Tariff.—Duty on manganese ore continued at ¼ cent per pound of contained manganese with ore from Cuba and the Philippines exempt from duty, and ore from the U.S.S.R. and certain neighboring countries dutiable at 1 cent per pound of contained manganese.

TABLE 11.—World production of manganese ore by countries [1 2]

Country [1]	Percent Mn [3]	1951–55 (average)	1956	1957	1958	1959	1960
North America:							
Cuba	36–50+	260,743	[4] 268,810	[4] 160,967	[4] 74,636	[4] 58,806	[5] 17,644
Mexico	30+	177,976	[3] 171,000	[3] 220,000	[3] 187,400	[3] 181,900	[3] 171,400
Panama	44+	----------	----------	2,154	4,489	----------	----------
United States (shipments)	35+	174,261	344,735	366,334	327,309	229,199	80,021
Total	---------	612,980	784,545	749,455	593,834	469,905	269,065
South America:							
Argentina	30–40	7,389	9,682	11,154	14,628	17,494	[3] 16,500
Brazil	38–50	233,512	342,645	1,011,939	972,413	1,068,415	[4] 942,205
British Guiana	40	----------	----------	----------	----------	----------	137,454
Chile	40–50	50,283	51,878	59,724	42,061	42,744	[3] 66,100
Peru	40+	4,242	11,826	16,917	3,242	1,262	1,905
Venezuela	38+	----------	10,318	32,930	9,039	3,955	----------
Total	---------	295,426	426,349	1,132,664	1,041,383	1,133,870	1,164,164
Europe:							
Bulgaria	30+	[6] 35,715	84,657	89,600	[3] 88,200	[3] 88,200	[3] 88,200
Greece	35+	20,184	8,695	17,545	22,046	33,069	38,581
Hungary	30+	112,309	[3] 94,000	[3] 132,000	[3] 132,000	[3] 132,000	[3] 132,000
Italy	30–	47,741	51,697	51,976	48,588	57,138	51,738
Portugal	35+	9,905	3,508	6,035	5,485	7,703	[3] 7,700
Rumania	35	184,027	259,054	292,402	220,755	216,910	[3] 209,400
Spain	30+	35,651	36,100	45,622	40,267	44,924	24,828
U.S.S.R.[7]	---------	4,959,100	5,443,200	5,674,700	5,915,000	6,080,300	[3] 6,393,400
Yugoslavia	30+	4,850	[3] 5,500	[3] 4,400	11,060	8,900	14,700
Total [1]	---------	5,409,482	5,986 411	6,314,280	6,483,401	6,669,144	[3] 6,960,600
Asia:							
Burma	35+	4,718	1,287	506	1,405	606	324
China [3]	---------	187,500	580,000	770,000	935,000	1,100,000	1,380,000
India	35+	1,714,383	1,946,126	1,852,701	1,406,652	1,308,919	1,267,657
Indonesia	35–49	22,623	118,858	59,338	48,909	40,515	12,026
Iran [8]	36–46	5,331	6,614	2,205	660	2,425	[3] 2,400
Japan	32–40	209,865	314,175	318,497	326,269	383,699	355,696
Korea, Republic of	30–48	3,921	2,158	3,533	287	495	1,521
Malaya	60	----------	----------	----------	----------	----------	3,222
Philippines	35–51	18,912	4,866	33,324	24,590	38,365	19,159
Portuguese India	32–50+	129,819	222,686	161,347	86,078	76,376	56,263
Thailand	40+	----------	450	381	1,100	452	582
Turkey	30–50	70,953	66,966	62,522	24,920	39,341	31,112
Total [3]	---------	2,368,000	3,264,000	3,264,000	2,856,000	2,991,000	3,130,000
Africa:							
Angola	38–48	50,793	29,647	23,518	38,499	39,314	25,728
Bechuanaland	50+	----------	----------	243	14,213	20,507	13,912
Congo, Republic of the (formerly Belgian)	48+	278,266	363,250	404,572	372,741	425,694	[3] 429,900
Ethiopia	51	----------	----------	----------	----------	[3] 1,500	1,683
Ghana (exports) [9]	48	749,525	712,154	718,306	574,672	589,853	600,261
Ivory Coast	48	----------	----------	----------	----------	----------	68,343
Morocco:							
Northern zone	50	1,709	1,795	732	----------	----------	----------
Southern zone	35–50	449,541	461,470	541,772	452,041	518,711	532,508
Rhodesia and Nyasaland, Federation of:							
Northern Rhodesia	30+	10,214	40,760	39,703	49,383	63,070	64,298
Southern Rhodesia	48+	585	816	1,785	2,512	2,126	1,676
South-West Africa	45+	30,610	57,262	89,661	103,049	49,442	67,439
Sudan [3]	36–44		7,700	8,800	6,600	440	----------
Union of South Africa	40+	827,060	768,395	787,878	934,097	1,069,196	1,316,124
United Arab Republic (Egypt region) [10]	57	4,319	5,087	10,315	48,730	67,318	[3] 104,700
Total	---------	2,402,622	2,448,336	2,627,285	2,596,537	2,847,171	[3] 3,226,600

See footnotes at end of table.

TABLE 11.—World production of manganese ore by countries [1] [2]—Continued

Country [1]	Percent Mn [3]	1951-55 (average)	1956	1957	1958	1959	1960
Oceania:							
Australia	45-48	27,672	66,510	86,153	66,845	100,241	[3] 68,300
Fiji	40+	[4] 7,196	25,067	38,858	20,503	14,566	13,073
New Caledonia	45+	9,362					
New Zealand	48+	315	175	41	116	114	[3] 110
Papua		23	14				54
Total		44,568	91,766	125,052	87,464	114,921	[3] 81,500
World total (estimate) [1]		11,133,000	13,001,000	14,213,000	13,659,000	14,226,000	14,832,000

[1] In addition to the countries listed, Czechoslovakia and Sweden report production of manganese ore (approximately 15 to 17 percent manganese content), but since the manganese content averages less than 30 percent, the output is not included in this table. Czechoslovakia averages 220,000 short tons annually and Sweden, approximately 16,500 tons.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Exports.
[5] United States imports.
[6] Average for 1952–55.
[7] Grade unstated. Source: The Industry of the U.S.S.R., Central Statistical Adminstration (Moscow).
[8] Year ending March 20 of year following that stated.
[9] Dry weight.
[10] In addition to high-grade ore shown in the table, Egypt produced the following tonnages of less than 30 percent manganese content: 1951–55 (average), 220,499; 1956, 215,761; 1957, 83,957; 1958, 74,303; 1959, 72,752; and 1960, 159,800 (estimated).

Compiled by Pearl J. Thompson, Division of Foreign Activities.

WORLD REVIEW

NORTH AMERICA

Cuba.—The 200-ton-per-day manganese sinter plant formerly used by Mohave Mining and Milling Co. near Wickenburg, Ariz., was reported sold to the Cuban Government in the early part of 1960.[4] The Minister of Agriculture stated on a Cuban television program on March 10 that: The Cuban Government would install three plants at Santiago so that 400 tons of manganese ore a day would be sintered by June; sintering capacity of 1,000 tons per day was planned by 1962; the Charco Redondo mine was producing 140 tons of manganese ore a day, planning to increase to 300 tons in June; and the value of this crude ore was $24 per ton without an assured market, whereas the value of sinter was $44 per ton with much better market prospects.[5] According to the Cuban press, Industria Minera de Felton shipped 2,000 tons of manganese ore to Czechoslovakia on November 8.[6] A trade agreement signed early in the year provided for export of manganese and other ores to Poland.[7]

Mexico.—On May 15, 1960, Ferroaleaciones de Mexico, S.A., started its new plant for producing ferromanganese and other ferroalloys at Estacion Banda, near Gomez Palacio, Durango. The company, incorporated some 20 months previously, was controlled by the same group of Mexican capitalists who controlled the large steel company, Fundidora de Fierro y Acero de Monterrey, S.A. A minority interest

[4] Western Mining and Industrial News, vol. 28, No. 6, June 1960, p. 9.
[5] U.S. Embassy, Havana, Cuba, State Department Dispatch G–219: Mar. 15, 1960, 2 pp.
[6] U.S. Embassy, Havana, Cuba, State Department Dispatch 1072: Nov. 9, 1960, 1 p.
[7] Mining Journal (London), vol. 254, No. 6504, Apr. 15, 1960, p. 438.

in the new company was reported held by Continental Ore Corp., New York. One 7,500 kw.-hr. electric furnace will produce ferromanganese, silicomanganese, and ferrosilicon, with annual alloy production exceeding 11,000 short tons. Fundicion de Acero Electrico, subsidiary of The Teziutlan Copper Co., continued to produce ferroalloys at Teziutlan, Puebla.[8]

SOUTH AMERICA

Brazil.—Allocation of railway cars for transportation of manganese ores for export was taken away from the ore producers association. The Government regulation responsible for this action permitted procurement of cars for ore for domestic use by standard requisition, thus giving priority for such shipments over those for export.[9] Brazilian manganese ore exports in 1960 totaled 942,000 tons, of which 64,000 tons was shipped from Urucum and 27,000 tons from Rio de Janeiro.[10] The only manganese ore exported from Bahia in 1960, according to quarterly reports, was 12,000 short tons destined for Poland.[11] Most of the 838,000 short tons of manganese ore exported from Amapa in 1960 went to the United States, but shipments also were made to United Kingdom, Poland, and France to the extent of 54,000 tons. In addition, a small shipment was made to Santos, Brazil.[12] Total shipments from Amapa in 1959 were 830,000 short tons, all of which went to the United States except for two small shipments to southern Brazil.[13] In 1958, Brazil produced 12,000 tons of ferromanganese and 3,000 tons of silicomanganese.[14] Ore from the Urucum deposits of western Brazil began to be received in the United States early in 1960, and exports of manganese ore from Minas Gerais were curtailed by administrative action and the voluntary action of producers. Amapa manganese ore was one of the strategic materials bartered by CCC for wheat.

British Guiana.—A mine camp, a simple crushing and washing plant (screens), and a 38-mile, 3-foot 6-inch gage railroad were constructed for the Arakaka manganese deposits at Matthews Ridge, on the Barima River, where an open-pit mine was developed to production. The mining lease for these deposits and for the Pipiani deposit (also in northwestern British Guiana) on the Barama River was granted in 1955 to Northwest Guiana Mining Co., Ltd., subsidiary of Union Carbide Corp. The deposits are residual, derived from manganiferous beds occurring in bedded Precambrian tuffs. Actual development, in unpopulated jungle, has been directed by African Manganese Co., Ltd. (Mines Management). The railroad was built from the washing plant near Arakaka to tidal water on the Kaituma River

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[8] U.S. Consulate General, Monterrey, Mexico, State Department Dispatch 74: Mar. 2, 1961, 2 pp.
[9] U.S. Embassy, Rio de Janeiro, Brazil, State Department Dispatch 978: Apr. 7, 1960, 2 pp.
[10] U.S. Embassy, Rio de Janeiro, Brazil, State Department Dispatch 953: Apr. 26, 1961, 2 pp.
[11] U.S. Consulate, Salvador, Brazil, State Department Dispatch 35: Jan. 31, 1961, p. 2.
[12] U.S. Consulate, Belem, Brazil, State Department Dispatch 20: Jan. 5, 1961, 1 p.
[13] U.S. Consulate, Belem, Brazil, State Department Dispatch 15: Jan. 13, 1960, 1 p.
[14] U.S. Embassy, Rio de Janeiro, Brazil, State Department Dispatch 1044: Apr. 28, 1960, p. 7 Encl. 1, p. 2 Encl. 2.

at Port Kaituma, where loading facilities and a ship-turning basin were constructed for shallow-draft boats of approximately 3,000-ton capacity. The waterway for these ore carriers was developed down the Kaituma to its junction with the Barima, thence down the Barima and out through the Mora Passage to the mouth of the Waini, still within British Guiana, and on to Trinidad [15] for transhipment to ocean vessels by Chaguaramas Terminals Ltd., a subsidiary of Aluminium, Ltd.[16] Ore shipments began to arrive in the United States in December.

Chile.—Manganese ore exports in 1960 were 22,300 short tons, of which 97 percent went to the United States and the remainder to West Germany. Exports of ferromanganese were 3,400 tons, of which 53 percent went to Columbia and the rest to Peru, United States, and Argentina. Silicomanganese exports amounted to only 800 tons, two-thirds of which went to the United States and the remainder to Venezuela.[17] In the later part of the year, negotiations were under way between the U.S. Department of Agriculture and the Government of Chile for proposed barter procurement by the former of 36,000 short tons of ferromanganese to be produced in Chile.

Peru.—All the manganese ore exported in 1959, approximately 1,500 short tons containing 42 percent manganese, went to the United States. Mina Gran Bretana was the chief producer in 1959. Small shipments of ore, containing 56 percent manganese and 3 percent zinc, were made from Eduardo Busso's prospect near the Perene River in east central Peru some 20 kilometers east of La Merced. This ore was reported to occur in jungle country as lenses along the contact between granite and marbleized limestone,[18] and was believed to have possibilities as a battery ore. Other deposits in the immediate area were reported to suggest larger tonnages of metallurgical ore of lower manganese and acceptable base metal contents.

Venezuela.—By decree of February 5, 1960, the entire territory of Venezuela was declared to be a national reserve insofar as the exploration and exploitation of manganese ores was concerned.[19] The Government cancelled 21 or approximately two-thirds of the existing manganese concessions because of failure to begin development within the specified period and suspension of mining operations during 2 consecutive years.[20]

EUROPE

France.—In 1959, imports of manganese ore totaled 694,000 short tons, of which 682,000 tons was metallurgical grade, and 12,000 tons was chemical grade. Morocco supplied 287,000 tons; India, 160,000 tons; U.S.S.R., 122,000 tons; and the Union of South Africa, 103,000 tons. Production of ferromanganese in 1959 was 259,000 tons; spiegeleisen, 149,000 tons.[21] China supplied manganese ore to France in 1960.

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[15] World Mining, vol. 13, No. 4, April 1960, pp. 32–33.
[16] American Metal Market, vol. 67, No. 112, June 13, 1960, p. 5.
[17] U.S. Embassy, Santiago, Chile, State Department Dispatch 606: Mar. 21, 1961, p. 2, p. 1 Encl. 3.
[18] U.S. Embassy, Lima, Peru, State Department Dispatch 653: May 4, 1960, pp. 10, 15.
[19] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 4, April 1960, p. 3.
[20] E&MJ Metal & Mineral Markets, Vol. 31, No. 44, Nov. 3, 1960, p. 3.
[21] Bureau of Mines, Mineral Trade Notes: Vol. 52, No. 4, April 1961, p. 33.

Greece.—Exports of manganese ore in 1959 totaled 33,000 short tons, of which 27,000 went to the United States, 3,000 to France, 1,600 to West Germany, 1,100 to Great Britain, and 400 to the Netherlands.[22] Battery-grade ore was delivered to the United States under its agricultural barter program.

Italy.—No manganese metal was produced in 1958 or 1959. Manganese ferroalloy production in short tons for these 2 years was as follows:

Year	Refined ferro-manganese	Carbon ferro-manganese	Silico-manganese	Spiegel-eisen	Silico-spiegel-eisen
1958	2,000	27,600	14,800	24,400	3,500
1959	4,200	21,100	24,000	4,300	300

Imports and exports in short tons for the 2 years were as follows:

Year	Manganese Metal (minimum 90 percent Mn)		Spiegeleisen (15 to 25 percent Mn)		Ferromanganese (25 to 90 percent Mn)		Ferrosilico-manganese	
	Imports	Exports	Imports	Exports	Imports	Exports	Imports	Exports
1958	33	----------	4,900	----------	19,800	360	2,100	----------
1959	92	----------	2,500	160	20,200	2,200	2,000	5,800

Italian production of ferruginous manganese ore stopped in 1958 because of increasing zinc content and was not resumed in 1959. Production in 1958 was 9,500 short tons, averaging 16.7 percent manganese, coming entirely from the Monte Argentario mine of Ferromin.[23]

Spain.—Production of ferromanganese in 1959 totaled 31,000 short tons.[24]

U.S.S.R.—Soviet exports of manganese ore in 1959 totaled 1,080,000 short tons and were distributed as follows: Poland, 290,000 tons; East Germany, 196,000 tons; France, 118,000 tons; United Kingdom, 116,000 tons; West Germany, 110,000 tons; Czechoslovakia, 104,000 tons; Norway, 42,000 tons; Sweden, 30,000 tons; Japan, 25,000 tons; Austria, 18,000 tons; Yugoslavia, 17,000 tons; and Italy, 14,000 tons. Exports of peroxide manganese ore, presumably battery grade, totaled 9,500 short tons, of which East Germany received 2,800 tons; Netherlands, 2,500 tons; Czechoslovakia, 1,100 tons; Poland, 900 tons; Finland, 550 tons; and the remainder was unaccounted. Exports of ferromanganese were 56,000 tons; and of silicomanganese, 1,000 tons.[25]

Yugoslavia.—Manganese ore was among a number of materials fixed free of import duty.[26]

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[22] U.S. Embassy, Athens, Greece, State Department Dispatch 673: Feb. 1, 1961, p. 2, Encl. 1, p. 6, Encl. 1.
[23] U.S. Embassy, Rome, Italy, State Department Dispatch 590: Dec. 30, 1960, p. 21, Encl. 1.
[24] U.S. Embassy, Madrid, Spain, State Department Dispatch 833: June 8, 1960, p. 4.
[25] Bureau of Mines, Mineral Trade Notes: Vol. 51, No. 3, Special Supp. 60, September 1960, 72 pp.
[26] U.S. Embassy, Belgrade, Yugoslavia, State Department Dispatch 555: Feb. 27, 1961, p. 4, Encl. 1.

ASIA

India.—Effective February 15, manganese ore royalty rates were reduced to levels prevailing before June 1958. This was a reduction from 12.5 to 7.5 percent of the sale price at the pit mouth for ore that contained 45 percent or more manganese and from 10 to 5 percent for ore that contained less than 45 percent manganese. Manganese dioxide, however, had a separate rate, fixed by regulation at 15 percent of pit-mouth value.[27] On November 23, 1960, the Government of India announced that, for the 3-year period beginning January 1, 1961, manganese ore exports would continue to be on a quota basis with annual quantities equal to those permitted in the 1959–60 licensing year. This policy required that private exporters register their sales with the State Trading Corp., and that barter transactions be handled exclusively by that agency.[28] High railway freight and port handling costs were among the difficulties to be overcome in making Indian ore prices competitive with those of other producing countries—a factor in negotiations for a barter agreement to exchange Indian manganese and iron ores for West German machinery and equipment.[29] In the second quarter of 1960, high quality manganese ore was offered for export at $30.50 per ton, f.o.b. Indian port, with low-grade ore offered at $17.00.[30] In 1959, 100,000 short tons of manganiferous ore, containing less than 35 percent manganese was produced;[31] preliminary figures for 1960 were 151,000 short tons of this grade.[32] In November 1960, one of the two electric furnaces of Khandelwal Ferro Alloys, Ltd., began producing ferromanganese at the newly built plant at Khanhan, near Kamptee and 12 miles from Nagpur, in the new State of Maharashtra (formerly part of Bombay State). Indian production of ferromanganese in 1959[33] was 67,000 short tons; preliminary figures for 1960 showed an increase to 92,000 tons. Tata Iron & Steel Co., Joda, produced 32,100 tons in 1959 and 20,100 tons in 1960; Ferro Alloys Corp., Garivadi, 14,600 and 37,000 tons, respectively; Electro Metallurgical Works, Dandeli, 9,500 and 10,000 tons; Jeypore Sugar Co. (Jeypore Mining Syndicate), Rayagada, 6,200 and 13,400 tons; Cambatta Ferro-Manganese Private, Ltd., Tumsar, 3,400 and 9,600 tons; Mysore Iron and Steel Works, Bhadravati, 1,500 tons in 1959 and none in 1960; and Khandelwal Ferro Alloys Ltd., Khanhan, 1,700 tons in 1960. Exports of ferromanganese in 1960 totaled 48,000 short tons, of which 97 percent went to the United States, whereas final 1959 figures showed 9,000 tons exported in that year, of which 75 percent went to the United States. Estimated domestic consumption in 1960 was 39,000 tons. Details of the much-publicized Indo-U.S. agricultural barter agreement were completed early in 1960; India agreed to supply 125,000 short tons of standard ferromanganese and 168,000 tons of manganese ore. Of the ore, 73,000

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[27] U.S. Embassy, New Delhi, India, State Department Dispatch 883: Mar. 24, 1960, p. 1, p. 1, Encl. 1.
[28] Bureau of Mines, Mineral Trade Notes: Vol. 52, No. 3, March 1961, pp. 23–25.
[29] Mining World, vol. 22, No. 12, November 1960, p. 78.
[30] U.S. Embassy, New Delhi, India, State Department Dispatch 96: Aug. 2, 1960, p. 8.
[31] U.S. Embassy, New Delhi, India, State Department Dispatch 1006: Apr. 25, 1960, p. 2, Encl. 1.
[32] U.S. Embassy, New Delhi, India, State Department Dispatch 1121: Apr. 28, 1961, pp. 1–3, Encl. 1.
[33] U.S. Embassy, New Delhi, India, State Department Dispatch 50: July 15, 1960, p. 40, Encl. 1.

tons was to be converted to ferromanganese in the United States and the remainder, in third countries. Prices of $229.60 per short ton, placed aboard railroad cars, c.i.f. eastern U.S. ports, were agreed to for the ferromanganese, and $0.90 per long ton unit, delivered foreign port including discharge, for ore of 46 to 48 percent manganese content. Delivery of the Indian-produced ferromanganese to the United States was to be completed by March 31, 1961, and ore to third countries for conversion by May 1, 1961.

The Geological, Mining and Metallurgical Society of India held a symposium on Indian iron and manganese ores in May 1960, for which 61 papers were contributed, covering distribution and geology of deposits, uses, trade, beneficiation, and economics.[34] The possibilities for producing electrolytic manganese metal in India were being investigated in 1960. The principal prospective market was reported to be the Government of India mint, which was making coins of 12 percent manganese content. Annual requirements of the mint were placed at 4,000 tons.[35]

Indonesia.—Virtually all manganese-ore-mining activities were taken over by the Government early in 1960.[36] In August a joint State concern was established by the central and regional governments for exploiting manganese on Java, and a tentative decision was made to erect a manganese-processing plant at Tjilatjap on the south coast.[37]

Japan.—According to the Japan Ferroalloy Producers Association, production of ferroalloys for the fiscal year ended March 1961 included 131,000 short tons of high carbon ferromanganese, 22,000 tons of medium carbon ferromanganese, 11,000 tons of low carbon ferromanganese, 98,000 tons of silicomanganese, and 4,700 tons of manganese metal.[38]

Malaya.—Eastern Minerals and Trading, Ltd. (1959), began mining manganese ore of high manganese content in October 1960 at Gual Perick, Kelantan, on the railroad some 5 miles from the Thailand border. Earlier, battery-grade ore was reported to have been discovered near the Perak-Kedah boundary.[39]

Philippines.—Although six firms shipped manganese ore in 1959, this ore was purchased mostly from small claim owners or from contractors working the shipper's property. General Base Metals, Inc., experimented with a process to produce from its ores a high-quality chemical-grade manganese dioxide suitable for use in dry-cell batteries, and a small pilot plant was under construction.[40] A promising discovery of high grade manganese ore associated with a copper deposit was being diamond-drilled by Acoje Chromite (Acoje Mining Co.) at Dimakawal in the jungle of east central Luzon.[41]

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[34] Journal of Mines, Metals and Fuels (Calcutta): Vol. 8, No. 6, June 1960, pp. 22–24.
[35] U.S. Consulate, Madras, India, State Department Dispatch 30: July 21, 1960, pp. 1–2.
[36] U.S. Embassy, Djakarta, Indonesia, State Department Dispatch 76: Aug. 1, 1960, p. 13.
[37] U.S. Embassy, Djakarta, Indonesia, State Department Dispatch 513: Jan. 10, 1961, p. 16.
[38] American Metal Market, vol. 68, No. 85, May 4, 1961, p. 19.
[39] Bureau of Mines, Mineral Trade Notes: Vol. 52, No. 6, June 1961, p. 26.
[40] U.S. Embassy, Manila, Philippine Islands, State Department Dispatch 653: June 21, 1960, pp. 19, 21, 50–53.
[41] Mining World, vol. 22, No. 9, August 1960, pp. 28–29.

Portuguese India.—Preliminary figures indicated that 37,000 short tons of manganese ore and 137,000 short tons of ferruginous manganese ore were exported in 1960.[42]

Turkey.—Thirteen private operators mined manganese ore in 1959. Exports for that year totaled 23,000 short tons, of which Yugoslavia received 6,800 tons; Spain, 5,900 tons; United States, 4,100 tons; France, 2,600 tons; Czechoslovakia, 1,700 tons; Italy, 1,200 tons; and United Kingdom, 700 tons. Imports of ferromanganese in 1959 were 280 tons, compared with 150 in 1958.[43] The Karabuk steel plant made 2,100 tons of ferromanganese in 1958 but none in 1959. In the latter year, the plant consumed 1,600 tons of ferromanganese in its open hearths and 9,600 tons of manganese ore as blast furnace burden.[44]

AFRICA

Angola.—Of the 43,000 short tons of manganese ore exported in 1959, 41,000 tons was shipped from the port of Luanda and 2,500 tons from Lobito; 1958 shipments of 9,400 tons were all through Luanda; and 1957 exports of 26,000 tons were 23,000 tons from Luanda and 2,800 tons from Lobito. Manganiferous ore production in 1959 was 3,500 tons, with none exported; 15,000 tons was produced in 1958 with 550 tons exported from Luanda; 32,000 tons was produced in 1957 with 43,000 tons exported from Luanda and 1,100 tons from Lobito.[45] Shippers had been handicapped by a shortage of rolling stock on the Luanda Railroad, but purchases of gondolas and widening of the gage in 1960 were expected to ease the shortage.[46] Increased shipments of Katanga (Congo) manganese ore and other mineral products through Angola to the port of Lobito resulted in a shortage of cars on the Benguela Railroad.[47] Late in 1960, the Portuguese Government approved a government-guaranteed $45,448,000 contract between Friedrick Krupp of Essen (West Germany), Hjgaard and Schultz A/S (Denmark), Soc. de Empreitados e Trabalhos Hidraulicos (Portugal), and Cia. Mineira do Lobito and subsidiary (Soc. Mineira Lombige) to construct rail lines and port facilities to aid export of iron and manganese ores.[48]

Bechuanaland.—Two manganese mines operated in 1960, one near Ootse and the other at Kgwakgwe in the Bangwaketse Tribal Zone. The latter placed a heavy-medium separation plant in operation.[49]

Ghana.—African Manganese Co., Ltd., conducted a vigorous exploration program. Either a steel mill or a ferromanganese plant was reported to be under consideration in the Ghana-U.S.S.R. technical assistance agreement of December 1960.[50] Metallurgical-grade man-

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[42] U.S. Embassy, Lisbon, Portugal, State Department Dispatch 376: Apr. 25, 1961, p. 1, Encl. 1.
[43] U.S. Embassy, Ankara, Turkey, State Department Dispatch 125: Aug. 25, 1960, pp. 24–26.
[44] U.S. Embassy, Ankara, Turkey, State Department Dispatch 609: Mar. 15, 1960, p. 5.
[45] U.S. Consulate, Luanda, Angola, State Department Dispatch 246: May 2, 1960, pp. 1–3, p. 1 Encl 1, p. 1 Encl. 2.
[46] U.S. Consulate, Luanda, Angola, State Department Dispatch 170: Jan. 12, 1961, p. 2; State Department Dispatch 224: Mar. 30, 1961, p. 11.
[47] Bureau of Mines, Mineral Trade Notes: Vol. 52, No. 1, January 1961, p. 38.
[48] U.S. Consulate, Luanda, Angola, State Department Dispatch 146: Dec. 21, 1960, 3 pp.
[49] Mining Magazine (London), vol. 104, No. 4, April 1961, p. 232.
[50] U.S. Embassy, Accra, Ghana, State Department Dispatch 450: Jan. 10, 1961, p. 5.

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ganese ore was delivered to the United States under the agricultural barter program.

Ivory Coast.—Exports of manganese ore in 1960 were 40,000 short tons.[51]

Morocco.—Production of chemical-grade manganese ore in 1960 was 104,000 short tons, all of which came from the Imini mine except for 680 tons from the Arbalou deposit, 590 tons from the Boulbab, and 50 tons from Bou Arfa. Production of metallurgical-grade ore was 429,000 tons, including 149,000 tons of sinter of 56 percent manganese content produced at Sidi Marouf from 180,000 tons of Imini ore and 32,000 tons of 33 percent manganese content sintered at Bou Arfa from 46,000 tons of Bou Arfa ore.[52] Of the chemical-grade ore produced in 1959, 86,000 tons was from Imini, 1,000 tons from Arbalou, 200 tons from Boulbab, 70 tons from Timedras, and 60 tons from the Hamarouet deposit of Société des Mines de Bou Arfa.[53] Société Anonyme Chérifienne d'Etudes Minieres (SACEM), a subsidiary of Cie. Mokta El Hadid, operated the Imini mine. The Moroccan Government purchased a 40-percent interest in SACEM. Imini ore was trucked across the Atlas Mountains to Marrakeech and from there by rail to the sinter plant at Sidi Marouf. A search for new deposits continued in the Imini area with possibilities for a railway over the Atlas Mountains should results of exploration warrant it. Exports of chemical-grade ore in 1959 were 85,000 short tons with the following distribution: United States, 63,000 tons; France, 11,000 tons; West Germany, 4,200 tons; United Kingdom, 3,700 tons; and Netherlands, 2,700 tons. Metallurgical-grade exports in 1959 were 159,000 short tons and were distributed as follows: France, 124,000 tons; Norway, 19,000 tons; Italy, 8,300 tons; United States, 6,200 tons; and Yugoslavia, 1,700 tons.[54] Plans for a plant in northeastern Morocco, capable of producing 22,000 tons per year of ferromanganese and 180,000 tons of steel, proposed use of manganese ore from Bou Arfa.[55]

Rhodesia and Nyasaland, Federation of.—Of 1959 manganese ore production in Northern Rhodesia, 28 percent came from the Kampumba mine and 16 percent from the Chiwefwe mine; both mines belonged to Gypsum Industries, Ltd. The Mashimba mine of Rhodesian Vanadium Corp., in the Fort Rosebery district, supplied 25 percent of the output. Manganese ore exports in 1959 totaled 59,000 short tons; the United States took 87 percent.[56] Average grade of manganese ore produced in Northern Rhodesia was 47.4 percent manganese in 1959;[57] and 47.9 percent in 1960.[58]

Union of South Africa.—Manganese ore production in 1960 was as follows: 40 percent manganese and less, 769,000 short tons; 40 to 45

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[51] U.S. Embassy, Abidjan, Ivory Coast, State Department Dispatch 157: Mar. 9, 1961, p. 5 Encl. 1, p. 1 Encl. 4.

[52] U.S. Consulate General, Casablanca, Morocco, State Department Dispatch 203: May 9, 1961, pp. 2–3 Encl. 1, p. 1 Encl. 4.

[53] U.S. Consulate General, Casablanca, Morocco, State Department Dispatch 36: Aug. 25, 1960, p. 2, Encl 1.

[54] Bureau of Mines, Mineral Trade Notes: Vol. 52, No. 1, January 1961, pp. 30–31.

[55] Mining Journal (London), vol. 255, No. 6524, Sept. 2, 1960, p. 259.

[56] U.S. Consulate General, Johannesburg, Union of South Africa, State Department Dispatch 57: Aug. 29, 1960, p. 12.

[57] U.S. Consulate General, Salisbury, Southern Rhodesia, State Department Dispatch 669: Apr. 29, 1960, p. 1, Encl. 2.

[58] U.S. Consulate General, Johannesburg, Union of South Africa, State Department Dispatch 345: Apr. 24, 1961, p. 1, Encl. 1.

percent, 320,000 tons; 45 to 48 percent, 170,000; and over 48 percent, 58,000. The corresponding figures for local sales in 1960 were 272,000 short tons, 251,000 tons, 50,000 tons, and 24,000 tons, respectively. Exports in 1960 totaled 895,000 tons;[59] in 1959, exports of 452,000 tons averaged 40.6 percent manganese.[60] Unexpected ferruginous areas in the manganese ores at the new Hotazel mine of South African Manganese, Ltd., resulted in more development work and less production than planned. Although production continued from the company properties near Lohathla, the higher grade ores were becoming more difficult to obtain there. Considerable quantities of lower grades of ore, which had been held in company stockpiles, were sold.[61] Electrolytic Metal Corp. (Pty.), Ltd., operated a small plant that made electrolytic manganese metal from the effluent of the uranium mill at the West Rand Consolidated gold mine, Krugersdorp, Transvaal. The product was exported to Europe.[62]

United Arab Republic (Egypt Region).—Since sequestration of the Sinai manganese properties (1956–57) through the end of 1959, efforts to regain markets were concentrated on sales of high grade ore analyzing as high as 95 percent manganese dioxide. The lower grade (21 percent manganese) ores of the deposit were bypassed or stockpiled. In 1960 a substantial quantity of the lower grade ores was sold to Europe, and attempts were made to return to the market a "Spanish grade" blend of 48 percent manganese content. Of the 1959 exports of 179,000 short tons of all grades, 76,000 tons was sold to the Netherlands and 26,000 tons to the United States. Sinai Manganese Co., an affiliate of the Economic Development Organization, expanded its operations to include mining gypsum, kaolin, and glass-sand deposits, but manganese mining continued to be its principal activity. The manganese and manganiferous ores were transported by overhead-bucket conveyor and narrow gage railway to the dock at Abu Zeneima; ores from new developments were trucked to the head of the bucket line. Approval was given for constructing a concentrator, electric powerplant, and salt-water distillery at Abu Zeneima. Plans called for the powerplant to use waste gases from a nearby oilfield.[63] A reequipment program for the company resulted in placing orders with British firms for mining plant, transportation equipment, and spare parts.[64]

OCEANIA

Australia.—Manganese ore production in 1960 came mainly from Western Australia, and the bulk was exported, Japan was an important buyer. Most of the newly discovered deposits of Western Australia proved too high in iron content for marketing.[65]

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[59] U.S. Consulate General, Johannesburg, Union of South Africa, State Department Dispatch 358: May 4, 1961, p. 2.
[60] U.S. Consulate General, Johannesburg, Union of South Africa, State Department Dispatch 233: Mar. 14, 1960, p. 3.
[61] South African Mining and Engineering Journal (Johannesburg), vol. 71, No. 3538, Nov. 25, 1960, pp. 1393–1394.
[62] U.S. Consulate General, Johannesburg, Union of South Africa, State Department Dispatch 145: Nov. 21, 1960, 1 p.
[63] U.S. Embassy, Cairo, United Arab Republic, State Department Dispatch 525: Jan. 11, 1961, p. 20.
[64] Mining Magazine (London), vol. 102, No. 3, March 1960, p. 194.
[65] Dunn, John A, The Australian Mineral Industry, 1960–61: Min. Chem. Eng. Review (Melbourne), vol. 53, No. 4, Jan. 16, 1961, p. 78.

TECHNOLOGY

An exhaustive compilation of thermodynamic data for manganese and its inorganic compounds was prepared at the Berkeley (Calif.) Thermodynamics Laboratory of the Federal Bureau of Mines. The published work considered all data available to May 1959 and included a bibliography.[66] In the Bureau laboratories at Bruceton, Pa., vapor pressures for liquid manganese were determined for the temperature range 1,250° to 1,550° C. The data were obtained, using a gas transport method, in the course of a general investigation of thermodynamic activities in liquid iron alloys.[67]

A Bureau report describing the results of examination of virtually all the manganese deposits of the Olympic Peninsula, Wash., 67 in number, disclosed that the ore bodies consisted for the most part of small lenses in which the manganese minerals occurred dominantly as silicates. Hausmannite (Mn_3O_4), however, was the ore mineral at the Crescent mine, the only significant ore producer of the region and the most notable exception to the usual form of occurrence.[68] California manganese deposits were cataloged; brief accounts of pertinent metallurgical tests were included.[69]

High extractions of maganese were obtained in laboratory investigations of sulfation-reduction of manganese oxides from California and Nevada low-grade or offgrade ores. Sawdust or lignin-sulfonates were used as reducing agents in place of roasting, and the procedure appeared adaptable to small deposits. The work was conducted at the Bureau's Reno (Nev.) Metallurgy Research Center.[70]

Satisfactory recoveries of manganese from mill middlings and tailings, both carbonates and oxides, were achieved in oil-emulsion flotation investigations in the laboratories of the Bureau's Albany (Oreg.) Metallurgy Research Center. Blending of feeds permitted applying the process to materials that alone proved too refractory.[71]

Albany also reported electric smelting tests which produced silicomanganese from rhodonitic raw and beneficiated material. This silicomanganese was used with highly satisfactory results in manufacturing steels at commercial plants. Hogged fuel, a waste product of the lumbering industry, was the principal reductant. It provided a bulky, porous charge, which controlled the rate of ore entry to the smelting zone and helped to attain adequate smelting temperatures. Lowest electrical energy consumption was 5,790 kw.-hr. per ton of alloy produced, comparing favorably with previously published energy-consumption figures for silicomanganese production.[72]

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[66] Mah, Alla D., Thermodynamic Properties of Manganese and Its Compounds: Bureau of Mines Rept. of Investigations 5600, 1960, 34 pp.

[67] Woolf, P. L., Zellars, G. R., Foerster, E., and Morris, J. P., Vapor Pressures of Liquid Manganese and Liquid Silver: Bureau of Mines Rept. of Investigations 5634, 1960, 10 pp.

[68] Magill, E. A., Manganese Deposits of the Olympic Peninsula, Wash.: Bureau of Mines Rept. of Investigations 5530, 1960, 82 pp.

[69] Trengove, Russell R., Reconnaissance of California Manganese Deposits: Bureau of Mines Rept. of Investigations 5579, 1960, 46 pp.

[70] Engel, A. L., and Heinen, H. J., Laboratory Treatment of California and Nevada Manganese Ores by Sulfation-Reduction and Other Methods: Bureau of Mines Rept. of Investigations 5641, 1960, 10 pp.

[71] Stickney, W. A., and Sanders, C. W., Recovering Manganese From Mill Rejects: Bureau of Mines Rept. of Investigations 5692, 1960, 11 pp.

[72] Banning, Lloyd H., Anable, Wallace E., and Hergert, William F., Experimental Electric Furnace Smelting of Siliceous Manganiferous Materials: Bureau of Mines Rept. of Investigations 5515, 1959, 16 pp.

A brief review of the more prominent manganese extractive processes was presented.[73]

Discussion of United States deposits of manganese oxides brought out the complexity of the manganese oxide minerals and the difficulties of identification. A total of 33 species was recognized. To a large extent, the work was based on mineral examinations conducted by the Geological Survey and the Bureau of Mines during World War II, and on analyses of numerous specimens collected during the course of the various examinations. Certain of the oxide minerals were concluded to be of supergene origin; another group, including hausmannite and franklinite, were always of hypogene origin; and a third group, including psilomelane, cryptomelane, pyrolusite, braunite, and manganite, appeared to have been formed by supergene processes at some localities and by hypogene processes at others. A zonal relation of the nonoxide manganese minerals, rhodochrosite, rhodonite, and alabandite, near or around bodies of base metal sulfides, was noted.[74]

Todorokite, a hydrated manganese oxide mineral formerly known only from the Todoroki mine, Hokkaido, Japan, was reported as occurring at numerous other localities and as being particularly abundant in Oriente, Cuba.[75] Other studies of manganese oxide minerals were reported.[76] Interest continued in the ocean-floor deposits of manganese oxide nodules.[77]

Chromium manganese antimonide, a brittle gray metallic compound that is not magnetic at lower temperatures, was discovered by E. I. du Pont de Nemours & Co., Inc., in its Central Research Department to acquire magnetic properties when heated to certain temperatures determined by its composition. This behavior is contrary to that of iron, manganese antimonide, and most other magnetic materials, which lose magnetism gradually as their temperature rises.[78]

A new gold alloy, containing copper, manganese, nickel, zinc, and cadmium, and as hard as steel, was reported to have been developed in the U.S.S.R. It does not oxidize nor lose its lustre, and it was hoped that it would have applications in watchmaking, jewelry, and electronics.[79]

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[73] DeHuff, Gilbert L., Manganese: Chap. in Mineral Facts and Problems, Bureau of Mines Bull. 585, 1960, pp. 507–508.

[74] Hewett, D. F., and Fleischer, Michael, Deposits of the Manganese Oxides: Econ. Geol., vol. 55, No. 1, January–February 1960, 55 pp.

[75] Straczek, J. A., Horen, Arthur, Ross, Malcolm, and Warshaw, Charlotte M., Studies of the Manganese Oxides–IV. Todorokite: Am. Mineral., vol. 45, Nos. 11–12, November–December 1960, pp. 1174–1184.

Frondel, C., Marvin, U. B., and Ito, J., New Occurrences of Todorokite: Am. Mineral., vol. 45, Nos. 11–12, November–December 1960, pp. 1167–1173.

Levinson, A. A., Second Occurrence of Todorokite: Am. Mineral., vol. 45, Nos. 7–8, July–August, 1960, pp. 802–807.

Ljunggren, Pontus, Todorokite and Pyrolusite From Vermlands, Taberg, Sweden: Am. Mineral., vol. 45, Nos. 1–2, January–February 1960, pp. 235–238.

[76] Fleischer, Michael, Studies of the Manganese Oxide Minerals–III. Psilomelane: Am. Mineral., vol. 45, Nos. 1–2, January–February 1960, pp. 176–187.

Faulring, G. M., Zwicker, W. K., and Forgeng, W. D., Thermal Transformations and Properties of Cryptomelane: Am. Mineral., vol. 45, Nos. 9–10, September–October 1960, pp. 946–959.

[77] Mero, John L., Mineral Resources on the Ocean Floor: Min. Cong. Jour., vol. 46, No. 10, October 1960, pp. 48–53.

Mero, John L., Minerals on the Ocean Floor: Sci. Am., vol. 203, No. 6, December 1960, pp. 64–72.

[78] Signal, vol. 15, No. 5, January 1961, pp. 60–61.

[79] Mining Journal (London), vol. 255, No. 6531, Oct. 21, 1960, p. 450.

Improved abrasion resistance in steel castings was said to be attained by two new austenitic manganese steels developed by Climax Molybdenum Co., Division of American Metal Climax, Inc. The addition of molybdenum permits higher carbon contents than normal for Hadfield manganese steels. One of the alloys, 12Mn–2Mo, combines toughness and abrasion resistance with high ductility; the other, 6Mn–1Mo, has exceptional abrasion resistance with only moderate ductility.[80] Jones & Laughlin Steel Corp. developed a series of manganese-molybdenum construction steels, identified as Jalloy-S, and said to combine high strength with ease of welding and forming.[81] Armco Steel Corp. announced development of a 21 percent chromium—6 percent nickel—9 percent manganese alloy steel—for use in automobile smog-control devices. The alloy meets the requirements of strength at high temperature with good corrosion resistance.[82]

Sulfur dioxide leaching of manganese from manganiferous silver ores at the Silver Peak, Nev., operations of United States Milling & Minerals Corp. permitted doubling of silver recoveries by ordinary cyanidation methods.[83]

A patent was issued to improve, by using a lower grade manganese dioxide as a catalyst, the chemical process for making synthetic battery-grade manganese dioxide by reaction of manganese sulfate and an alkali metal chlorate. The product was claimed to be equal or superior to that made by electrolytic means. Also claimed were more efficient oxidation, less reaction time, lower acid concentration, and lower temperatures than attained with previously known chlorate methods.[84]

A process was patented for recovering manganese from rhodonite by roasting with sodium carbonate under reducing conditions in the presence of a solid carbonaceous material to about 850° to 900° C. for about 1½ hours, quenching and grinding, leaching out sodium and silica at boiling temperatures, and acid-leaching the solid residue to recover manganese.[85]

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[80] American Metal Market, vol. 67, No. 134, July 14, 1960, p. 9.
[81] Journal of Metals, vol. 12, No. 11, November 1960, p. 833.
[82] American Metal Market, vol. 67, No. 201, Oct. 19, 1960, p. 11.
[83] American Metal Market, vol. 67, No. 59, Mar. 28, 1960, p. 7.
[84] Welsh, Jay Y. (assigned to Manganese Chemicals Corp., Minneapolis, Minn.), Process for Producing Manganese Dioxide: U.S. Patent 2,956,860, Oct. 18, 1960.
[85] Beam, Chester R., and Berthold, Cornelius E. (assigned to American Potash & Chemical Corp.), Process for the Recovery of Manganese Compounds From Rhodonite: U.S. Patent 2,959,477, Nov. 8, 1960.

Mercury

By H. M. Callaway [1] and Gertrude N. Greenspoon [2]

OUTPUT OF MERCURY at domestic mines, 33,200 flasks in 1960, rose 6 percent above 1959. Significant increases in California, Nevada, and Alaska more than offset declines in Idaho and Oregon. Although consumption of mercury was maintained above 50,000 flasks for the sixth consecutive year, it was 7 percent below 1959 and the lowest since 1954. Mercury imports for consumption fell sharply; the annual total was the smallest since 1947 and 35 percent less than in 1959. Despite a fairly constant price for most of 1960, the price decline in the last 5 months was enough to lower the average annual price 7 percent below 1959.

Government assistance in exploration for mercury deposits was continued through the Office of Minerals Exploration (OME). Two contracts were negotiated in 1960.

With increased output in virtually all the major mercury-producing countries, world production of mercury in 1960 rose 9 percent to 254,000 flasks, the highest annual rate since 1942.

TABLE 1.—Salient mercury statistics

	1951–55 (average)	1956	1957	1958	1959	1960
United States:						
Producing mines	61	147	120	101	71	75
Production flasks [1]	14,335	24,177	34,625	38,067	31,256	33,223
Value thousands	$3,441	$6,284	$8,552	$8,720	$7,110	$7,002
Imports:						
For consumption flasks	57,684	47,316	42,005	30,196	30,141	19,488
General do	57,132	52,009	45,449	30,973	30,260	19,515
Exports do	506	1,080	1,919	320	640	357
Reexports do	711	2,025	3,275	934	553	317
Stocks Dec. 31 do	24,818	22,310	25,388	11,274	13,580	19,761
Consumption do	50,329	54,143	52,889	52,617	54,895	51,167
Price: New York, average per flask	$231.40	$259.92	$246.98	$229.06	$227.48	$210.76
World: Production flasks	166,000	221,000	246,000	251,000	[2] 233,000	254,000
Price: London, average per flask	$225.26	$238.68	$232.36	$214.98	$208.61	$197.86

[1] Flasks as used in this chapter refers to a 76-pound flask.
[2] Revised figure.

LEGISLATION AND GOVERNMENT PROGRAMS

Through the Office of Minerals Exploration (OME) the Government participated to the extent of 50 percent of the financial risk with private industry in exploratory ventures judged capable of

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

TABLE 2.—Salient mercury statistics

(Flasks)

Year	United States						World production	United States (percent of world total)
	Production	Imports for consumption	Exports	Apparent consumption	Price			
					Average per flask at New York	Adjusted by wholesale index [1]		
1910	20,330	9	1,898	18,441	[2] $47.69	$104	107,053	19
1911	20,976	6,209	287	26,898	[2] 47.16	112	120,423	17
1912	24,734	1,088	306	25,516	[2] 43.03	96	120,650	21
1913	19,947	2,259	1,125	21,081	[2] 40.07	88	117,465	17
1914	16,330	8,090	1,427	22,993	[2] 48.95	110	108,601	15
1915	20,756	5,551	3,328	22,979	[2] 88.17	195	112,871	18
1916	29,538	5,585	8,763	26,360	[2] 127.16	229	101,544	29
1917	35,683	5,138	10,636	30,185	[2] 107.72	141	115,087	31
1918	32,450	6,631	3,057	36,024	[2] 125.12	147	99,256	33
1919	21,133	10,495	8,987	22,641	[2] 93.38	104	89,940	23
1920	13,216	13,982	1,533	25,665	[2] 82.20	82	84,470	16
1921	6,256	10,462	388	16,330	[2] 46.07	73	61,916	10
1922	6,291	16,697	287	22,701	[2] 59.74	95	91,819	7
1923	7,833	17,836	314	25,355	[2] 67.39	103	93,040	8
1924	9,952	12,996	205	22,743	[2] 70.69	111	89,138	11
1925	9,053	20,580	201	29,432	[2] 84.24	125	103,344	9
1926	7,541	25,634	114	33,061	[2] 93.13	143	115,969	7
1927	11,128	19,941	(3)	[4] 30,900	118.16	191	149,905	7
1928	17,870	14,562	(3)	[4] 32,300	123.51	196	149,083	12
1929	23,682	14,917	(3)	[4] 38,500	122.15	197	162,699	15
1930	21,553	3,725	(3)	[4] 25,200	115.01	205	108,985	20
1931	24,947	549	[5] 4,984	20,512	87.35	184	99,069	25
1932	12,622	3,886	[5] 214	16,294	57.93	138	82,644	15
1933	9,669	20,315	(3)	[4] 29,700	59.23	138	59,828	16
1934	15,445	10,192	(3)	[4] 25,400	73.87	152	76,939	20
1935	17,518	7,815	(3)	[4] 25,200	71.99	138	100,261	17
1936	16,569	18,088	263	34,400	79.92	152	123,878	13
1937	16,508	18,917	454	35,000	90.18	161	133,136	12
1938	17,991	2,362	713	19,600	75.47	148	150,000	12
1939	18,633	3,499	1,208	20,900	103.94	207	145,000	13
1940	37,777	171	9,617	[6] 26,800	176.87	346	215,000	18
1941	44,921	7,740	2,590	[6] 44,800	185.02	326	275,000	16
1942	50,846	[7] 38,941	[7] 345	[6] 49,700	196.35	306	265,000	19
1943	51,929	[7] 47,805	[7] 385	[6] 54,500	195.21	291	236,000	22
1944	37,688	19,553	750	[6] 42,900	118.36	175	163,000	23
1945	30,763	68,617	1,038	[6] 62,429	134.89	196	131,000	23
1946	25,348	13,894	907	[6] 31,552	98.24	125	154,000	16
1947	23,244	13,008	884	[6] 35,581	83.74	87	168,000	14
1948	14,388	31,951	526	[6] 46,253	76.49	73	107,000	13
1949	9,930	103,141	577	[6] 39,857	79.46	80	121,000	8
1950	4,535	56,080	447	[6] 49,215	81.26	79	143,000	3
1951	7,293	47,860	241	[6] 56,848	210.13	183	147,000	5
1952	12,547	71,855	400	[6] 42,556	199.10	178	151,000	8
1953	14,337	83,393	546	[6] 52,259	193.03	175	160,000	9
1954	18,543	64,957	890	[6] 42,796	264.39	240	180,000	10
1955	18,955	20,354	451	[6] 57,185	290.35	262	185,000	10
1956	24,177	47,316	1,080	[6] 54,143	259.92	227	221,000	11
1957	34,625	42,005	1,919	[6] 52,889	246.98	210	246,000	14
1958	38,067	30,196	320	[6] 52,617	229.06	192	251,000	15
1959	31,256	30,141	640	[6] 54,895	227.48	190	233,000	13
1960	33,223	19,488	357	[6] 51,167	210.76	176	254,000	13

[1] Quoted price divided by Bureau of Labor Statistics wholesale price index (1947–49=100.)
[2] Quoted price for 75-pound flask calculated to equivalents for 76-pound flasks.
[3] Not separately classified for 1927–30 and 1933–35.
[4] Estimated by Bureau of Mines.
[5] From a special compilation, Bureau of Foreign and Domestic Commerce.
[6] Actual consumption.
[7] Large quantities reexported in 1942 and 1943 are included in imports but not exports.

increasing the Nation's resources for selected mineral commodities. In 1960 two new contracts were made to explore for mercury ores. Colorado Oil & Gas Corp. obtained financial assistance for exploration of the Abbott mine area, Lake County, Calif. Estimated total cost of the project was $35,060. A. O. Bartell executed a similar contract for $14,920 to explore the Nisbet mine, Clackamas County, Oreg.

DOMESTIC PRODUCTION

Production of primary mercury in the United States rose 6 percent to 33,200 flasks. Output increased in Alaska, California, and Nevada; production in Idaho and Oregon declined. Although the quantity of ore treated dropped 6 percent, the average grade treated rose 1.1 pounds per ton to 9.7—the highest since 1949. Output of secondary mercury rose 8 percent.

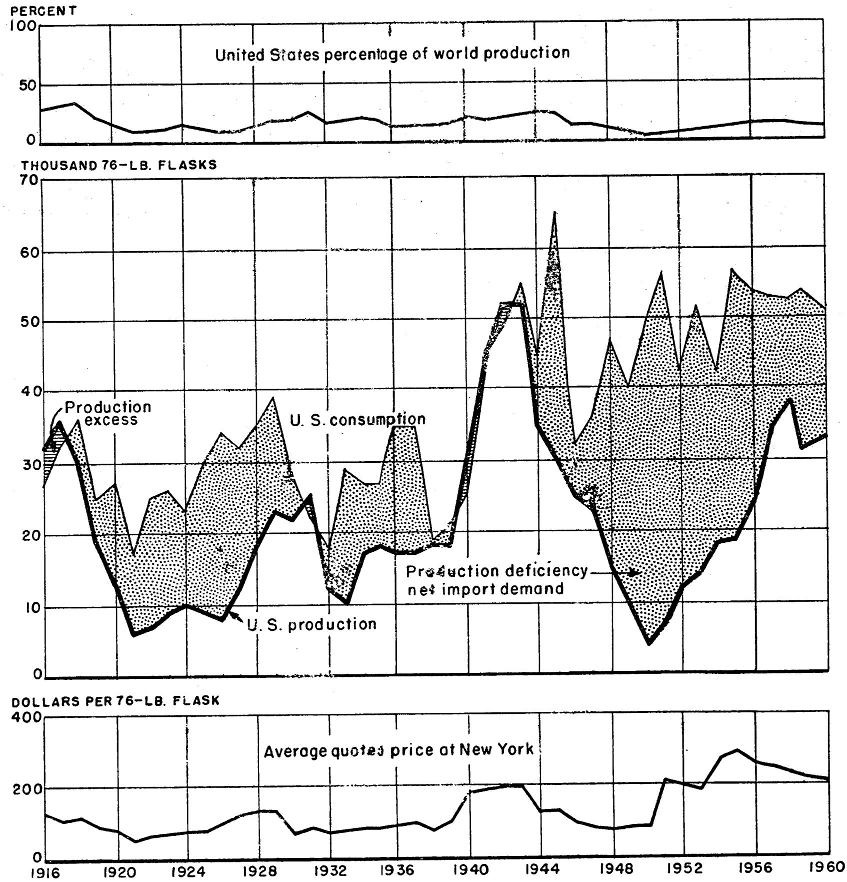

FIGURE 1.—Trends in production, consumption, and price of mercury, 1916–60.

California remained the leading mercury-producing State and supplied 56 percent of the U.S. total. Output increased 10 percent; the number of producing properties rose from 37 to 42; and the quantity of ore treated gained 5 percent. The Abbott, New Idria, Buena Vista, and Mount Jackson (including Great Eastern) properties accounted for 87 percent of the State total compared with 81 percent in 1959.

Nevada remained in second place, furnishing 24 percent of the U.S. total. Output was 9 percent greater than in 1959 and established a new production peak. The Cordero mine in Humboldt County, the leading producer in the State, ranked second in the United States. Its production rose 8 percent over 1959.

Output in Alaska was 19 percent more than in 1959 and represented 13 percent of the total U.S. production. The State ranked third in output of mercury for the fourth successive year. Most of the output came from the Red Devil mine, Kuskokwim River region.

Production in Idaho dropped 22 percent; the State supplied 5 percent of the U.S. total. Output at the Idaho-Almaden mine in Washington County, the only producer, fell 11 percent.

The lowest production since 1954 was recorded in Oregon in 1960. Output dropped 58 percent and accounted for only 2 percent of the total U.S. production. The closure of the Bonanza mine, Douglas County, and lower output at the Bretz mine, Malheur County, were responsible for the decreased output.

The remainder of the 1960 production, less than 1 percent, came from Arizona and Texas.

TABLE 3.—Mercury produced in the United States, by States

Year and State	Producing mines	Flasks	Value [1]	Year and State	Producing mines	Flasks	Value [1]
1959:				1960:			
Alaska	2	3,743	$851,458	Alaska	3	4,459	$939,779
California	37	17,100	3,889,908	California	42	18,764	3,954,700
Idaho	2	1,961	446,088	Idaho	1	1,538	324,149
Nevada	20	7,156	1,627,847	Nevada	20	7,821	1,648,354
Oregon	4	1,224	278,435	Oregon	5	513	108,120
Arizona and Texas	6	72	16,379	Arizona and Texas	4	128	26,977
Total	71	31,256	7,110,115	Total	75	33,223	7,002,079

[1] Value calculated at average New York price.

TABLE 4.—Mercury produced in the United States, by States

(Flasks)

Year	Alaska	Arizona	Arkansas	California	Idaho	Nevada	Oregon	Texas	Utah	Washington	Other[1]	Total
1910	------	------	------	16,985	------	69	------	3,276	------	------	------	20,330
1911	------	------	------	18,612	------	69	------	2,295	------	------	------	20,976
1912	------	------	------	20,254	------	2,516	------	1,964	------	------	------	24,734
1913	------	224	------	15,386	------	1,623	------	2,714	------	------	------	19,947
1914	------	11	------	11,154	------	2,062	------	3,103	------	------	------	16,330
1915	------	[2]	------	14,095	------	2,296	[2]	4,359	------	------	6	20,756
1916	------	5	------	20,768	------	2,169	299	6,223	------	74	------	29,538
1917	------	39	------	23,623	5	984	383	10,649	------	------	------	35,683
1918	------	------	------	22,366	21	1,030	693	8,340	------	------	------	32,450
1919	------	------	------	15,005	------	746	429	4,953	------	------	------	21,133
1920	------	------	------	9,719	------	82	24	3,391	------	------	------	13,216
1921	------	------	------	3,015	1	[2]	[2]	[2]	------	------	3,240	6,256
1922	------	------	------	3,360	------	[2]	2	[2]	------	------	2,929	6,291
1923	------	------	------	5,375	[2]	[2]	[2]	[2]	------	------	2,458	7,833
1924	------	[2]	------	7,861	[2]	[2]	[2]	[2]	------	------	2,091	9,952
1925	------	30	------	7,514	[2]	532	------	[2]	------	------	977	9,053
1926	[2]	[2]	------	5,651	6	194	------	[2]	------	482	1,208	7,541
1927	[2]	[2]	------	5,672	------	419	2,055	[2]	------	559	2,423	11,128
1928	------	[2]	------	6,977	------	2,867	3,710	[2]	------	[2]	4,316	17,870
1929	[2]	[2]	------	10,139	------	4,764	3,657	[2]	------	1,397	3,725	23,682
1930	[2]	[2]	------	11,451	------	3,282	2,919	[2]	------	1,079	2,822	21,553
1931	[2]	[2]	[2]	13,448	------	2,217	5,011	[2]	------	560	3,711	24,947
1932	[2]	[2]	[2]	5,172	------	474	2,523	[2]	------	407	4,046	12,622
1933	------	------	[2]	3,930	------	387	1,342	[2]	[2]	[2]	4,010	9,669
1934	------	[2]	488	7,808	------	300	3,460	[2]	------	330	3,059	15,445
1935	------	[2]	304	9,271	------	190	3,456	[2]	------	106	4,191	17,518
1936	------	[2]	[2]	8,693	------	211	4,126	[2]	25	[2]	3,514	16,569
1937	------	37	[2]	9,743	------	198	4,264	[2]	------	[2]	2,266	16,508
1938	[2]	------	[2]	12,277	------	336	4,610	[2]	------	[2]	768	17,991
1939	------	[2]	364	11,127	[2]	828	4,592	[2]	------	------	1,722	18,633
1940	162	740	1,159	18,629	[2]	5,924	9,043	[2]	53	[2]	2,067	37,777
1941	[2]	873	2,012	25,714	[2]	4,238	9,032	[2]	19	[2]	3,033	44,921
1942	[2]	701	2,392	29,906	[2]	5,201	6,935	[2]	[2]	[2]	5,711	50,846
1943	786	541	1,532	33,812	4,261	4,577	4,651	1,769	------	------	------	51,929
1944	[2]	548	191	28,052	[2]	2,460	3,159	1,095	------	------	2,183	37,688
1945	[2]	[2]	[2]	21,199	627	4,338	2,500	[2]	------	------	2,099	30,763
1946	699	95	11	17,782	868	4,567	1,326	------	------	------	------	25,348
1947	127	------	------	17,165	886	3,881	1,185	------	------	------	------	23,244
1948	100	------	------	11,188	543	1,206	1,351	------	------	------	------	14,388
1949	100	------	------	4,493	------	4,170	1,167	------	------	------	------	9,930
1950	------	------	------	3,850	------	680	5	------	------	------	------	4,535
1951	------	[2]	------	4,282	357	1,400	1,177	[2]	------	------	77	7,293
1952	28	------	------	7,241	887	3,523	868	------	------	------	------	12,547
1953	40	------	------	9,290	[2]	3,254	648	[2]	------	------	1,105	14,337
1954	1,046	163	------	11,262	609	4,974	489	------	------	------	------	18,543
1955	[2]	477	------	9,875	1,107	5,750	1,056	[2]	------	------	690	18,955
1956	3,280	[2]	------	9,017	3,394	5,859	1,893	[2]	------	------	734	24,177
1957	5,461	28	------	16,511	2,260	6,313	3,993	[2]	------	[2]	59	34,625
1958	3,380	53	------	22,365	2,625	7,336	2,276	[2]	------	[2]	32	38,067
1959	3,743	[2]	------	17,100	1,961	7,156	1,224	[2]	------	------	72	31,256
1960	4,459	[2]	------	18,764	1,538	7,821	513	[2]	------	------	128	33,223

[1] Includes States indicated by footnote 2.
[2] Figure withheld to avoid disclosing individual company confidential data; included with "Other."

A total of 75 mines, 71 in 1959, contributed to production; 6 properties, each producing 1,000 flasks or more, supplied 85 percent of the U.S. total. The leading producers were as follows:

State:	*County*	*Mine*
Alaska	Aniak district	Red Devil.
California	San Benito	New Idria.
	San Luis Obispo	Buena Vista.
	Sonoma	Mount Jackson (including Great Eastern).
Idaho	Washington	Idaho-Almaden.
Nevada	Humboldt	Cordero.

In addition to the foregoing mines, the following mercury operations produced 100 flasks or more:

State:	*County*	*Mine*
Arizona	Maricopa	Turnbull.
California	Kings	Little King (Fredanna).
	Lake	Abbott.
	Santa Barbara	Gibraltar.
	Santa Clara	Guadalupe, New Almaden mine and dumps.
	Sonoma	Culver-Baer.
	Yolo	Reed.
Nevada	Esmeralda	B&B.
	Humboldt	Cahill.
	Nye	Horse Canyon.
	Pershing	Freckles (Roman).
Oregon	Douglas	Bonanza.
	Malheur	Bretz.

These 20 mines produced 98 percent of the domestic mercury output.

TABLE 5.—Mercury ore treated and mercury produced in the United States [1]

(Until 1954 excludes some material from old dumps)

Year	Ore treated (short tons)	Mercury produced		Year	Ore treated (short tons)	Mercury produced	
		Flasks	Pounds per ton of ore			Flasks	Pounds per ton of ore
1927	99,969	10,711	8.1	1944	300,385	37,333	9.4
1928	142,131	14,841	7.9	1945	209,009	29,754	10.8
1929	248,314	19,461	6.0	1946	157,469	24,929	12.0
1930	288,503	18,719	4.9	1947	139,311	22,823	12.5
1931	260,471	22,625	6.6	1948	103,220	13,891	10.2
1932	108,118	11,770	8.3	1949	71,977	9,745	10.3
1933	78,089	8,381	8.2	1950	35,115	4,312	9.3
1934	126,931	13,778	8.2	1951	81,067	6,934	6.5
1935	135,100	15,280	8.6	1952	135,197	12,500	7.0
1936	141,962	14,007	7.5	1953	138,090	14,262	7.8
1937	186,578	16,316	6.6	1954	174,083	18,524	8.1
1938	199,954	17,816	6.8	1955	222,740	18,819	6.4
1939	191,892	18,505	7.3	1956	244,148	24,109	7.5
1940	449,940	37,264	6.3	1957	309,632	34,058	8.4
1941	652,141	43,873	5.1	1958	328,155	37,209	8.6
1942	733,360	49,066	5.1	1959	275,903	31,109	8.6
1943	613,111	50,761	6.3	1960	258,071	33,106	9.7

[1] Excludes mercury produced from placer operations and from cleanup activity at furnaces and other plants.

Production of mercury from secondary sources rose 8 percent over 1959. Mercury was reclaimed from dental amalgam, oxide and acetate sludges, and battery scrap.

TABLE 6.—Production of secondary mercury in the United States

Year:	*Flasks*
1956	5,850
1957	5,800
1958	5,400
1959	4,950
1960	5,350

CONSUMPTION AND USES

Consumption of mercury in the United States dropped 7 percent to 51,200 flasks. The decrease was attributed mostly to a decline in the rate at which new chlorine-caustic soda plants have increased capacity in recent years. The quantity of mercury used to initiate new capacity is essentially nondissipative and is shown in the consumption table in the category labeled "Other." Mercury dissipated in production in this process is shown under the category "Electrolytic preparation of chlorine and caustic soda."

Mercury consumption during the first half of the year was considerably above that of the last half of 1959, but during the July–September interval consumption fell sharply. Increases during the final quarter, owing chiefly to expanded use in electrical and industrial applications, failed to offset the third-quarter slump. An expansion in capacity at a North Carolina chlorine sodium plant also contributed to the increase in the October–December period.

The use of mercury increased several hundred flasks each in antifouling and mildew retarding paints; industrial, electrical, laboratory, and control instruments; and electrolytic production of chlorine and caustic soda. Use in industrial and agricultural insecticides, bactericides and fungicides, and pulp preparation and paper manufacture declined considerably. However, it was the large drop in mercury used in installation of new chlorine-caustic soda plants that accounted for the net decrease in consumption of mercury during 1960.

TABLE 7.—Mercury consumed in the United States by uses

(Flasks)

Use	1951-55 (average)	1956	1957	1958	1959	1960
Agriculture (includes insecticides, fungicides, and bactericides for industrial purposes)	7,122	9,930	6,337	6,270	3,202	2,974
Amalgamation	185	239	244	248	265	255
Catalysts	1,166	871	859	816	965	1,018
Dental preparations [1]	1,107	1,328	1,371	1,741	1,828	1,783
Electrical apparatus [1]	9,600	9,764	9,151	9,335	8,905	9,268
Electrolytic preparation of chlorine and caustic soda	2,335	3,351	4,025	4,547	5,828	6,211
General laboratory use	900	984	894	968	1,110	1,302
Industrial and control instruments [1]	5,786	6,114	6,028	6,054	6,164	6,525
Paint:						
Antifouling	1,114	511	568	749	993	1,360
Mildew proofing	(2)	(2)	(2)	(2)	2,521	2,861
Paper and pulp manufacture	(3)	(3)	(3)	(3)	4,360	3,481
Pharmaceuticals	1,887	1,600	1,751	1,430	1,717	1,729
Redistilled [1]	8,594	9,483	9,703	9,448	9,331	9,678
Other	10,533	9,968	11,958	11,011	7,706	2,722
Total	50,329	54,143	52,889	52,617	54,895	51,167

[1] A breakdown of the "redistilled" classification showed ranges of 48 to 39 percent for instruments, 12 to 5 percent for dental preparations, 44 to 32 percent for electrical apparatus, and 12 to 8 percent for miscellaneous uses in 1951–59, compared with 45 percent for instruments, 9 percent for dental preparations, 28 percent for electrical apparatus, and 18 percent for miscellaneous uses in 1960.

[2] Data not available.

[3] Included with agriculture.

STOCKS

Stocks of mercury held by consumers and dealers, the largest since 1957, rose 47 percent in 1960. The increase was due in part to metal accumulated for chlorine and caustic soda plant installation and expansion for the near future.

Of the total metal in stock, the part held by producers rose 36 percent in 1960 but accounted for only 13 percent of total industry inventories.

In addition to the stocks shown in table 9, 16,000 flasks were in the supplemental stockpile at the end of 1960, and the national stockpile contained inventories of metal that may not be disclosed.

TABLE 8.—Stocks of mercury, Dec. 31

(Flasks)

Year	Producer	Consumer and dealer	Total
1951-55 (average)	798	24,020	24,818
1956	1,210	21,100	22,310
1957	3,588	21,800	25,388
1958	674	10,600	11,274
1959	1,880	11,700	13,580
1960	2,561	17,200	19,761

Mercury withdrawn from inventory for installation and expansion of chlorine and caustic soda plants, mercury-boiler plants, and other nondissipative uses actually constitutes a reserve of metal. In the event these plants are dismantled or more urgent demands for mercury develop, this mercury could be reclaimed and used. At the beginning of 1960 the quantity of mercury in use at chlorine and caustic soda plants totaled 94,000 flasks and in boilers nearly 22,000 flasks.

PRICES

The average price for mercury in the United States was $210.76 a flask, approximately $17 below the 1959 figure. At the beginning of the year mercury was quoted at a range of $211–$213. Slight increases in February and early March brought the price to $214–$216. In late April a downward trend began that continued to the latter part of July when the price stabilized and remained at $209 a flask throughout the rest of the year.

The average price for the year in London was $197.86 a flask, about $11 below 1959. The year's high was £71 15s. ($200.90) a flask quoted during most of January, and the low of £69 ($193.20) quoted during the last week in September.

TABLE 9.—Average monthly prices of mercury at New York and London

(Per flask)

Month	1959		1960	
	New York [1]	London [2]	New York [1]	London [2]
January	$218.00	$207.68	$211.00	$200.71
February	218.00	207.89	212.21	199.91
March	224.64	209.90	214.00	198.52
April	240.55	220.81	213.33	198.86
May	245.00	218.48	212.00	198.70
June	240.27	215.86	211.27	197.59
July	236.13	210.88	210.30	197.29
August	229.38	202.56	209.00	196.89
September	223.81	201.17	209.00	195.06
October	223.33	201.63	209.00	197.16
November	216.61	201.62	209.00	198.35
December	214.09	200.79	209.00	196.24
Average	227.48	208.61	210.76	197.86

[1] Engineering and Mining Journal, New York.
[2] Mining Journal (London) prices in terms of pounds sterling were converted to U.S. dollars by using average rates of exchange recorded by Federal Reserve Board.

FOREIGN TRADE [3]

Imports.—Mercury imports for consumption decreased markedly in 1960 to 19,500 flasks. This quantity was approximately two-thirds the 1959 imports. Although imports from Spain were nearly 4,700 flasks less than in 1959, Spain continued to be the chief foreign supplier of mercury to the U.S. market. Following the 1959 import pattern, Italy, Mexico, and Yugoslavia in 1960 ranked respectively, second, third, and fourth as shippers to U.S. consumers. Additional small quantities were received from Canada, Chile, Colombia, Peru, and New Zealand. Total value of the shipments was $3.5 million. Of the mercury received from Canada 14 flasks entered the country duty free.

Exports.—Exports of mercury dropped considerably to 357 flasks. The decline in quantity was only partly reflected by a decline in value. Shipments ranging from less than 1 to 87 flasks went to 29 countries, with Canada, France, Colombia, Venezuela, and Saudi Arabia the major recipients.

Of the foreign mercury imported by the United States 317 flasks were reexported, mainly to Canada.

Tariff.—The duty of 25 cents a pound ($19 a flask) on imported mercury, in effect since 1922, was continued.

[3] Figures on U.S. imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 10.—U.S. imports for consumption of mercury, by countries

Country	1951-55 (average)		1956		1957		1958		1959		1960	
	Flasks	Value (thousands)	Flasks	Value (thousands)	Flasks	Value (thousands)	Flasks	Value (thousands)	Flasks	Value (thousands)	Flasks	Value (thousands)
North America:												
Canada	216	$47	80	$21	66	$16	50	$7	125	$23	20	$5
Honduras	2	(1)										
Mexico	9,097	1,700	11,536	2,618	5,280	1,023	8,251	1,506	3,516	646	2,419	382
Total	9,315	1,747	11,616	2,639	5,346	1,039	8,301	1,513	3,641	669	2,439	387
South America:												
Bolivia	4	(1)					9	2	11	2		
Chile			25	6			514	102	813	164	139	26
Colombia					15	4	80	12			30	6
Peru	20	6	372	89	244	52	345	61	589	112	49	8
Total	24	6	397	95	259	56	948	177	1,413	278	218	40
Europe:												
Germany, West	50	8										
Italy	21,415	3,484	16,810	3,934	8,056	1,869	1,133	221	6,146	1,256	3,420	627
Netherlands	100	10	20	5								
Spain	20,489	3,341	15,713	3,667	25,276	5,677	18,494	3,729	17,111	3,400	12,464	2,278
Sweden	136	21										
Switzerland	41	5										
United Kingdom	10	(1)	350	78	2,500	560	(2)	(1)	235	48		
Yugoslavia	6,034	1,098	2,350	579	568	132	220	46	954	198	900	170
Total	48,275	7,967	35,243	8,263	36,400	8,238	19,847	3,996	24,446	4,902	16,784	3,075
Asia:												
India	5	1										
Japan	55	4										
Philippines							1,100	236	400	81		
Turkey			60	13					100	36		
Total	60	5	60	13			1,100	236	500	117		
Africa: Morocco	10	2										

Oceania:												
Australia	----------	----------	----------	----------	----------	----------	----------	----------	126	23	----------	----------
New Zealand	----------	----------	----------	----------	----------	----------	----------	----------	15	3	47	8
Total	----------	----------	----------	----------	----------	----------	----------	----------	141	26	47	8
Grand total	57,684	[3] 9,727	47,316	11,010	42,005	9,333	30,196	5,922	30,141	5,992	19,488	3,510

[1] Less than $1,000.
[2] Less than 1 flask.
[3] 1954 data known to be not comparable with other years.

Source: Bureau of the Census.

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TABLE 11.—U.S. imports [1] of mercury, by countries

(Flasks)

Country	1951–55 (average)	1956	1957	1958	1959	1960
North America:						
Canada	216	80	66	50	125	20
Honduras	2					
Mexico	9,256	12,502	5,991	8,350	3,631	2,459
Total	9,474	12,582	6,057	8,400	3,756	2,479
South America:						
Bolivia	4			9	11	
Chile		125		1,160	400	139
Colombia			15	80	30	
Peru	20	372	244	345	599	49
Total	24	497	259	1,594	1,040	188
Europe:						
Germany, West	50					
Italy	20,784	17,592	9,208	1,015	6,175	3,447
Netherlands	30	20				
Spain	20,345	18,104	25,993	18,644	17,509	12,444
Sweden	136					
Switzerland	41					
United Kingdom	(2)	564	2,500	(2)	185	
Yugoslavia	6,172	2,590	1,432	220	954	910
Total	47,558	38,870	39,133	19,879	24,823	16,801
Asia:						
Japan	55					
Philippines				1,100	400	
Turkey	11	60			100	
Total	66	60		1,100	500	
Africa: Morocco	10					
Oceania:						
Australia					126	
New Zealand					15	47
Total					141	47
Grand total	57,132	52,009	45,449	30,973	30,260	19,515

[1] Data are "general" imports; that is, they include mercury imported for immediate consumption plus material entering the country under bond.
[2] Less than 1 flask.

Source: Bureau of the Census.

TABLE 12.—U.S. exports of mercury

Year	Flasks	Value	Year	Flasks	Value
1951–55 (average)	506	$117,660	1958	320	$95,003
1956	1,080	284,418	1959	640	92,255
1957	1,919	483,892	1960	357	82,957

Source: Bureau of the Census.

TABLE 13.—U.S. reexports of mercury

Year	Flasks	Value	Year	Flasks	Value
1951–55 (average)	711	$130,176	1958	934	$198,501
1956	2,025	475,667	1959	553	119,038
1957	3,275	763,303	1960	317	62,015

Source: Bureau of the Census.

WORLD REVIEW

The highest annual world production of mercury since 1942 was achieved in 1960 as output rose 9 percent to an estimated 254,000 flasks. Increased output was recorded in all major mercury-producing countries.

TABLE 14.—World production of mercury by countries[1]

(Flasks)[2]

Country	1951-55 (average)	1956	1957	1958	1959	1960
North America:						
Mexico	14,615	19,529	21,068	22,556	16,420	20,103
United States	14,335	24,177	34,625	38,067	31,256	33,223
South America:						
Bolivia (exports)	4	----------	----------	10	12	----------
Chile	231	575	678	3,343	2,007	[3] 2,000
Colombia	[4] 36	----------	99	203	95	89
Peru	45	335	411	1,983	2,526	3,034
Europe:						
Austria	21	6	6	----------	----------	----------
Czechoslovakia [5]	725	725	725	725	725	[3] 725
Italy	53,816	62,309	63,237	58,712	45,833	55,492
Rumania	323	419	394	353	387	[3] 400
Spain	41,304	48,269	54,750	55,382	51,680	[3] 56,000
U.S.S.R.[3]	12,000	22,000	25,000	25,000	25,000	25,000
Yugoslavia	14,516	13,228	12,328	12,270	13,344	14,069
Asia:						
China [3]	6,900	17,000	17,000	17,000	23,000	[6] 23,000
Japan	5,318	8,334	11,872	10,900	16,131	[3] 16,500
Philippines	[4] 635	3,015	3,363	3,321	3,520	[3] 3,000
Turkey	1,102	1,079	720	1,486	[7] 1,321	[3] 1,300
Africa: Tunisia	[4] 166	22	----------	39	198	166
World total (estimate)	166,000	221,000	246,000	251,000	233,000	254,000

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] 76-pound flasks.
[3] Estimate.
[4] 1 year only, as 1955 was the 1st year of commercial production.
[5] Estimate according to the 47th Annual issue of Metal Statistics (Metallgesellschaft), except Czechoslovakia 1960.
[6] Data represent estimate of 1959 production; 1960 production may be larger.
[7] Exports.

Compiled by Augusta W. Jann, Division of Foreign Activities.

Italy.—Despite a 21-percent increase in output, Italy continued in second place among leading mercury-producing countries. Exports were 17,700 flasks greater than in 1959 and the largest since 1956.

TABLE 15.—Italy: Exports of mercury by countries[1]

(Flasks)

Destination	1959	1960	Destination	1959	1960
Australia	540	322	Norway	252	55
Belgium-Luxembourg	----------	249	Poland	1,018	2,602
Brazil	6	482	Sweden	----------	438
Canada	----------	351	Switzerland	560	690
Czechoslovakia	119	400	Union of South Africa	293	1,120
Denmark	3,501	1,801	United Kingdom	10,626	10,658
Finland	1,099	----------	United States	5,967	3,333
France	2,149	4,453	Other countries	682	757
Germany, West	6,489	23,946			
India	238	1,047	Total	35,140	52,887
Netherlands	1,601	183			

[1] This table incorporates some revisions.

Compiled from Customs Returns of Italy by Bertha M. Duggan and Corra A. Barry, Division of Foreign Activities.

Mexico.—Mercury production in Mexico increased 22 percent in 1960. Virtually all of Mexico's output is exported and for many years the United States received most of the Mexican metal. In 1960, however, more than half of Mexico's output went to Japan.

The development of mercury deposits in the Opal area, Durango, was discussed.[4]

Spain.—Spain ranked first among the principal mercury-producing countries for the second consecutive year. Output rose 8 percent over 1959 and was the largest since 1942.

An addition that doubled capacity of the Pacific mecury plant at Almaden was completed during 1960 and an auxiliary ore handling system was designed.

Installation of a new mercury ore treatment plant was begun by Astur-Belga de Minas, S. A. at its La Esperanza mine near Oviedo in northern Spain. High arsenic content of the ore led to construction of an arsenic oxide recovery chamber installed between the dust collectors and the condensing system. Plant capacity was 165 short tons of ore treatment per day.[5]

United Kingdom.—Foreign-trade data for the United Kingdom indicated that consumption of mercury in 1960 was the largest since 1954. Imports of metal dropped only 2 percent, but reexports fell 14 percent. The new supply of mercury available for consumption was 21,000 flasks.

	1951–55 (average)	1956	1957	1958	1959	1960
Imports	18,340	19,600	18,200	19,200	25,700	25,300
Reexports	4,420	4,000	15,300	5,100	5,000	4,300
Apparent consumption	13,920	15,600	2,900	14,100	20,700	21,000

Reexports of mercury in flasks were as follows:

Destination:	*1959*
Australia	473
Belgium	338
Denmark	216
Finland	315
France	134
Germany, West	130
Hong Kong	256
India	1,147
Netherlands	311
Sweden	435
Union of South Africa	332
Other	878
	4,965

Yugoslavia.—Rudnik Zivega Srebra, a State-controlled company, started construction of a new mercury plant at its famous Idria mine in Slovenia. The plant was designed to treat 275 short tons of ore per day. The feature unit was a 120-foot rotary kiln 84 inches in

[4] Parliman, Clifford R., Mining in Mexico: Mines Mag., vol. 50, No. 9, September 1960, pp. 13–14.
[5] Gordon I. Gould & Co., San Francisco, Calif., Letter to Bureau of Mines, March 1961.

diameter. Conventional oil-firing and dust-collecting equipment were to be used with a double-tank-type condensing system.[6] Virtually all the mercury produced in Yugoslavia came as usual from the Idria mine and, output rose 5 percent to 14,100 flasks in 1960.

TECHNOLOGY

The Federal Bureau of Mines published[7] the results of research conducted at its Albany, Oreg., Metallurgy Research Center on the feasibility of recovering mercury sulfide minerals from several types of low-grade domestic ores by flotation. The investigation was aimed at lowering the economical cutoff grade of mercury ores and thereby increasing the domestic reserve. Statistical analysis was used to determine reliability of test results. Batch scale tests on ore containing over 0.50 percent mercury showed recoveries of over 90 percent at concentrate grades of 10 to 20 percent mercury. Approximately 80 percent of the mercury from ores containing only 0.10 percent mercury was recovered in a 5-percent concentrate by batch tests. Continuous-circuit tests yielded recoveries up to 90 percent, depending on the ore grade, at concentrate grades of 15 percent mercury.

Results of experiments relating to luminescence of zinc sulfide-mercury sulfide solid solutions[8] were published. In efforts to obtain emissions in longer wavelengths from electronically excited phosphors, distortions were made in the crystal lattice of luminescent materials by substitution of various activator atoms. The position of mercury in the Periodic Chart indicated the system (Zn,Hg)S to be of interest. The effects of the low sublimation temperature of HgS that would normally preclude solid state activator incorporation was overcome by firing the two sulfides in evacuated and sealed silica tubes. All phosphors of the system (Zn,Hg)S:Cu:NaCl containing up to 80 percent mercury sulfide (HgS) yielded the desirable responsive cubic crystal structure although the mercury sulfide used in preparing the solid solutions was hexagonal. The shift in emission spectra to longer wavelengths was noted to be similar to that caused by cadmium substitution, but of a magnitude four times as great. At low mercury concentrations, however, the fluorescent was found to be weak.

Two new acetamide derivatives in which mercury replaces hydrogen in the amide group to yield compounds having fungicidal and insecticidal properties were described.[9] Each was being tested for control of a fungus that attacks sugar beet seed, later resulting in a condition in the beet called "black leg." Toxicity had yet to be evaluated.

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[6] Work cited in footnote 5.

[7] Town, J. W., McClain, R. S., and Stickney, W. A., Flotation of Low-Grade Mercury Ores: Bureau of Mines Rept. of Investigations 5598, 1960, 34 pp.

[8] Wachtel, A., (Zn,Hg)S and (Zn,Cd,Hg)S Electroluminescent Phosphors: Jour. Electrochem. Soc., vol. 107, No. 8, August 1960, pp. 682–688.

[9] Chemical Age (London), vol. 84, No. 2162, Dec. 17, 1960, p. 1027.

Mica

By Milford L. Skow [1] and Gertrude E. Tucker [2]

TONNAGE and value of domestic scrap mica sold or used by producers in the United States again reached new highs in 1960. Although the Government purchasing program for domestic mica continued at a high level, sales of sheet mica larger than punch and circle were the lowest since 1954. Most of this mica went into Government inventories, and industry continued to depend largely on imports. Consumption of block, film, and splittings declined, but sales of scrap and ground mica increased substantially. Total imports declined slightly, although imports of scrap mica were higher than in 1959.

TABLE 1.—Salient mica statistics

	1951-55 (average)	1956	1957	1958	1959	1960
United States:						
Domestic, sold or used by producers:						
Sheet mica----thousand pounds--	691	888	690	661	706	579
Value------------thousands--	$1,797	$2,757	$2,492	$2,844	$3,419	$2,830
Scrap and flake mica thousand short tons--	79	86	92	93	[1] 102	120
Value------------thousands--	$1,891	$1,850	$2,109	$2,065	[1] $2,665	$2,962
Ground mica [2] thousand short tons--	81	91	96	98	[1] 107	120
Value------------thousands--	$4,752	$6,228	$6,073	$5,560	[1] $5,646	$5,605
Consumption, block and film thousand pounds--	[3] 3,661	3,822	3,340	2,856	2,868	2,776
Value---------------thousands--	[3] $4,975	$5,708	$4,651	$3,632	$4,449	$3,988
Consumption, splittings thousand pounds--	9,935	8,662	8,037	5,329	7,223	6,227
Value---------------thousands--	$7,582	$4,435	$4,018	$2,720	$3,464	$2,875
Imports for consumption thousand short tons--	14	14	12	10	11	11
Exports---------------------do----	3	5	5	5	5	4
Consumption, apparent, sheet thousand pounds--	14,885	12,711	12,564	11,616	[1] 12,675	9,210
World: Production---------------do----	280,000	305,000	320,000	315,000	345,000	410,000

[1] Revised figure.
[2] Domestic and some imported scrap mica.
[3] Average for 1954-55.

LEGISLATION AND GOVERNMENT PROGRAMS

Purchasing and research programs for mica were continued by various Government agencies under authority delegated by the Office of Civil and Defense Mobilization (OCDM). OCDM established basic and maximum stockpile objectives for phlogopite block mica,

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formerly listed in Group II of the List of Strategic and Critical Materials for Stockpiling. Only high-heat phlogopite was to be credited toward stockpile objectives. Stained B and lower qualities of muscovite block mica, inventories of which had been retained to supplement stockpile-quality mica in an emergency, were removed from Group II of the stockpile list.

Defense Materials Service.—Government mica purchases at the three mica-purchasing depots of General Services Administration (GSA) resulted in 238,375 pounds of full-trimmed muscovite block mica (0.007 inch thick) in 1960—16 percent less than in 1959 but nevertheless the second highest annual total. Mica purchased under this program since its beginning in 1952 yielded 1,815,400 pounds of full-trimmed block, 1,120,444 pounds of punch, 195,459 pounds of other sheet, and 14,983,495 pounds of scrap. The full-trimmed block was 80 percent ruby mica. In 1960 the quantity of Stained or better qualities of full-trimmed muscovite block obtained from Government purchases was 14 percent less than in 1959 and was equivalent to 15 percent of the total 1960 fabrication of muscovite block and film of these qualities, regardless of grade.

TABLE 2.—Yield of full-trimmed muscovite ruby and nonruby block mica from domestic purchases by GSA in 1960, by grades, qualities, and depots

(Pounds)

Depot and grade	Ruby				Nonruby			
	Good Stained or better	Stained	Heavy Stained	Total	Good Stained or better	Stained	Heavy Stained	Total
Spruce Pine, N.C.:								
2 and larger	384	395	120	899	331	28	7	366
3	830	979	217	2,026	487	70	8	565
4	2,221	2,275	588	5,084	872	139	27	1,038
5	9,292	13,038	2,849	25,179	2,469	1,022	210	3,701
5½	5,554	7,016	2,358	14,928	1,187	634	203	2,024
6	20,793	45,980	15,015	81,788	5,148	5,982	1,792	12,922
Total	39,074	69,683	21,147	129,904	10,494	7,875	2,247	20,616
Franklin, N.H.:								
2 and larger	27	99	86	212	-	-	-	-
3	86	276	205	567	-	[1]	[1]	[1]
4	240	710	485	1,435	[1]	[1]	1	1
5	1,316	3,893	2,310	7,519	1	3	1	5
5½	1,105	3,355	2,257	6,717	1	3	1	5
6	5,234	16,562	10,337	32,133	6	7	3	16
Total	8,008	24,895	15,680	48,583	8	13	6	27
Custer, S. Dak.:								
2 and larger	18	168	71	257	-	-	-	-
3	41	458	198	697	-	-	[1]	[1]
4	58	1,118	339	1,515	-	[1]	[1]	[1]
5	317	5,811	2,777	8,905	[1]	[1]	2	2
5½	121	2,961	1,147	4,229	[1]	[1]	1	1
6	878	12,772	9,983	23,633	1	2	3	6
Total	1,433	23,288	14,515	39,236	1	2	6	9
Grand total	48,515	117,866	51,342	217,723	10,503	7,890	2,259	20,652

[1] Less than 1 pound.

TABLE 3.—Yield of byproducts from domestic purchases of ruby and nonruby mica by GSA in 1960, by depots

(Pounds)

Depot	Ruby			Nonruby		
	Miscellaneous [1]	Punch	Scrap	Miscellaneous [1]	Punch	Scrap
Spruce Pine, N.C.	3,411	23,068	1,223,883	680	3,377	183,563
Franklin, N.H.	1,090	29,024	425,389	(2)		(2)
Custer, S. Dak.	1,927	24,679	281,812	1	5	123
Total	6,428	76,771	1,931,084	681	3,382	183,686

[1] Includes some full-trimmed thins and block of lower than Heavy Stained qualities.
[2] Less than 1 pound.

All Defense Production Act contracts for the procurement of mica from foreign sources had been terminated by GSA by June 30. However, a number of importers accepted the offer to convert unfulfilled portions of these agreements to barter contracts and continued to furnish some block and film mica for Government inventory.

Activities under the industry-Government program authorized by OCDM for research on substitutes for strategic natural mica were diminished further. Contracts with National Bureau of Standards (NBS) and with Synthetic Mica Co., Division of Mycalex Corp. of America, both for research on reconstituting synthetic mica, were terminated early in the year by GSA. By December 31, contracts for research to develop usable, reconstituted, synthetic-mica sheet remained in force with the Federal Bureau of Mines and General Telephone & Electronics Laboratories, Inc., which included laboratories formerly operated by Sylvania Electric Products, Inc. GSA also terminated the contract with NBS for research on properties of natural mica for electron-tube use. NBS planned to complete this study with its own funds.

Commodity Credit Corporation.—Muscovite block and film and phlogopite splittings were received during the year under 1 carryover and 11 new barter contracts for agricultural commodities. No muscovite splittings or phlogopite block mica was contracted for or received under this program.

Office of Minerals Exploration (OME).—This office was established in September 1958 by the Secretary of the Interior under authority of Public Law 701, 85th Cong., to give financial assistance in exploring for unknown or undeveloped sources of certain minerals, including strategic mica. From the beginning of the program to December 31, 1960, four mica exploration contracts with a total value of $51,584 were executed by OME. During 1960, OME terminated three of these with a contract value of $46,584.

DOMESTIC PRODUCTION

Sheet Mica.—The quantity of crude sheet mica sold or used by producers declined 18 percent during 1960 to the lowest total since 1950. Sales of sheet mica larger than punch and circle were 23 percent lower than in 1959, but the average value per pound was somewhat higher. Most of this mica was sold to the Government at above-market prices

TABLE 4.—Mica sold or used by producers in the United States

Year and State	Sheet mica						Scrap and flake mica [3]		Total	
	Uncut punch and circle mica		Uncut mica larger than punch and circle [1]		Total sheet mica [2]					
	Pounds	Value	Pounds	Value	Pounds	Value	Short tons	Value	Short tons	Value
1951–55 (average)	534, 019	$83, 509	156, 615	$1, 713, 587	690, 634	$1, 797, 096	79, 374	$1, 890, 804	79, 720	$3, 687, 900
1956	593, 620	53, 914	294, 251	2, 703, 159	887, 871	2, 757, 073	86, 309	1, 849, 573	86, 753	4, 606, 646
1957	425, 737	34, 341	264, 315	2, 458, 121	690, 052	2, 492, 462	92, 438	2, 109, 463	92, 783	4, 601, 925
1958	376, 005	31, 044	285, 339	2, 813, 425	661, 344	2, 844, 469	93, 347	2, 064, 632	93, 675	4, 909, 101
1959	383, 529	36, 653	322, 866	3, 382, 837	706, 395	3, 419, 490	[4] 101, 541	[4] 2, 665, 337	[4] 101, 893	[4] 6, 084, 827
1960:										
Colorado	----------	----------	----------	----------	----------	----------	340	4, 500	340	4, 500
Georgia	4, 546	544	5, 672	88, 103	10, 218	88, 647	(5)	(5)	(5)	(5)
Maine	112	11	26, 730	274, 896	26, 842	274, 907	171	5, 653	184	280, 560
New Hampshire	3, 000	150	77, 065	904, 150	80, 065	904, 300	415	14, 342	455	918, 642
New Mexico	----------	----------	(5)	(5)	(5)	(5)	235	6, 780	(5)	(5)
North Carolina	322, 588	20, 923	107, 605	1, 390, 517	430, 193	1, 411, 440	47, 281	1, 099, 502	47, 496	2, 510, 942
South Carolina	----------	----------	101	1, 112	101	1, 112	(5)	(5)	(5)	(5)
South Dakota	----------	----------	30, 887	145, 154	30, 887	145, 154	205	9, 748	220	154, 902
Virginia	----------	----------	103	1, 116	103	1, 116	----------	----------	(6)	1, 116
Undistributed [7]	----------	----------	576	3, 659	576	3, 659	71, 282	1, 821, 189	71, 522	1, 921, 387
Total	330, 246	21, 628	248, 739	2, 808, 707	578, 985	2, 830, 335	119, 929	2, 961, 714	120, 217	5, 792, 049

[1] Includes the full-trimmed mica equivalent of hand-cobbed mica, 1952-60.
[2] Includes small quantities of splittings in certain years.
[3] Includes finely divided mica recovered from mica and sericite schist and mica that is a byproduct of feldspar and kaolin beneficiation.
[4] Revised figure. California, also, was an "Undistributed" State in 1959.
[5] Included with "Undistributed" to avoid disclosing individual company confidential data.
[6] Less than 1 ton.
[7] Figures include Alabama, Arizona, California, Connecticut, Idaho, Montana, Pennsylvania, Tennessee, Wyoming, and States indicated by footnote 5.

under the domestic mica purchasing program. North Carolina, with 74 percent of the total output of domestic sheet mica, continued to be the principal producing State. New Hampshire, South Dakota, Maine, and Georgia were other large producers.

Scrap and Flake Mica.—Demand for scrap and flake mica sold or used by grinders increased for the fourth consecutive year and reached a record high in tonnage and value. The quantity increased 18 percent and the value 11 percent over 1959. North Carolina again was the principal producer, accounting for about 40 percent of the tonnage. Arizona, Georgia, Alabama, South Carolina, and Tennessee also furnished considerable quantities.

Ground Mica.—Sales of ground mica increased 12 percent in tonnage but decreased about 1 percent in value compared with 1959. Dry-ground mica constituted 90 percent of the tonnage and was used principally for roofing materials, paint, joint cement, and well-drilling compounds. Wet-ground mica was used chiefly in paint and rubber. Production was reported by 30 grinders in 23 dry-grinding and 10 wet-grinding plants. Southern Mica Co., Johnson City, Tenn., became the Carolina-Southern Mining Co., Inc., Kingsport, Tenn. Dixie Mines, Inc., Heflin, Ala., C. O. Fiedler, Inc., Ogilby, Calif., and Hassett Mining Co., Burnsville, N.C., were listed as producers of dry-ground mica for the first time. Harry Hamilton, Winterhaven, Calif., reported a small production of wet-ground mica. Beryl Ores Co., which produced dry-ground mica at Arvada, Colo., in 1959, did not operate in 1960.

TABLE 5.—Ground mica sold by producers in the United States, by methods of grinding

Year	Dry-ground		Wet-ground		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1951–55 (average)	68, 221	$2, 987, 083	12, 630	$1, 764, 899	80, 851	$4, 751, 982
1956	77, 665	4, 150, 996	13, 605	2, 077, 062	91, 270	6, 228, 058
1957	83, 025	4, 015, 353	13, 307	2, 058, 055	96, 332	6, 073, 408
1958	85, 106	3, 714, 962	12, 423	1, 845, 102	97, 529	5, 560, 064
1959	[1] 93, 121	[1] 3, 515, 729	14, 059	2, 130, 543	[1] 107, 180	[1] 5, 646, 272
1960	108, 242	3, 834, 481	12, 121	1, 770, 969	120, 363	5, 605, 450

[1] Revised figure.

CONSUMPTION AND USES

Sheet Mica.—Consumption of total sheet mica (block, film, and splittings) in the United States decreased 11 percent to 9 million pounds from 10.1 million pounds in 1959.

Domestic fabrication of muscovite block and film mica decreased 3 percent from 1959 to slightly less than 2.8 million pounds. The largest portion of this, 62 percent, went into electronic applications, principally tubes. Fabrication of muscovite block and film mica was reported by 21 companies in nine States. New Jersey, with 5, had the most plants but reported 15 percent less fabrication than in 1959. About 49 percent (1.3 million pounds) of the domestically fabricated block and film mica came from 13 companies in three States—New Jersey (5), New York (4), and North Carolina (4).

Consumption of mica splittings continued its downward trend with a 14-percent decrease in quantity and a 17-percent decrease in value. Muscovite splittings from India continued to constitute the bulk of the consumption (95 percent by weight); the remainder was principally phlogopite splittings from the Malagasy Republic. Mica splittings were fabricated by 11 companies at 12 plants in nine States. About 55 percent (3.4 million pounds) of the splittings was used at four plants—two in New York, one in New Hampshire, and one in Massachusetts.

Built-Up Mica.—Various forms of built-up mica were produced domestically from splittings for use principally as electrical insulation. Segment plate was the form in greatest demand (26 percent of the total built-up mica), followed closely by tape (24 percent) and molding plate (22 percent). Total consumption of built-up mica declined 16 percent in quantity and 19 percent in value from 1959.

Reconstituted Mica.—This sheet material, which is formed by papermaking procedures from specially delaminated natural mica scrap, substituted for built-up mica in many applications and also was the dielectric material in special capacitors. General Electric Co. at Coshocton, Ohio, and Samica Corp. (subsidiary of Minnesota Mining & Manufacturing Co.) at Rutland, Vt., continued to be the only producers. Total output, slightly greater than in 1959, was the largest since production began in 1952.

Synthetic Mica.—Commercial production of synthetic mica flake, principally for use in glass-bonded mica ceramic materials, was continued by Electronic Mechanics, Inc., Clifton, N.J., and Synthetic Mica Co., Division of Mycalex Corp. of America, West Caldwell, N.J. Electronic Mechanics processed its crude product to recover high-quality crystals of synthetic mica, 1 square inch or larger. These crystals were split and punched for commercial use in special electronic-tube and other applications.

Other Substitutes for Sheet Mica.—Farnam Manufacturing Co., Inc., Asheville, N.C., continued to manufacture a heat-resistant electrical-insulation product from finely divided natural mica bonded with water-soluble aluminum phosphate. The material was produced as rigid sheets and in various shapes.

Ground Mica.—A 16-percent increase in demand for dry-ground mica combined with a 14-percent decrease in demand for wet-ground mica to give a net increase of 12 percent in total sales of ground mica. Roofing materials and paint continued to lead in consumption of ground mica. All major end uses except roofing materials took smaller proportions of the total ground mica than in 1959.

TABLE 6.—Fabrication of muscovite ruby and nonruby block and film mica and phlogopite block mica, by qualities and end-product uses in the United States in 1960

(Pounds)

Variety, form, and quality	Electronic uses				Nonelectronic uses			Grand total
	Capacitors	Tubes	Other	Total	Gago glass and diaphragms	Other	Total	
Muscovite:								
Block:								
Good Stained or better	405	16,572	2,075	19,052	5,548	795	6,343	25,395
Stained	7,324	1,154,157	2,456	1,163,937	1,661	19,950	21,611	1,185,548
Lower than Stained [1]	300	444,039	37,333	481,672	1,005	1,017,600	1,018,605	1,500,277
Total	8,029	1,614,768	41,864	1,664,661	8,214	1,038,345	1,046,559	2,711,220
Film:								
First quality	5,132	----------	----------	5,132	----------	----------	----------	5,132
Second quality	47,462	----------	----------	47,462	----------	100	100	47,562
Other quality	2,425	----------	----------	2,425	----------	----------	----------	2,425
Total	55,019	----------	----------	55,019	----------	100	100	55,119
Block and film:								
Good Stained or better [2]	52,999	16,572	2,075	71,646	5,548	895	6,443	78,089
Stained [3]	9,749	1,154,157	2,456	1,166,362	1,661	19,950	21,611	1,187,973
Lower than Stained	300	444,039	37,333	481,672	1,005	1,017,600	1,018,605	1,500,277
Total	63,048	1,614,768	41,864	1,719,680	8,214	1,038,445	1,046,659	2,766,339
Phlogopite: Block (all qualities)	----------	----------	835	835	----------	9,049	9,049	9,884

[1] Includes punch mica.
[2] Includes First- and Second-quality film.
[3] Includes other-quality film.

TABLE 7.—Fabrication of muscovite ruby and nonruby block and film mica in the United States in 1960, by qualities and grades

(Pounds)

Form, variety, and quality	Grade					
	No. 4 and larger	No. 5	No. 5½	No. 6	Other [1]	Total
Block:						
Ruby:						
Good Stained or better	4,775	2,266	1,531	13,293	680	22,545
Stained	10,967	53,022	75,132	915,978	91,056	1,146,155
Lower than Stained	87,124	131,524	75,931	431,308	494,451	1,220,338
Total	102,866	186,812	152,594	1,360,579	586,187	2,389,038
Nonruby:						
Good Stained or better	1,416	32	---------	1,402	---------	2,850
Stained	1,210	5,690	2,240	30,253	---------	39,393
Lower than Stained	19,756	25,329	5,159	627	229,068	279,939
Total	22,382	31,051	7,399	32,282	229,068	322,182
Film:						
Ruby:						
First quality	1,407	925	700	1,200	---------	4,232
Second quality	20,603	15,002	7,598	3,384	---------	46,587
Other quality	---------	---------	---------	---------	2,425	2,425
Total	22,010	15,927	8,298	4,584	2,425	53,244
Nonruby:						
First	---------	---------	700	200	---------	900
Second	145	110	720	---------	---------	975
Other	---------	---------	---------	---------	---------	---------
Total	145	110	1,420	200	---------	1,875

[1] Figures for block mica include "all smaller than No. 6" grade and "punch" mica.

TABLE 8.—Consumption and stocks of mica splittings in the United States, by sources

(Thousand pounds and thousand dollars)

	Canadian		Indian		Malagasy (Formerly Madagascan)		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Consumption:								
1951–55 (average)	[1] 115	[1] $63	9,094	$6,977	[2] 726	[2] $542	9,935	$7,582
1956	---------	---------	7,996	3,945	666	490	8,662	4,435
1957	(3)	(3)	7,531	3,617	[3] 506	[3] 401	8,037	4,018
1958	(3)	(3)	4,982	2,437	[3] 347	[3] 283	5,329	2,720
1959	(3)	(3)	6,726	3,098	[3] 497	[3] 366	7,223	3,464
1960	---------	---------	5,915	2,642	312	233	6,227	2,875
Stocks, Dec. 31:								
1951–55 (average)	[4] 31	[4] 14	7,212	6,274	[5] 431	[5] 367	7,674	6,655
1956	(3)	(3)	5,077	2,814	[3] 374	[3] 304	5,451	3,118
1957	(3)	(3)	4,942	2,594	[3] 325	[3] 267	5,267	2,861
1958	(3)	(3)	3,392	1,801	[3] 316	[3] 258	3,708	2,059
1959	---------	---------	3,057	1,387	347	244	3,404	1,631
1960	---------	---------	2,839	1,270	316	212	3,155	1,482

[1] Includes Canadian, 1951–54, and domestic and Mexican, 1951.
[2] Includes Canadian, 1955.
[3] Canadian included with Madagascan.
[4] Average for 1951–53 data.
[5] Includes Canadian, 1954–55.

TABLE 9.—Built-up mica[1] sold or used in the United States, by products

(Thousand pounds and thousand dollars)

Product	1959		1960	
	Quantity	Value	Quantity	Value
Molding plate	1,232	$2,785	1,015	$2,325
Segment plate	1,390	3,119	1,210	2,886
Heater plate	799	2,586	510	1,478
Flexible (cold)	519	1,880	541	1,894
Tape [2]	1,402	6,720	1,117	5,260
Other	116	898	177	747
Total	5,458	17,988	4,570	14,590

[1] Consists of alternate layers of binder and irregularly arranged and partly overlapped splittings.
[2] Includes a small quantity of built-up mica for "Other combination materials."

TABLE 10.—Ground mica sold by producers in the United States, by uses

Use	1959		1960	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Roofing	[1] 36,574	[1] $925	53,918	$1,272
Wallpaper	519	74	569	85
Rubber	12,101	869	10,020	785
Paint	21,178	1,865	22,007	1,873
Plastics	[1] 2,394	[1] 127	488	58
Welding rods	1,769	116	(2)	(2)
Joint cement	14,863	1,017	13,189	837
Well drilling	12,508	388	10,775	299
Other uses [3]	[1] 5,274	[1] 265	9,397	396
Total	[1] 107,180	[1] 5,646	120,363	5,605

[1] Revised figure.
[2] Included with "Other uses."
[3] Includes mica used for molded electric insulation, house insulation, Christmas-tree snow, annealing, welding rods (1960), and other purposes.

PRICES AND SPECIFICATIONS

Prices offered by mica fabricators for domestic clear sheet mica (roughly trimmed), as reported in E&MJ Metal and Mineral Markets were unchanged from 1959 and ranged from 7 to 12 cents a pound for the smallest size (punch) to $4 to $8 a pound for 6- by 8-inch sheets. Stained or electric mica was quoted 10 to 20 percent lower.

The Government continued to purchase domestically produced full-trimmed and half-trimmed muscovite mica at prices established in May 1956. Government prices for hand-cobbed mica have not changed since 1954; however, purchasing procedures have varied.

North Carolina scrap mica was quoted throughout the year at $20 to $30 a short ton, depending on quality. Prices for dry- and wet-ground mica were steady.

A task force of the American Society for Testing Materials (ASTM) began preparing for the Indian industry a set of standard block mica samples, equivalent to the ASTM official standards. Another task force continued to investigate problems that have become apparent in the operation of the Armcorp Waviness Tester.

TABLE 11.—Prices for domestically produced muscovite mica purchased by the Government in 1960, by grade and quality

Form, variety, and grade	Price per pound					Price per short ton
	Full-trimmed			Half-trimmed		
	Good Stained or better	Stained	Heavy Stained	Stained	Heavy Stained	
Block and film mica:						
Ruby:						
No. 3 and larger	$70.00	$31.90	$14.80	$12.00	$8.00	
No. 4 and No. 5	40.00	18.25	6.85	5.00	4.00	
No. 5½ and No. 6	17.70	7.55	4.00	3.00	2.00	
Nonruby:						
No. 3 and larger	70.00	25.55	11.85	9.60	6.40	
No. 4 and No. 5	40.00	14.60	5.45	4.00	3.20	
No. 5½ and No. 6	17.70	6.55	4.00	2.40	1.60	
Hand-cobbed mica:						
Ruby						$600
Nonruby						540

TABLE 12.—Price of dry- and wet-ground mica in the United States in 1960 [1]

(Cents per pound)

Mica	Value	Mica	Value
Dry-ground:		Wet-ground [2]—Continued	
Paint, 100-mesh	4	Paint or lacquer, less than carlots [3]	9
Plastic, 100-mesh	4	Rubber	8
Roofing, 20- to 80-mesh	3	Rubber, less than carlots [3]	8¾
Wet-ground: [2]		Wallpaper	8¾
Biotite	6½	Wallpaper, less than carlots [3]	9
Biotite, less than carlots [3]	7¼	White, extra fine	8¼
Paint or lacquer	8¼	White, extra fine, less than carlots [3]	9

[1] In bags at works, carlots, unless otherwise noted.
[2] Freight allowed east of the Mississippi River, one-half cent higher west of the Mississippi River, 1 cent higher west of the Rockies.
[3] Exwarehouse or freight allowed east of the Mississippi River.

Source: Oil, Paint and Drug Reporter.

FOREIGN TRADE [3]

Imports.—Total quantity of mica imported for consumption was 2 percent lower than in 1959. Declines in imports of manufactured mica and uncut sheet and punch were largely counteracted by a 34-percent increase in tonnage of scrap mica. The large decrease (44 percent) in value of total mica imports resulted chiefly from the big drop in imports of uncut sheet and punch, which has a high unit value. Imports of this material were down 66 percent in quantity and 72 percent in value from 1959.

General imports of muscovite block and film mica for 1959, compiled by the U.S. Tariff Commission and not previously available, are shown.

Exports.—Total exports of mica and mica products were 21 percent lower than in 1959. Ground-mica exports, which again comprised most of the total, dropped about 21 percent, but exports of other manufactured mica rose 13 percent. Exports of unmanufactured mica were the smallest since 1956 but were second high in value for the years since World War II.

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

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TABLE 13.—U.S. imports and exports of mica

Year	Imports for consumption								Exports	
	Uncut sheet and punch		Scrap		Manufactured		Total		All classes	
	Pounds	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1951-55 (average)	2,444,097	[1] $3,637	6,090	[1] $91	6,362	[1] $10,760	13,674	[1] $14,488	2,682	$1,269
1956	1,958,907	[1] 3,747	7,218	79	5,411	[1] 7,926	13,608	[1] 11,752	4,896	1,717
1957	1,841,840	[1] 3,359	5,187	57	5,766	[1] 8,031	11,874	[1] 11,447	5,355	1,550
1958	2,181,056	5,092	4,064	48	5,053	8,800	10,208	13,940	4,741	1,217
1959	[2] 3,220,412	[2] 7,305	4,644	57	5,042	7,443	[2] 11,296	[2] 14,805	5,102	1,239
1960	1,088,021	2,081	6,240	86	4,266	6,139	11,050	8,306	4,012	1,311

[1] Data known to be not comparable with other years.
[2] Revised figure.

Source: Bureau of the Census.

TABLE 14.—U.S. imports for consumption of mica, by kinds and countries [1]

Year and country	Unmanufactured									
	Waste and scrap, valued not more than 5 cents per pound				Untrimmed phlogopite mica from which no rectangular piece exceeding 1 by 2 inches in size may be cut		Other			
	Phlogopite		Other				Valued not above 15 cents per pound, n.e.s.		Valued above 15 cents per pound	
	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
1951-55 (average)	619,811	$6,450	11,560,210	[2] $84,873	115,518	$21,038	224,215	$19,006	2,104,364	[2] $3,597,336
1956	365,794	3,050	14,070,144	75,847	----	----	209,274	16,858	1,749,633	[2] 3,730,824
1957	----	----	10,373,171	56,888	----	----	220,460	16,424	1,621,380	[2] 3,342,465
1958	----	----	8,128,613	48,169	----	----	10,317	1,182	2,170,739	5,090,800
1959	----	----	9,287,998	56,825	----	----	132,420	7,872	[3] 3,087,992	[3] 7,297,452
1960:										
North America:										
Canada	----	----	11,100	278	----	----	----	----	----	----
Jamaica	----	----	----	----	----	----	----	----	251	373
Mexico	----	----	----	----	----	----	----	----	385	893
South America:										
Argentina	----	----	----	----	----	----	88,186	5,775	69,859	18,155
Brazil	----	----	99,207	2,700	----	----	21,344	1,797	549,158	978,438
Europe:										
Spain	----	----	----	----	----	----	----	----	110	694
United Kingdom	----	----	11,631	157	----	----	----	----	2,000	13,494
Asia:										
India	----	----	8,951,600	51,392	----	----	3,400	479	305,868	920,401
Japan	----	----	----	----	----	----	----	----	100	100
Africa:										
Angola	----	----	3,299,497	30,801	----	----	----	----	14,034	29,817
British East Africa	----	----	----	----	----	----	6,050	549	15,235	75,009
Malagasy Republic	----	----	----	----	----	----	----	----	3,660	8,134
Mozambique	----	----	----	----	----	----	----	----	1,891	2,669
Rhodesia and Nyasaland, Federation of	----	----	----	----	----	----	----	----	100	197
Sudan	----	----	----	----	----	----	----	----	1,584	4,726
Union of South Africa	----	----	107,680	944	----	----	----	----	843	12,112
Oceania: Australia	----	----	----	----	----	----	----	----	3,963	6,297
Total	----	----	12,480,715	86,272	----	----	118,980	8,600	969,041	2,071,509

Year and country	Manufactured—films and splittings							
	Not cut or stamped to dimensions				Cut or stamped to dimensions		Total films and splittings	
	Not above 12/10,000 of an inch in thickness		Over 12/10,000 of an inch in thickness					
	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
1951-55 (average)	10,091,865	[2] $5,656,136	2,098,103	[2] $3,740,622	50,830	[2] $908,823	12,240,798	[2] $10,305,581
1956	7,708,637	2,684,774	2,757,479	3,651,949	62,918	[2] 1,064,288	10,529,034	[2] 7,401,011
1957	9,303,287	[2] 3,871,615	1,936,041	[2] 2,569,468	71,652	[2] 1,050,799	11,310,980	[2] 7,491,882
1958	7,628,263	4,551,191	2,268,139	3,135,871	40,884	646,800	9,937,286	8,333,862
1959	7,059,064	2,806,063	2,726,667	2,643,361	80,696	1,261,977	9,866,427	6,711,401
1960:								
North America:								
Jamaica	255	1,332	3,259	17,584	2,739	10,906	6,253	29,822
Mexico	26	136	4,570	4,520	14,044	282,441	18,640	287,097
South America:								
Argentina			2,061	2,248			2,061	2,248
Brazil	528,212	524,796	347,024	440,962	1,495	6,369	876,731	972,127
Europe:								
Austria	12,500	1,611					12,500	1,611
France					57	1,183	57	1,183
Germany, West					289	7,605	289	7,605
Netherlands					24	560	24	560
Spain			87	418	724	3,606	811	4,024
United Kingdom	76,950	14,831	1,097	5,584	12,423	267,746	90,470	288,161
Asia:								
India	6,102,161	2,180,353	626,122	744,151	32,465	193,880	6,760,748	3,118,384
Japan			1,600	1,777	15,742	345,670	17,342	347,447
Pakistan					500	463	500	463
Africa:								
Angola			485	1,272			485	1,272
Malagasy Republic [4]	464,840	312,103	99	194			464,939	312,297
Rhodesia and Nyasaland, Federation of			755	106			755	106
Somali Republic					1,985	1,658	1,985	1,658
Sudan			1,940	2,045			1,940	2,045
Total	7,184,944	3,035,162	989,099	1,220,861	82,487	1,122,087	8,256,530	5,378,110

See footnotes at end of table.

TABLE 14.—U.S. imports for consumption of mica, by kinds and countries [1]—Continued

Year and country	Manufactured—cut or stamped to dimensions, shape, or form		Manufactured—other: Mica plates and builtup mica		Manufactured—other: All mica manufactures of which mica is the component material of chief value		Manufactured—other: Ground or pulverized	
	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
1951-55 (average)	54,048	[2] $77,688	30,449	[2] $185,799	42,083	[2] $169,948	355,882	$20,010
1956	59,518	[2] 79,273	110,963	[2] 200,130	54,703	[2] 241,248	69,000	4,140
1957	31,904	[2] 44,099	37,866	[2] 85,933	103,924	[2] 406,952	46,000	2,760
1958	2,711	4,328	21,561	24,796	96,456	434,259	48,238	2,863
1959	5,310	9,144	30,403	29,065	135,326	690,088	46,049	2,965
1960:								
North America:								
Canada							46,000	2,760
Jamaica					2,392	4,694		
Mexico	300	330			15,214	55,408		
South America: Brazil					60,620	227,471		
Europe:								
Belgium-Luxembourg			71,351	59,632				
France					110	4,169		
Germany, West					86	214		
Netherlands					2,755	14,467		
Spain					260	891		
United Kingdom	5,204	6,735	203	557	38,559	291,174		
Asia:								
India	1,238	1,736	830	5,262	31,772	78,947		
Japan					1,086	6,248		
Africa: Angola					13	110		
Total	6,742	8,801	72,384	65,451	152,867	683,793	46,000	2,760

[1] Changes in Minerals Yearbook 1959, 1950-54 (average) should read as follows: p. 781, Manufactured—films and splittings—Cut or stamped to dimensions—46,078 pounds ($788,534): Total films and splittings—14,642,758 pounds ($12,875,621); p. 782, Manufactured—Cut or stamped to dimensions, shape or form—63,021 pounds ($90,736).
[2] Data known to be not comparable with other years.
[3] Changes in Minerals Yearbook 1959, p. 780, should read as follows: Other unmanufactured—Valued above 15 cents per pound—Brazil, 961,868 pounds ($1,836,715); India, 1,898,258 pounds ($5,085,284), total all countries 3,087,992 pounds ($7,297,452).
[4] Effective July 1, 1960; formerly Madagascar.

Source: Bureau of the Census.

TABLE 15.—U.S. imports[1] of muscovite block and film mica, by qualities and principal countries

(Pounds)

Quality	India		Brazil		Other		Total	
	1958	1959	1958	1959	1958	1959	1958	1959
Block:								
Good Stained and better	91,250	238,542	129,719	109,495	43,339	182,499	264,308	530,536
Stained	1,638,942	2,206,100	765,482	679,548	51,816	108,963	2,456,240	2,994,611
Heavy Stained	198,441	790,971	669,818	629,838	8,598	79,714	876,857	1,500,523
Lower	63,757	54,618	146,320	205,667	1,367	143,774	211,444	404,059
Total	1,992,390	3,290,231	1,711,339	1,624,548	105,120	514,950	3,808,849	5,429,729
Film:								
First quality	25,027	23,081	-------	-------	248	-------	25,275	23,081
Second quality	73,913	59,496	-------	975	802	18,677	74,715	79,148
Other quality	17,900	33,581	-------	-------	-------	-------	17,900	33,581
Total	116,840	116,158	-------	975	1,050	18,677	117,890	135,810
Block and film:								
Good Stained and better[2]	190,190	321,119	129,719	110,470	44,389	201,176	364,298	632,765
Stained[3]	1,656,842	2,239,681	765,482	679,548	51,816	108,963	2,474,140	3,028,192
Heavy Stained	198,441	790,971	669,818	629,838	8,598	79,714	876,857	1,500,523
Lower	63,757	54,618	146,320	205,667	1,367	143,774	211,444	404,059
Total	2,109,230	3,406,389	1,711,339	1,625,523	106,170	533,627	3,926,739	5,565,539

[1] Data are "general imports"; that is, they include mica imported for immediate consumption plus material entering the country under bond.
[2] Includes First- and Second-quality film.
[3] Includes other-quality film.

Source: U.S. Tariff Commission from official documents of the U.S. Bureau of Customs.

TABLE 16.—U.S. exports of mica and manufactures of mica, by countries

Year and destination	Unmanufactured		Manufactured			
			Ground or pulverized		Other	
	Pounds	Value	Pounds	Value	Pounds	Value
1951–55 (average)	360,524	$55,360	4,747,369	$267,885	256,999	$945,800
1956	546,673	91,991	8,901,497	485,879	343,159	1,138,861
1957	911,006	46,391	9,256,170	520,557	541,432	983,446
1958	1,030,540	90,565	8,198,367	430,820	254,198	695,626
1959	1,072,894	126,492	8,915,109	459,425	216,040	652,863
1960:						
North America:						
Bahamas	----------	----------	190	244	580	600
Canada	166,101	29,340	3,398,971	156,988	150,196	416,965
Canal Zone	----------	----------	----------	----------	56	614
Cuba	60,000	2,020	167,540	5,890	1,279	3,762
Dominican Republic	----------	----------	22,000	1,760	114	464
Guatemala	----------	----------	46,600	3,684	----------	----------
Haiti	----------	----------	----------	----------	257	1,031
Jamaica	2,310	1,522	69,000	1,926	1,232	1,282
Mexico	74,476	33,749	251,500	14,038	4,990	23,082
Netherlands Antilles	----------	----------	----------	----------	2	474
South America:						
Argentina	----------	----------	----------	----------	2,604	5,041
Bolivia	----------	----------	60,000	2,100	----------	----------
Brazil	----------	----------	12,740	706	2,787	7,919
British Guiana	----------	----------	----------	----------	48	676
Chile	----------	----------	48,000	1,500	5,014	19,515
Colombia	1,760	3,385	118,000	6,570	17,442	33,513
Ecuador	----------	----------	14,400	1,182	----------	----------
Peru	----------	----------	124,100	6,031	5,191	6,061
Uruguay	1,800	208	----------	----------	1,191	8,985
Venezuela	98,896	2,633	577,250	25,250	1,902	6,599
Europe:						
Austria	----------	----------	----------	----------	476	986
Belgium-Luxembourg	1,053	3,036	104,754	7,930	2,506	11,886
Denmark	----------	----------	----------	----------	494	2,947
France	1,113	1,156	268,850	21,793	4,528	32,038
Germany, West	2,302	2,982	366,600	30,154	4,059	41,616
Greece	800	784			----------	----------
Iceland	----------	----------	24,000	1,806	----------	----------
Italy	160,006	4,383	580,950	36,665	1,195	9,351
Netherlands	----------	----------	1,400	276	819	1,986
Portugal	----------	----------	6,900	612	45	1,446
Spain	----------	----------	13,200	990	----------	----------
Sweden	----------	----------	----------	----------	4,938	45,774
Switzerland	19,472	15,975	30,200	2,280	----------	----------
United Kingdom	10,837	9,538	----------	----------	1,460	10,193
Yugoslavia	----------	----------	60,000	4,846	66	628
Asia:						
Bahrein	----------	----------	----------	----------	6	480
India	----------	----------	24,500	1,838	300	1,458
Indonesia	----------	----------	8,600	782	----------	----------
Iraq	----------	----------	----------	----------	274	550
Israel	----------	----------	34,400	3,046	141	929
Japan	100,000	2,140	----------	----------	12,003	70,519
Kuwait	----------	----------	36,000	1,590	----------	----------
Philippines	----------	----------	53,000	5,120	5,706	3,241
Saudi Arabia	----------	----------	----------	----------	208	827
Taiwan	----------	----------	----------	----------	588	1,100
Africa:						
Algeria	----------	----------	19,300	942	----------	----------
Congo, Republic of the and Ruanda-Urundi [1]	----------	----------	----------	----------	390	1,668
Ethiopia	----------	----------	----------	----------	34	244
Libya	----------	----------	387,400	14,183	----------	----------
Union of South Africa	----------	----------	145,400	7,382	805	4,029
Oceania:						
Australia	1,000	250	----------	----------	7,428	47,982
New Zealand	----------	----------	1,500	113	----------	----------
Total	701,926	113,101	7,077,245	370,217	243,354	828,461

[1] Effective July 1, 1960: formerly Belgian Congo.

Source: Bureau of the Census.

WORLD REVIEW

World production of mica exceeded 400 million pounds for the first time. This record-high total was 19 percent higher than in 1959, chiefly because of increased scrap production in the United States, India, and Union of South Africa.

Angola.—Mica production increased, probably because matters regarding claims north of Luanda were settled. Cia. Mineira do Lobito took full control of the D'Aboim Ingles claim.[4]

Argentina.—Based on incomplete figures, exports of mica were slightly greater in quantity and almost 50 percent greater in value than the 202 short tons valued at $69,000 recorded in 1959. About 45 percent of the 1960 exports went to the United States, 35 percent to Italy, and 15 percent to Mexico.[5]

Australia.—The Commonwealth Mica Pool, a governmental agency, stopped buying locally produced mica in December, and the Pool was to be discontinued completely as soon as practicable. The Pool had incurred a loss on its operations each year partly because of costs involved in disposing of mica stocks acquired during earlier years. The Tariff Board in June 1958 recommended retention of the 27.5 percent customs duty on mica from India, Australia's principal supplier, but opposed the request by mica miners for a subsidy on production. Because of losses by the Pool and a continued decrease in the number of miners since the Tariff Board report, the Cabinet decided that this activity by the Government was no longer justified.[6]

Brazil.—Exports of mica, 904 short tons in 1958 and 992 short tons valued at US $1,260,000 in 1959, decreased appreciably in 1960. Cessation of purchases for the United States stockpile in midyear removed a major market for Brazilian mica.[7]

Canada.—A new scrap-mica producing deposit was reported in Loughborough Township, Ontario. Initial production comprised 100 tons of scrap mica from the surface, but recovery of sheet mica also was planned.[8]

India.—Changes in the policy on mineral concessions had improved the outlook for mica production in Rajasthan and Ajmer. Rajasthan now ranks next to Bihar in mica production.[9]

Termination of U.S. Government contracts to obtain imported mica for the stockpile removed a large market for block and film mica. As a result, exports to the United States became an appreciably smaller part of the total mica shipped from India.[10]

Total exports of mica from India, 33,500 tons valued at US $22.4 million, were 7,500 tons greater in quantity but US $1.5 million less in value than in 1959. The decline in value resulted from the decrease in exports of block mica, which has a high unit value. The increased quantity was accounted for largely by scrap mica exports, which rose

[4] U.S. Consulate, Luanda, Angola, State Department Dispatch 249: Apr. 11, 1961, p. 5.
[5] U.S. Embassy, Buenos Aires, Argentina, State Department Dispatch 976: Feb. 7, 1961, p. 5.
[6] Bureau of Mines, Mineral Trade Notes: Vol. 52, No. 3, March 1961, pp. 25–26.
[7] U.S. Embassy, Rio de Janeiro, Brazil, State Department Dispatch 1044: Apr. 28, 1960, encl. 1, p. 4; State Department Dispatch 1137: May 19, 1960, p. 6.
[8] Northern Miner (Toronto, Canada), New Mica Producer Ships Small Tonnage: Vol. 46, Oct. 13, 1960, p. 10.
[9] Mining Journal (London), Mineral Resources of Rajasthan and Ajmer: Vol. 254, No. 6503, Apr. 8, 1960, p. 408.
[10] U.S. Consulate, Calcutta, India, State Department Dispatch 792: May 23, 1960, p. 6.

TABLE 17.—World production of mica by countries [1] [2]

(Thousand pounds)

Country [1]	1951-55 (average)	1956	1957	1958	1959	1960
North America:						
Canada (shipments):						
Block	240	79	108	90	49	1,270
Splittings	4	2	15	----------	----------	
Ground	1,120	1,493	910	1,380	591	
Scrap	1,153	269	247	35	174	
United States (Sold or used by producers):						
Sheet	691	888	690	661	706	579
Scrap	158,748	172,618	184,876	186,694	203,082	239,858
South America:						
Argentina:						
Sheet	1,153	322	212	[3] 192	[3] 403	[3] 397
Scrap	26	2	2			
Brazil	3,937	2,926	3,265	2,829	2,553	[4] 2,645
Europe:						
Austria	134	----------	----------	134	216	317
Norway, including scrap	2,515	3,749	4,630	4,519	5,291	6,614
Spain	22	26	24	20	11	(5)
Sweden:						
Block	24	----------	----------	----------	----------	----------
Ground	362	392	474	421	[4] 440	[4] 440
Yugoslavia	----------	18	37	4	4	9
Asia:						
Ceylon	7	----------	----------	----------	----------	----------
India (exports):						
Block	3,825	6,065	4,411	5,243	6,305	5,216
Splittings	16,585	14,663	16,645	14,264	15,988	17,469
Scrap	19,861	27,282	27,915	24,001	29,242	42,829
Taiwan, including scrap	240	29	11	(5)	(5)	----------
Africa:						
Angola:						
Sheet	40	53	46	46	20	26
Scrap and splittings	322	968	844	716	384	855
Kenya	2	----------	----------	15	22	2
Malagasy Republic (phlogopite):						
Block	496	77	139	234	271	256
Splittings	1,109	1,109	2,011	2,152	1,922	1,973
Morocco, Southern zone:						
Sheet	7	----------	----------	----------	----------	----------
Scrap	22	----------	----------	----------	----------	----------
Mozambique, including scrap	13	26	66	4	7	2
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia, Sheet	15	7	1	2	(5)	1
Southern Rhodesia:						
Block	179	123	71	108	106	90
Scrap	445	----------	----------	----------	----------	----------
South-West Africa	51	----------	----------	----------	234	----------
Sudan:						
Block	----------	----------	13	225	----------	----------
Scrap	----------	----------		154	----------	----------
Tanganyika (exports):						
Sheet	176	128	148	108	117	179
Ground	7	----------	----------	----------	----------	----------
Scrap	159	280	----------	24	190	----------
Union of South Africa:						
Sheet	9	1	2	2	(5)	2
Scrap	5,198	5,038	4,226	4,259	3,752	7,284
Oceania: Australia:						
Block	68	29	37	31	33	[4] 70
Scrap	37	----------	40	62	141	
Damourite	1,058	1,058	1,455	1,080	1,100	[4] 1,100
World total (estimate) [1] [2]	280,000	305,000	320,000	315,000	345,000	410,000

[1] Mica is also produced in China, Rumania, and U.S.S.R., but production data are not available; estimates for these countries are included in the total.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Exports.
[4] Estimate.
[5] Less than 500 pounds.

Compiled by Liela S. Price, Division of Foreign Activities.

from 14,600 tons valued at U.S. $294,000 in 1959 to 21,400 tons valued at US $441,000.[11]

The Mica Export Promotion Council formed the nucleus of an inspection service to maintain quality of exports, but exporters reportedly have not taken advantage of preshipment inspection of exports. The Council negotiated with the Mica Importers Association, with offices in New York City, regarding a set of visual standards for mica and also commented on a draft by the Association on rules and procedures for arbitration of disputes regarding mica quality and grade.[12]

In March, the Mica Merchants Association in Giridih, Bihar, called a strike in protest against the multipoint sales tax imposed on mica and other commodities. The strike not only brought mica trade in the area to a standstill but also threw out of work the thousands of employees of small processing plants and the large number of splitters working at home. The strike was called off unconditionally in April.[13]

Malagasy Republic.—Exports of mica were expected to be about the same as in 1959 when the total was 985 tons valued at US$1,142,000. The bulk of this was splittings, 792 tons valued at $930,000.[14]

Rhodesia and Nyasaland, Federation of.—The small production of mica reported for 1959 was expected to continue during 1960. Most of the production came from seven mines in the Miami area of Southern Rhodesia. Exports of unmanufactured sheet mica to the United States in 1959 totaled 2,503 pounds valued at US$3,584.[15]

Sudan.—The mica-bearing pegmatites in the Shereik region, which produced a small quantity of mica in 1956–58, were not being worked. A. R. Girais & Sons was seeking financial assistance to develop its mining concession in the area.[16]

Tanganyika.—The Department of Mines, assisted by the Geological Survey, organized and conducted in April and again in October a 3-week course of instruction in the simpler aspects of prospecting, mining, and preparation of mica.[17]

Exports of sheet mica were valued at US$222,300 compared with US$147,800 in 1959.[18]

U.S.S.R.—The U.S.S.R. is an important producer of mica for its own needs, but Russian industry was beginning to use Indian mica. Splittings comprised the bulk of the mica obtained from India, but some block and condenser films were included.[19]

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[11] U.S. Consulate, Calcutta, India, State Department Dispatch 618: June 6, 1961, encl. 1, pp. 3–4.
[12] U.S. Consulate, Calcutta, India, State Department Dispatch 792: May 23, 1960, p. 6; State Department Dispatch 808: May 31, 1960, p. 1.
[13] U.S. Consulate, Calcutta, India, State Department Dispatch 684: Apr. 11, 1960, 2 pp.; State Department Dispatch 714: Apr. 21, 1960, 1, p.
[14] Bureau of Mines, Mineral Trade Notes: Vol. 52, February 1961, pp. 19–20.
[15] U.S. Consulte, Salisbury, Federation of Rhodesia and Nyasaland, State Department Dispatch 732: May 19, 1960, p. 3.
U.S. Consulate, Johannesburg, Union of South Africa, State Department Dispatch 57: Aug. 29, 1960, p. 21.
[16] U.S. Embassy, Cairo, Egypt, State Department Dispatch 645: Mar. 16, 1960, encl. 1, p. 1.
U.S. Embassy, Ankara, Turkey, State Department Dispatch 549: Feb. 23, 1960, 27 pp.
[17] Mining Journal (London), East Africa's First Prospecting Course: Vol. 254, June 10, 1960, pp. 672–673; Mining Miscellany: Vol. 255, Sept. 30, 1960, p. 362.
[18] Mining Journal (London), Tanganyika's Record Year: Vol. 256, Mar. 3, 1961, p. 235.
[19] U.S. Embassy, Moscow, U.S.S.R., State Department Dispatch 335: Nov. 17, 1960. encl. 1, p. 4.

United Kingdom.—The Board of Trade accepted bids from the Spruce Pine Mica Co., Spruce Pine, N.C., for 670 pounds of large-size high-quality mica. This mica was part of a World War II Stockpile.[20]

TECHNOLOGY

Natural Mica.—A publication concerning mica deposits and the mica industry in Canada also discussed the properties, preparation, uses, and prices of mica.[21] The Geological Survey of Canada awarded funds to Queen's University for a study of the crystallization of mica and its relation to determining the age of certain minerals.[22] Examination of some pegmatites in southern India disclosed a large area suitable for mica prospecting.[23]

Operations of a small mica mine in Maine were described briefly.[24] Information was obtained on recovering scrap mica as one of the products from a deposit in Colorado,[25] and occurrences of muscovite and sericite in New Mexico were described.[26] Structural and petrographic studies were used to indicate the course of crystallization in two well-defined segments of a zoned pegmatite.[27]

Two articles were published in a series on studies of the ceramic properties of mixtures of mica and clay minerals.[28]

The high indices of refraction and the green color of a dioctahedral potassium mica were attributed to the iron content.[29] An examination of formulas calculated from published analyses of various natural micas showed the relationship of layer charge to substituted cations.[30] From study of analyses reported in the literature, an investigator concluded that the composition of most lithium micas can be interpreted as derived from muscovite or siderophyllite.[31] Aluminum-free boron phlogopite and biotite and probably boron-bearing muscovite were synthesized in an investigation of substituting boron for aluminum in the tetrahedral position of hydrous phyllosilicates.[32] The trioctahedral micas were determined to be members of a complete sys-

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[20] Electronic News, Spruce Pine Buys Mica from Britain: Vol. 5, Feb. 1, 1960, p. 24.

[21] Hoadley, J. W., Mica Deposits of Canada: Department of Mines and Technical Surveys, Canada, Econ. Geol. Series No. 19, Ottawa 1960, 141 pp.

[22] Mining Journal (London), Geology Grants to Universities: Vol. 255, Dec. 9, 1960, pp. 654–655.

[23] Subramanyan, K. V., Mica in Cuddapah and Anantapur Districts (India): Current Science (Bangalore, India), vol. 29, January 1960, p. 55.

[24] Engineering and Mining Journal, Maine Mica Mine Increases Production: Vol. 161, February 1960, p. 220.

[25] Gilkey, M. M., Hyatt Ranch Pegmatite, Larimer County, Colo.: Bureau of Mines Rept. of Investigations 5643, 1960, 18 pp.

[26] Northrop, S. A., Minerals of New Mexico: Univ. of New Mexico Press, Rev. ed., 1959, 665 pp.

[27] Norton, J. J., Hugo Pegmatite, Keystone, South Dakota: Geol. Survey Prof. Paper 400–B, 1960, pp. B67–B70.

[28] Brindley, G. W., and Udagawa, S., High-Temperature Reactions of Clay Mineral Mixtures and Their Ceramic Properties; Kaolinite-Mica-Quartz Mixtures with 25 Weight Percent Quartz; Jour. Am. Ceram. Soc., vol. 43, February 1960, pp. 59–65.

Brindley, G. W., and Maroney, D. M., High-Temperature Reactions of Clay Mineral Mixtures and Their Ceramic Properties: Reactions of Kaolinite-Mica-Quartz Mixtures Compared with the K_2O–Al_2O_3–SiO_2 Equilibrium Diagram: Jour. Am. Ceram. Soc., vol. 43, October 1960, pp. 511–516.

[29] Foster, M. D., Bryant, B., and Hathaway, J., Iron-Rich Muscovitic Mica from the Grandfather Mountain Area, North Carolina: Am. Mineral., vol. 45, July–August 1960, pp. 839–951.

[30] Foster, M. D., Layer Charge Relations in the Dioctahedral and Trioctahedral Micas: Am. Mineral., vol. 45, March–April 1960, pp. 383–398.

[31] Foster, M. D., Interpretation of the Composition of Lithium Micas: Geol. Survey Prof. Paper 354–E, 1960, pp. 115–146.

[32] Eugster, H. P., and Wright, T. L., Synthetic Hydrous Boron Micas; No. 202 in Short Papers in the Geological Sciences, Geological Survey Research 1960: Geol. Survey Prof. Paper 400–B, 1960, pp. B441–B442.

tem with phlogopite at one end and siderophyllite and lepidomelane at the other.[33]

A French article on the structure of muscovite was abstracted [34] as were articles on the release of argon from muscovite, biotite, and phlogopite [35] and on the examination of tracks of fission products in mica crystals.[36] Additional information on effects of radiation on mica was published.[37] A reexamination of a Tasmanian hydromuscovite resulted in a different interpretation of its atomic structure.[38] The structure of micas was shown to influence their susceptibility to ion exchange.[39]

Two articles in Russian discussed the forces involved in splitting mica along the cleavage plane.[40] The exchange of surface potassium ions on contact of mica surfaces in air was discussed in relation to adhesion of the surfaces.[41]

A machine was described for stacking and handling flat pieces of mica incidental to their use in electronic tube assemblies,[42] and an apparatus was developed for classifying mica by electrical measurement.[43]

Mica was reported in use as a window in an image tube,[44] as an anchor for components in a special type of cathode-ray tube,[45] and as a window material in high-vacuum apparatus.[46] Tests on animals indicated that biotite mica reduces the passage of radioactive contaminants in food into body tissues.[47]

Data on properties of mica and mica products appeared in a number of articles,[48] and problems with mica dielectrics were discussed.[49]

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[33] Foster, M. D., Interpretation of the Composition of the Trioctahedral Micas: Geol. Survey Prof. Paper 354–B, 1960, pp. 11–49.

[34] Gatineau, L., and Méring, J., [Structure of Muscovite]: Clay Minerals Bull., vol. 3, 1958, pp. 238–243 (in French); Ceram. Abs., vol. 43, July 1960, p. 179.

[35] Gerling, E. K., and Morozova, I. M., [Determination of Activation Energy of Liberation of Argon from Micas]: Geokhimiya (U.S.S.R.), No. 4, 1957, pp. 304–311; Technical Translations, Office of Technical Services, U.S. Department of Commerce, Washington, D.C., vol. 3, Apr. 13, 1960, p. 411.

[36] Bonfiglioli, G., Brovetto, P., and others, Electron Microscopy Examination of Tracks of Fission Products in Mica Crystals: Final report on Contract AF 61(514) 1333, March 1960, 40 pp.; U.S. Govt. Research Reports, U.S. Department of Commerce, Washington, D.C., vol. 34, Sept. 16, 1960, p. 342.

[37] Seed, T. J., Electron Damage in Mica: Jour. Appl. Phys., vol. 31, July 1960, p. 1300.

[38] Radoslovich, E. W., Hydromuscovite with the $2M_2$ Structure—A Criticism: Am. Mineral., vol. 45, July–August 1960, pp. 894–898.

[39] Bassett, W. A., Role of Hydroxyl Orientation in Mica Alteration: Bull. Geol. Soc. America, vol. 71, April 1960, pp. 449–455.

[40] Metsik, M. S., [Theory of Mica-Crystal Splitting]; Fizika tverdogo tela, vol. 1, July 1959, p. 1084–1091.

Deryagin, B. V., and Metsik, M. S., [The Role Played by Electric Forces in Mica Splitting Along the Cleavage Planes]: Fizika tverdogo tela, vol. 1, October 1959, pp. 1521–1528.

[41] Gaines, G. L., Jr., Adhesion and Ion Exchange between Mica Surfaces: Nature, vol. 183, Apr. 18, 1959, pp. 1109–1110.

[42] Collins, D. M., and Boller, E. H. (assigned to Industrial Mica Corp.), Mica Flat Handling Systems: U.S. Patent 2,935,830, May 10, 1960.

[43] Mandal, S. S., and Roy, S. B., Rapid Classification of Mica on the Basis of Electrical Properties: Central Glass & Ceram. Res. Inst. Bull. (Calcutta), vol. 6, July–September 1959, pp. 136–139.

[44] Research and Development, New Products: Vol. 11, October 1960, p. 64.

[45] Materials in Design Engineering, Materials at Work: Vol. 52, September 1960, p. 179.

[46] Espe, W., [Mica as a Construction Material in High-Vacuum Technique]: Trans. of Vakuum-Technik (Germany), vol. 8, No. 1, 1959, pp. 15–19; Technical Translations, Office of Technical Services, U.S. Department of Commerce, Washington, D.C., vol. 4, Nov. 25, 1960, p. 567.

Anderson, J. M., Thin Vacuum-Tight Mica Window Suitable for Baking at 500° C.: Rev. Sci. Instr., vol. 31, August 1960, pp. 898–899.

[47] Mining Congress Journal, News and Views: Vol. 46, July 1960, p. 83.

[48] Materials in Design Engineering, Properties of Materials; Other Nonmetallics: Vol. 52, Mid-November 1960, p. 286.

Hessinger, P. S., Inorganic Plastics Insulation: Plastic World, vol. 18, October 1960, pp. 18–19.

Materials in Design Engineering, Properties of Materials; Mica, Sheet, Molded: Vol. 50, Mid-October 1959, p. 272.

[49] New, A. A., Some Mechanisms of Failure of Capacitors with Mica Dielectrics: Proc. Inst. Elec. Eng., vol. 107, pt. B., July 1960, pp. 357–364.

Scrap mica was ground wet in a porcelain-lined ball mill to give an excellent product.[50] A mobile mill was used to produce dry-ground mica [51] which was separated from the ore by a multiple-step pneumatic process.[52] A mill was developed for grinding and classifying mica and other materials by means of fluid energy,[53] as was a cyclone separator for separating mica from silt.[54]

Ground mica was used in resinous surface coatings,[55] in friction material for brake linings,[56] in flame retarding composition for fabrics,[57] in bituminous coating compositions,[58] in coatings for a liquid-gas contact pad,[59] in a release coating for fiberboard containers,[60] and in a composition for removing surface corrosion from metals.[61]

The addition of platy wet-ground mica to acrylic latex exterior paints was beneficial to gloss and color retention, light transmission, and water-vapor sealing properties of the paint film.[62] Wet-ground mica in formulations of paints based on water soluble resins imparts increased vapor resistance to the films.[63] Two methods were demonstrated for evaluating the influence of differences in particle size and shape of pigmentation.[64]

Synthetic Mica.—Insulation engineers were showing increased interest in synthetic mica because of its purity and properties at high temperature.[65]

Research on synthetic mica by the Federal Bureau of Mines continued at its Norris Metallurgy Research Laboratory, Norris, Tenn. Principal efforts were directed toward studying crystal growth, producing micas of various compositions, and determining properties of various synthetic micas. Synthetic micas with various cationic substitutions were used to make a large number of satisfactory fluormica ceramics having properties dependent on composition and processing techniques.[66]

The U.S. industry-Government program to develop substitutes for strategic natural mica continued to seek a method for converting flake synthetic mica into a suitable sheet material. Efforts were focused

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[50] Majumdar, K. K., Two Notes on Mineral Processing, (1) Preparation of Wet-Ground Mica: Min. Magazine (London), vol. 103, July 1960, p. 9.

[51] Mining Record, Mobile Mica Mill Tests Favorably: Vol. 71, Feb. 25, 1960, p. 1.

[52] Mencimer, M. E., Dry Beneficiation Process: U.S. Patent 2,928,542, Mar. 15, 1960.

[53] Croft, G. M. (assigned to Majac, Inc.), Impact Mill: U.S. Patent 2,932,458, Apr. 12, 1960.

[54] Fenske, D. H., and Sorenson, R. T. (assigned to International Minerals & Chemical Corp.), Cyclone Separator: U.S. Patent 2,929,501, Mar. 22, 1960.

[55] Chemical Age (London), Mica for Surface Coatings: Vol. 83, Mar. 12, 1960, p. 454.

[56] Maierson, T., and Todd, R. A. (assigned to General Motors Corp.), Friction Material for Use in Brakes: U.S. Patent 2,954,853, Oct. 4, 1960.

[57] McCluer, J. D. (assigned to Thermoid Co.), Flame Retarding Composition and Fabric Treated Therewith: U.S. Patent 2,948,641, Aug. 9, 1960.

[58] Wilkinson, C. E. (assigned to Texaco, Inc.), Asphaltic Compositions: U.S. Patent 2,923,639, Feb. 2, 1960; Coating Compositions and Coated Structures: U.S. Patent 2,939,794, June 7, 1960.

[59] Frohmader, S. H. (assigned to Research Products Corp.), Mineral Coated Liquid-Gas Contact Pad: U.S. Patent 2,955,064, Oct. 4, 1960.

[60] Wilkins, C. W. (assigned to Owens-Illinois Glass Co.), Cleavable Release Coating: U.S. Patent 2,926,829, Mar. 1, 1960.

[61] Hilton, S. (assigned to E. & A. West, Ltd.), Composition for the Removal of Corrosion from Metal Surfaces: U.S. Patent 2,937,149, May 17, 1960.

[62] Wet-Ground Mica Association, Inc., The Influence of Wet-Ground Mica on Acrylic Latex Exterior House Paints: Tech. Bull. 41, April 1960, 5 pp.

[63] Wet-Ground Mica Association, Inc., The Use of Platy Wet-Ground Mica in Paints Based on Water-Soluble Resins. Pt. 2: Tech. Bull. 42, July 1960, 5 pp.

[64] Wet-Ground Mica Association, Inc., Test Methods for the Water Vapor Permeability and Heat Reflectance of Pigmented Organic Coatings: Tech. Bull. 43, September 1960, 6 pp.

[65] Electronic News, Broader Use of Mica Sought Through Synthetic Processes: Vol. 5, June 13, 1960, p. 31.

[66] Shell, H. R., Effect of Isomorphic Substitutions on Properties of Fluormica Ceramics: Bureau of Mines Rept. of Investigations 5667, 1960, 40 pp.

principally on bonding the flakes by recrystallization or other means and forming a useful reconstituted sheet from water-swelling fluormicas.

The U.S. Air Materiel Command continued to sponsor synthetic mica research at Synthetic Mica Co., Division of Mycalex Corp. of America, under a contract in effect since May 1958. The objective of the program was to develop a commercially feasible technique for producing large-area, single crystals of fluorphlogopite mica.

A furnace and method for producing synthetic mica were claimed to give a purer product and higher yield.[67] Synthetic mica was proposed as a treating material in the processing of cast iron and other metals to improve the microstructure and other properties of the cast metal.[68]

Soviet scientists continued their research on synthetic mica. A laboratory for synthetic mica reportedly was being organized as part of the Institute for Rare Metals at Irkutsk, Siberia.[69] General information on the properties of synthetic mica was reported,[70] and glass films less than 100 microns thick were claimed to have properties comparable to those of natural mica.[71]

Built-Up and Reconstituted Products from Natural and Synthetic Mica.— Evaluation of reconstituted natural mica as a substitute for natural mica in electronic tubes and capacitors continued to be sponsored by the U.S. Army Signal Supply Agency. In one of these contracts, Micamold Electronics Manufacturing Corp., Brooklyn, N.Y., concluded tests of resin-impregnated reconstituted mica as a capacitor material. Certain types of capacitors using these impregnated mica papers as dielectric materials met all military specifications, but other types failed some of the tests.[72] In the other of these contracts, General Electric Co., Owensboro, Ky., fabricated tube spacers from mica paper bonded with an undisclosed inorganic material and incorporated them in certain types of electronic tubes. Work was completed during the year and, although the final report was not issued, results reported indicated that reconstituted mica is a promising substitute for natural mica in some electronic tubes. However, some changes may be required in tube processing, spacer thickness, and pattern dimensions.[73]

The properties and applications of impregnated mica paper, alone and in combination with reinforcing materials, were discussed.[74] An insulation consisting of silicone-bonded mica paper between layers of silicone-varnished glass cloth had a greater dielectric strength than either mica paper or built-up mica.[75] Improved tensile strength and moisture resistance were claimed for a mica paper impregnated with

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[67] Worden, E. C. (assigned to Synthetic Mica Corp.), Method and Apparatus for Manufacturing Synthetic Mica: U.S. Patent 2,923,754, Feb. 2, 1960.

[68] Evans, N. R., Mica Treated Metals: U.S. Patent 2,932,564, Apr. 12, 1960; Cast Iron and Process for Making Same: U.S. Patent 2,932,567, Apr. 12, 1960.

[69] E&MJ Metal and Mineral Markets, Siberia Will Become Synthetic Mica Center: Vol. 31, Jan. 14, 1960, p. 3.

[70] Akhtyrskiy, K. [Information about New Materials]: Promyshlenno-Ekonomicheskaya Gazeta, vol. 5, Apr. 13, 1960, p. 4.

[71] Loktionov, Ye. [A Competitor of Mica]: Ekonomicheskaya Gazeta, No. 16 (688), June 18, 1960, p. 4.

[72] Micamold Electronics Manufacturing Corp., Reconstituted Mica Paper for Capacitors: Quart. Progress Repts. 11–12, Contract No. DA–36(039)–SC–75959, January–June 1960.

[73] General Electric Company Receiving Tube Department, Evaluation of Reconstituted Natural Mica for Use in Electron Tubes: Tenth Quart. Progress Rept., Contract DA–36 (039)–SC–75960, January–March 1960.

[74] Schwartz, F., Impregnated Mica Paper is Excellent Insulator: Materials in Design Eng., vol. 52, July 1960, pp. 114–115.

[75] Materials in Design Engineering, Mica Insulation High in Dielectric Strength: Vol. 52, October 1960, pp. 196–198.

an anhydrous alkyl orthosilicate and further processed to produce silicon-bonded alkoxy groups.[76] Bonding of reconstituted mica by impregnation with alkylorthotitanate and subsequent hydrolysis also was said to give a superior insulating material.[77] Various silicates and silicones were used to bond natural or synthetic mica into an insulating sheet material.[78] Another insulating sheet material was formed from two sheets of polytetrafluorethylene with a layer of silicone-bonded mica flakes or splittings in between.[79]

Electrophoresis of a suspension of finely divided synthetic mica in various anhydrous alcohols was a suggested method of forming a reconstituted mica sheet insulation.[80]

Pilot-plant production of two kinds of synthetic mica paper was reported.[81] Synthetic mica also was the primary crystalline phase in a ceramic material suitable for higher temperatures than the standard glass-bonded material.[82] Another high-temperature glass-bonded mica was reported suitable for potentiometer coil forms.[83] Glass-bonded natural mica was compared with a number of other insulators, and some processing advantages of the glass-bonded material were discussed.[84]

An insulating material was reported made in Japan from mica waste and glass fibers.[85]

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[76] Gaines, G. L., Jr., and Bueche, A. M. (assigned to General Electric Co.), Mica Paper: U.S. Patent 2,948,329, Aug. 9, 1960.

[77] Corrin, M. L. (assigned to General Electric Co.), Method of Impregnating Mica Paper with an Alkyl Orthotitanate and Product Produced Thereby: U.S. Patent 2,948,640, Aug. 9, 1960.

[78] Brown, S. W. (assigned to North American Aviation, Inc.), Silicon-Mica Composition: U.S. Patent 2.953,466, Sept. 20, 1960.

[79] Traynor, E. J., Jr. (assigned to Westinghouse Electric Corp.), Flexible Bonded Mica Insulation: U.S. Patent 2,949,150, Aug. 16, 1960.

[80] McNeill, W., and Jonassen, H. B. (assigned to the United States of America as represented by the Secretary of the Army), Reconstituted Synthetic Mica and Its Process of Making: U.S. Patent 2.936.218, May 10. 1960.

[81] Materials in Design Engineering, Synthetic Mica Paper Resists Fire, Solvents: Vol. 51, February 1960, pp. 200–202; Synthetic Mica Paper Useful up to 1,800° F: Vol. 52, December 1960, pp. 180–182.

[82] Hessinger, P. S., and Weber, T. W., Development of a Synthetic Mica Ceramic Suitable for Use at 750° C.: Bull. Am. Ceram. Soc., vol. 39, January 1960, pp. 10–13.

[83] Electronic News, Glass-Bonded Mica for Pot Coil Forms: Vol. 5, Aug. 15, 1960, p. 43.

[84] Faloon, J. E., Glass-Bonded Mica: Materials in Design Eng., vol. 51, February 1960, pp. 96–99.

[85] Electronic News, Develop Insulators from Mica Waste: Vol. 5, June 27, 1960, p. 40.

Molybdenum

By Wilmer McInnis[1] and Mary J. Burke[2]

UNITED STATES production of molybdenum during 1960 was 10 percent higher than the previous annual high reached in 1955.

Domestic consumption of molybdenum contained in concentrate increased substantially compared with 1959, mainly because of greater foreign demand for molybdic oxide.

Domestic exports were higher than in any past year, chiefly because of increased use of molybdenum in alloy steelmaking by Western European and Japanese producers.

New laboratory processes for producing metallic molybdenum were investigated, and commercial production and fabrication facilities were enlarged.

TABLE 1.—Salient molybdenum statistics

(Thousand pounds of contained molybdenum and thousand dollars)

	1951–55 (average)	1956	1957	1958	1959	1960
United States:						
Concentrate:						
Production	51,961	57,462	60,753	41,069	50,956	68,237
Shipments	52,645	57,126	57,143	42,328	51,603	69,941
Value[1]	$52,075	$63,901	$67,605	$50,371	$64,655	$87,406
Consumption	32,222	42,652	38,954	31,298	37,448	44,784
Imports for consumption	68		27	1		
Stocks, Dec. 31: Mine and plant	6,257	2,920	7,093	5,643	4,074	3,481
Primary products:						
Production	31,509	41,208	37,698	30,915	36,294	43,427
Shipments	31,591	42,820	36,865	31,359	41,658	45,777
Consumption	(2)	33,497	30,016	24,231	32,350	31,837
Stocks, Dec. 31: Producer	3,378	2,812	5,789	8,081	5,958	8,157
World: Production	62,000	70,300	76,200	57,700	[3] 70,200	89,400

[1] Largely estimated by Bureau of Mines.
[2] Data not available.
[3] Revised figure.

LEGISLATION AND GOVERNMENT PROGRAMS

General Services Administration (GSA) contracted with a domestic firm to have a quantity of molybdenum concentrate in the national stockpile upgraded to molybdic oxide containing about 4 million pounds of molybdenum.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

Government financial assistance in exploration of molybdenum mineral deposits was available from the Office of Minerals Exploration (OME), but no new contracts were negotiated during the year.

Individual validated licenses were required during 1960 for the export of molybdenum ores, concentrates, and primary products.

DOMESTIC PRODUCTION

Molybdenum production from the Climax mine in Colorado, together with the quantities recovered as a byproduct from copper in Arizona, Nevada, New Mexico, and Utah and from tungsten ores in California, exceeded the 1959 output by 34 percent. Mine shipments of molybdenum contained in concentrate were 36 percent higher than in 1959 and were 5 percent higher than the previous annual high reached in 1942 when shipments exceeded production by more than 9 million pounds. Of the 69.9 million pounds of molybdenum contained in concentrate shipped during the year, 46.6 million pounds went to domestic firms and 23.3 million pounds was shipped for export to foreign nations.

Molybdenum Mines.—The Climax mine in Lake County, Colo., was the only domestic mine operated chiefly for molybdenum. The mine, one of the world's largest underground operations, was worked on two levels (the Phillipson at 11,470 feet elevation and the Storke at 11,170 feet) by large-scale caving methods. According to the firm's annual report to its stockholders, a record 11,684,000 tons of ore was mined. The ore was milled and treated in flotation cells to produce a concentrate containing over 90 percent MoS_2. Tailing from flotation cells was further processed in a separate byproduct plant where tungsten and tin concentrates were recovered.

Climax Molybdenum Co. continued work on the development of another mining level 300 feet below the Storke level and started work on an access development tunnel in a new area of the ore body known as the Ceresco Ridge. The firm planned to mine ore from the new area through a separate adit at 11,470 feet elevation.

Climax Molybdenum Co. sold its houses at Climax and Leadville, Colo. to John W. Galbreath and Co. Those at Climax were being moved to Leadville.

Molybdenum Corporation of America continued exploration of its molybdenite deposit in Taos County, N. Mex. The firm announced that exploration from June 15, 1957, to June 30, 1960, had indicated 260 million tons of ore that averaged 5 pounds of molybdenum disulfide per ton, and further exploration indicated additional ore, of which some was said to contain about 3 percent MoS_2.

Byproduct Sources.—Molybdenum recovered from copper and tungsten ores increased 28 percent compared with 1959, but because of expanded output from the Climax Molybdenum mine the quantity recovered from all byproduct sources comprised a smaller percentage of the total domestic production than in 1959. The molybdenum concentrate produced by Duval Sulphur & Potash Co. in Arizona was converted to molybdic oxide before shipment, and part of the molybdenum recovered by Union Carbide Nuclear Co. in California was converted to oxide before shipment. The other byproduct producers shipped molybdenite concentrate.

CONSUMPTION AND USES

Domestic consumption of molybdenum contained in concentrate was higher than in any year since 1943. The 20-percent increase over the quantity consumed during 1959 was due mainly to shipments of molybdic oxide for export rather than to greater demand for molybdenum products by domestic consumers. Except for relatively small quantities used in producing purified molybdenum disulfide and for direct additions to steel, the molybdenum concentrate consumed was converted to molybdic oxide, which was used to produce virtually all other primary molybdenum products. In addition to data given in tables 1 and 2 on consumption of molybdenum concentrate and production of molybdenum products, a quantity of molybdenum concentrate held in the national stockpile was converted to molybdic oxide and to ferromolybdenum.

TABLE 2.—Production, shipments, and stocks of molybdenum products in the United States

(Thousand pounds of contained molybdenum)

	Product					
	Molybdic oxide [1]		Metal powder		Ammonium molybdate	
	1959	1960	1959	1960	1959	1960
Received from other producers	3,080	4,436	110	31	47	24
Gross production during year	33,816	40,337	2,517	2,692	1,716	2,216
Used to make other products listed here	11,545	9,457	210	90	1,426	2,044
Net production	22,271	30,880	2,307	2,602	290	172
Shipments:						
Domestic consumers	26,156	27,406	2,401	2,465	220	247
Export	3,038	6,586			10	
Total	29,194	33,992	2,401	2,465	230	247
Producer stocks, Dec. 31	2,326	3,660	287	456	181	129

	Product				Total	
	Sodium molybdate		Other [2]			
	1959	1960	1959	1960	1959	1960
Received from other producers	4	45		3	3,241	4,539
Gross production during year	361	476	11,067	9,304	49,477	55,025
Used to make other products listed here	2			7	13,183	11,598
Net production	359	476	11,067	9,297	36,294	43,427
Shipments:						
Domestic consumers	374	492	9,242	8,151	38,393	38,761
Export		2	217	428	3,265	7,016
Total	374	494	9,459	8,579	41,658	45,777
Producer stocks, Dec. 31	86	114	3,078	3,798	5,958	8,157

[1] Includes molybdic oxide briquets, molybdic acid, and molybdenum trioxide.
[2] Includes ferromolybdenum, calcium molybdate, phosphomolybdic acid, molybdenum disulfide, and pellets.

Because many small consumers of molybdenum products were not canvassed during 1960, data given in table 3 were estimated to have comprised 91 percent of the total new molybdenum consumed by the domestic industries.

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Owing to a sharp decline in alloy steel production after the first quarter of 1960, molybdenum consumption decreased from 11,000,000 pounds in the first quarter to about 6,200,000 pounds in the fourth quarter. This resulted in a slight decrease in total molybdenum consumption for the year compared with 1959 when a prolonged steel strike curtailed the use of molybdenum in alloy steelmaking. Exceptions to the general decline from 1959 were the uses of molybdenum in making steel mill rolls, high-temperature alloys, welding rods, catalysts, lubricants, and metallic molybdenum shapes. The quantity of molybdenum powder consumed in making wire, rod, forgings, and other shapes increased 6 percent compared with 1959. In addition, 775,000 pounds of molybdenum powder, pellets, and other metallic forms (excluding scrap) were consumed in making high temperature and other special alloys compared with 497,000 pounds in 1959. The electric, electronic, aircraft and missile, and glass industries were among the major consumers of metallic molybdenum and its alloys.

TABLE 3.—Consumption of molybdenum products by end uses in 1960

(Thousand pounds of contained molybdenum)

End use	Molybdic oxides [1]	Ferro-molybdenum [2]	Molybdenum metal powder	Ammonium molybdate	Sodium molybdate	Other [3]	Total
Steel:							
High speed	1,061	622				73	1,756
Hot-work tool	222	65				2	289
Other tool	208	112				4	324
Stainless	1,922	1,819				18	3,759
Other alloy [4]	13,944	1,724				53	15,721
Steel mill rolls	1,050	102					1,152
Gray and malleable castings	366	2,371	2			18	2,757
Welding rods		259					259
High-temperature alloys	513	166	32			635	1,346
Molybdenum powder:							
Wire, rod and sheet			829				829
Other			1,507				1,507
Chemicals:							
Inorganic pigments	467			10	22		499
Organic pigments	125			4	226	2	357
Catalysts	326			45	1		372
Miscellaneous [5]	63	369	13	17	3	445	910
Total	20,267	7,609	2,383	76	252	1,250	31,837
Stocks at consumer plants Dec. 31	2,504	1,147	70	8	28	223	3,980

[1] Includes technical and purified oxides.
[2] Includes molybdenum silicide and calcium molybdate.
[3] Includes thermite molybdenum and molybdenum pellets, purified molybdenum disulfide, and molybdenite concentrate.
[4] Includes quantities that were believed used in producing high-speed and stainless steels because some firms failed to specify individual uses.
[5] Includes magnets, other special alloys, friction material, lubricants, pesticides, refractories, and packings.

Because of the continuing demand for metallic molybdenum shapes, molybdenum-base alloys, and other refractory metals, Sylvania Electric Products, Inc., enlarged its refractory metals processing plant at Towanda, Pa.; General Electric Co. started construction of a new refractory metals plant at Cleveland, Ohio; and Climax Molybdenum Co. started constructing facilities to produce molybdenum powder and installed another vacuum melting furnace at its Coldwater, Mich., plant. Wah Chang Corp. moved its molybdenum and tungsten production and fabrication facilities to a newly constructed plant at Fair Lawn, N.J., and installed a second electron-beam melting furnace at its Albany, Oreg., research center for use in the study of basic properties of molybdenum and other refractory metals. Metals and Residues, Inc., completed installation of new molybdenum and tungsten reduction facilities at its Springfield, N.J., plant and molybdenum production was discontinued by its subsidiary firm, Johnson & Funk Metallurgical Corp., at Huntsville, Ala.

The quantity of molybdenum compounds consumed in making catalysts increased 58 percent compared with 1959, but the quantity used in making organic and inorganic pigments declined 5 percent. Calcium molybdate ($CaMoO_4$), zinc molybdate ($ZnMoO_4$), and zinc polymolybdate ($5ZnO.7MoO_3$) were reported to be good corrosion resisting pigments in paints used as primers for steel.[3]

STOCKS

Stocks of molybdenum contained in concentrate at mines and at plants making molybdenum products decreased 15 percent. Producer stocks of molybdenum products increased 37 percent, and stocks at consumer plants decreased 13 percent.

PRICES

There were no changes in the prices quoted by E&MJ Metal and Mineral Markets for molybdenum during 1960. The prices quoted for molybdenum concentrate and primary products, f.o.b. shipping point were: Molybdenite concentrate, 95 percent MoS_2, $1.25 per pound of contained molybdenum, plus cost of container, Climax, Colo.; molybdenum trioxide, MoO_3, bags $1.46, cans $1.47 per pound of contained molybdenum; ferromolybdenum, powdered $1.82, other sizes $1.76 per pound of contained Mo; and carbon-reduced molybdenum powder, $3.35 per pound. Hydrogen-reduced molybdenum powder, 99.5 percent pure, was quoted by the American Metal Market at $3.15–4.10 per pound, depending on mesh size.

Effective February 1, Climax Molybdenum Co., reduced prices on molybdenum disulfide lubricant products by $0.15 per pound. The new base prices for domestic resale were: Molysulfide, Technical-grade, $1.15 per pound; and molysulfide, Technical-fine, $1.35 per pound.

FOREIGN TRADE[4]

Imports.—There were no imports for consumption of molybdenum ore and concentrate into the United States. Imports for consumption of molybdenum products included: Ferromolybdenum, molybdenum metal and powder, calcium molybdate, and other compounds and alloys of molybdenum containing 24,195 pounds of molybdenum valued at $21,612; molybdenum ingots, shots, bars, or scrap molybdenum or molybdenum carbide with a gross weight of 154,108 pounds, valued at $25,812; and molybdenum sheets, wire, or other forms not elsewhere provided for, with a gross weight of 19,148 pounds, valued at $244,020.

[3] Chemical and Engineering News. Molybdates: New Pigments for Primers: Vol. 38, No. 46, Nov. 14, 1960, p. 58.
[4] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 4.—Molybdenum reported by producers as shipments for export from the United States

(Thousand pounds of contained molybdenum)

Product	1959	1960
Molybdenite concentrate	15,294	23,341
Molybdic oxide	3,038	6,586
All other primary products	227	430

TABLE 5.—U.S. exports of molybdenum products

(Pounds, gross weight)

Product	1959	1960
Ferromolybdenum [1]	248,012	424,819
Metal and alloys in crude form and scrap	15,172	295,004
Wire	12,395	9,639
Powder	11,314	9,620
Semifabricated forms (mainly rods, sheets, and tubes)	8,921	4,940

[1] Ferromolybdenum contains about 60-65 percent molybdenum.

Source: Bureau of the Census.

TABLE 6.—U.S. exports of molybdenum ore and concentrate (including roasted concentrate), by countries

Destination	1959		1960	
	Molybdenum content (pounds)	Value	Molybdenum content (pounds)	Value
North America:				
Canada	243,737	$335,712	915,473	$909,978
Mexico	600	910	3,268	3,638
Total	244,337	336,622	918,741	913,616
South America:				
Argentina	1,000	1,600	400	698
Brazil			1,986	2,512
Chile			3,000	4,410
Total	1,000	1,600	5,386	7,620
Europe:				
Austria	1,597,175	2,291,279	1,985,863	2,961,352
Belgium-Luxembourg	51,415	79,027	29,200	45,163
France	2,467,769	3,165,071	4,907,280	6,291,624
Germany, West	6,023,620	7,703,833	7,205,098	9,169,392
Italy	963,133	1,231,803	1,729,162	2,223,635
Netherlands	327,137	451,690	296,373	446,539
Sweden	1,368,596	1,747,365	1,785,497	2,244,095
Switzerland	82,816	106,551		
United Kingdom	4,074,786	5,288,599	6,630,386	8,476,785
Total	16,956,447	22,065,218	24,568,859	31,858,585
Asia:				
Japan	1,625,986	2,339,886	4,716,978	7,020,365
Philippines	3,500	5,550	3,600	5,524
Total	1,629,486	2,345,436	4,720,578	7,025,889
Africa: Rhodesia and Nyasaland, Federation of	1,009	1,545		
Oceania: Australia	20,000	27,800	30,932	41,681
Grand total	18,852,279	24,778,221	30,244,496	39,847,391

Source: Bureau of the Census.

Exports.—Domestic exports of molybdenum contained in concentrate and molybdic oxide increased 60 percent compared with 1959 and were higher than in any past year. The increase in the exports was due mainly to expanded use of molybdenum in alloy steelmaking by Western European and Japanese steel producers. Of the 30.2 million pounds exported, 24 percent went to West Germany, 22 percent to the United Kingdom, 16 percent to France, 16 percent to Japan, and the rest to 12 other countries.

Ferromolybdenum valued at $489,140 was exported to 12 countries; molybdenum wire exports were valued at $277,140; and exports of molybdenum powder were valued at $32,463. Other molybdenum products exported included molybdenum metal and alloys in crude form and scrap valued at $367,870 and molybdenum and molybdenum alloys in semifabricated forms valued at $74,008.

Tariff.—There were no changes in the import duties on molybdenum ores and concentrates and primary molybdenum products. The duties imposed under various trade agreements to the Tariff Act of 1930 on imports from all countries, except the U.S.S.R. and other designated Communist countries and areas, were: Molybdenum ores and concentrates, 30 cents per pound of contained molybdenums; ferromolybdenum, molybdenum metal and powder, calcium molybdate, and other compounds and alloys of molybdenum, 25 cents per pound of molybdenum plus 7.5 percent ad valorem; and sheets, wire, or other forms of molybdenum or molybdenum carbide, 25.5 percent ad valorem.

WORLD REVIEW

No official statistics were available on molybdenum production in the U.S.S.R. and other Communist bloc nations, but estimates for those countries are included in the world total. Free-world production of 75.1 million pounds was mainly from the United States (91 percent), and Chile (6 percent), with Canada, Mexico, Japan, Norway, and the Philippines, accounting for virtually all the rest.

NORTH AMERICA

Canada.—The Molybdenite Corporation of Canada, Ltd., produced molybdenum from its La Corne mine in Quebec. The molybdenite ore mined contained bismuth, which was recovered as a byproduct of the molybdenum. Molybdenum output declined compared with 1959, mainly because the ore mined and treated was lower grade.

Preissac Molybdenite Mines, Ltd., in which Molybdenite Corporation of Canada, Ltd., owned a substantial interest, planned to construct a plant at its molybdenite property in Preissac Township, northwestern Quebec. Indicated ore reserves of the deposit were said to be on the order of 1,250,000 tons averaging 0.53 percent MoS_2. Another molybdenite deposit in Preissac Township, owned by Anglo American Molybdenite Mining Corp., was explored further by Dumont Nickel Corp. Estimated ore reserves of the deposit were 2,240,000 tons averaging close to 0.50 percent MoS_2.[5]

[5] Engineering and Mining Journal, In Canada, Quebec, vol. 161, September 1960, p. 200.

TABLE 7.—World production of molybdenum in ores and concentrates by countries [1] [2]

(Thousand pounds)

Country [1]	1951-55 (average)	1956	1957	1958	1959	1960
Australia	2	(3)	2	4	(3)	(3)
Austria	20	2				
Canada	403	842	785	888	747	758
Chile	3,183	3,122	2,998	2,972	3,785	4,440
China	(4)	(4)	(4)	[5] 2,200	[5] 3,300	[6] 3,300
Japan	320	534	600	683	793	842
Korea, Republic of	18	31	31	68	49	97
Mexico	42	33	29	57	57	132
Norway	317	366	397	481	498	[5] 498
Peru	4			(3)		
Philippines					97	95
Portugal	[7] 7	11	18			
Union of South Africa			13	9		
U.S.S.R	(4)	(4)	[5] 9,300	[5] 9,300	[5] 9,900	[5] 11,000
United States	51,961	57,462	60,753	41,069	50,956	68,237
Yugoslavia	15	4	4	4	[5] 4	
World total (estimate) [1]	62,000	70,300	76,200	57,700	70,200	89,400

[1] Molybdenum is also produced in North Korea, Rumania, and Spain, but production is negligible.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Less than 500 pounds.
[4] Data not available; estimate by senior author of chapter included in total.
[5] Estimate.
[6] Data represents estimated 1959 production; 1960 production may be larger.
[7] Average for 1953–55.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

Mexico.—A molybdenite deposit was discovered in Manuel M. Dieguez Municipality in the State of Jalisco, Mexico. Preliminary exploration indicated that the deposit may be large, but the work had not progressed sufficiently to delineate the ore body.

SOUTH AMERICA

Chile.—Molybdenum production in Chile was higher than in any past year. All output was recovered as a byproduct of copper. The producing firms were Braden Copper Co., a subsidiary of Kennecott Copper Corporation, and Andes Copper Mining Co. and Chile Exploration Co., subsidiaries of The Anaconda Company. A labor strike during October–December 1960, combined with flotation problems experienced in separating the molybdenite from the copper sulfide concentrate, caused output at the Chile Exploration Co. Chuquicamata plant to fall far below expectation. Andes Copper Mining Co. started operating the molybdenum recovery unit at its El Salvador mine late in 1959, and by the end of 1960 it was reported that the unit was operating smoothly with recovery at about 80 percent. The unit, which is said to be on three main levels, was described.[6] Braden Copper Co. continued to be Chile's major producer of molybdenum. Output from the firm's El Teniente plant comprised about two-thirds of the total molybdenum produced in Chile in 1960.

Exports of molybdenite concentrate from Chile during 1960 totaled 2,895 short tons, with an estimated molybdenum content of 3,240,000 pounds. Of the total exports, 30 percent was shipped to the United

[6] Opkins, Jerold S., and Hauser, Irving, Molybdenum plant. Min. Eng., vol. 12, April 1960, pp. 370A–370C.

Kingdom, 35 percent to West Germany, 15 percent to the Netherlands, 14 percent to Sweden, and 6 percent to France. Producer stocks of concentrate at yearend totaled 1,574 short tons containing about 1,700,000 pounds of molybdenum.

EUROPE

Italy.—A molybdenite deposit in central Sardinia was reportedly being developed, and a plant was being constructed for processing 50 tons of ore a day. The plant was expected to be ready for operation in 1961.

ASIA

China.—An important molybdenum deposit was reported to have been discovered in the Ch'in-ling Mountain area of Shensi Province, China.[7] The Yang-chia-chang-tzu molybdenum deposit in Manchuria was believed to have been the source of most of the molybdenum produced in China during 1960, but data on output were not available.

TECHNOLOGY

The Federal Bureau of Mines research program on molybdenum involved the study of rock mechanics in mining, recovery of molybdenum from copper sulfide ores and uranium plant solutions, and the preparation and evaluation of molybdenum, its alloys, and compounds. Research on the preparation of molybdenum resulted in the development of a laboratory scale fused-salt-bath electrolytic process for electrowinning 99.8 percent pure molybdenum from impure molybdenum trioxide.[8]

In other studies, the oxygen content of molybdenum was reduced from 270 parts per million to less than 10 parts per million by fused-salt electrorefining, and thermodynamic data on molybdenum dioxide and molybdenum trioxide were published.[9]

Battelle Memorial Institute compiled and published research data on production processes, properties of molybdenum and its alloys, melting and casting, brazing, and on other studies.[10]

Climax Molybdenum Co. reviewed engineering data on metallic molybdenum and published a report containing sections on applications, physical properties, mechanical properties, resistance to corrosion, resistance to and protection from oxidation, fabrication of parts, methods of production, laboratory techniques, weight tables, and references.[11] The firm developed an austenitic manganese steel containing 12 percent manganese and 2 percent molybdenum, which was

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[7] Bureau of Mines, Mineral Trade Notes: Special Supplement No. 59, vol. 50, March 1960, p. 29.

[8] Heinen, H. J., and Zadra, J. B., Electrowinning Molybdenum, Preliminary Studies, Bureau of Mines Rept. of Investigations, 5795, 1961, 8 pp.

[9] King, E. G., Weller, W. W., and Christensen, A. V., Thermodynamics of Some Oxides of Molybdenum and Tungsten, Bureau of Mines Rept. of Investigations, 5664, 1960, 22 pp.

[10] Defense Metals Information Center, Production and Availability of Some High-Purity Metals: DMIC Memorandum 76, Dec. 2, 1960, pp. 25–28; Physical and Mechanical Properties of Commercial Molybdenum—Base Alloys: DMIC Report 140, Nov. 30, 1960, 142 pp.; Melting and Casting of the Refactory Metals Molybdenum, Columbium, Tantalum, and Tungsten: DMIC Report 139, Nov. 18, 1960, pp. 15–19; Brazing for High-Temperature Service: DMIC Report 149, Feb. 21, 1961, pp. 19–20; Strain Aging of Refractory Metals: DMIC Report 134, Aug. 12, 1960, pp. 35–43; Preliminary Design Information of Recrystallized Mo–0.5 Ti Alloy for Aircraft and Missiles; DMIC Memorandum 79, Jan. 16, 1961, 11 pp.

[11] Climax Molybdenum Co., Molybdenum Metal; 1960, 110 pp.

reported to combine toughness and abrasion resistance with a high degree of ductility, and another containing 6 percent manganese and 1 percent molybdenum, which was supposed to have good abrasion resistance with only moderate ductility.[12] Allegheny Ludlum Steel Corp. developed a magnetic alloy containing 79 percent nickel, 4 percent molybdenum, and 17 percent iron that was reported to have excellent permeability and core loss properties.

Research projects conducted under Federal Government contracts included: The preparation of molybdenum by direct thermal dissociation of molybdenum disulfide; tin reduction of molybdenum disulfide; hydrogen reduction of molybdenum pentachloride; preparation of molybdenum alloys by Kroll reduction techniques; welding of molybdenum and tungsten by electron beam; and development and production of improved molybdenum sheet by powder metallurgy and by arc-melt techniques. Among other research projects in cooperation with the Federal Government was the construction of a pilot plant for fabricating molybdenum and other refractory metals in an inert atmosphere at temperatures up to about 4,500° F. The plant, constructed at Bridgeville, Pa., by Universal-Cyclops Steel Corp., was described.[13]

Single crystals of molybdenum measuring up to about ¾ inch in diameter and 12 inches long were grown by an arc fusion process, and crystals about 18 inches long with a cross section of 1 by 3 inches were grown by electron beam melting.[14]

Among the patents issued were several concerning beneficiation, extraction, and alloys.[15]

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[12] Foundry, Resists Abrasion: Vol. 88, Nov. 1960, p. 148.

[13] Steel. 'InFab' Hot Works Refractory Metals: Vol. 146, No. 24, June 13, 1960, pp. 116–117.

[14] Materials in Design Engineering, Single Crystals of Refractory Metals Now Available: Vol. 52, No. 2, August 1960, pp. 13–14.

Journal of Metals, Mo Single Crystals: Vol. 12, December 1960, p. 899.

[15] Henderson, Harry B. (assigned to The Anaconda Company), Recovery of Molybdenite by Flotation: U.S. Patent 2,957,576, Oct. 25, 1960.

Zimmerley, S. R. and others (assigned to Kennecott Copper Corp.), Acid Process for Production of High-Grade Molybdenum Oxide: U.S. Patent 2,965,447, Dec. 20, 1960.

Pilloton, Roger L., and Crayton, Philip H. (assigned to Union Carbide Corp., New York), Process for Recovering Tungsten Values From Tungsten-Bearing Ore: U.S. Patent 2,963,-342, Dec. 6, 1960.

Pilloton, Roger L., and Crayton, Philip H. (assigned to Union Carbide Corp., New York), Method of Separating Molybdenum and Tungsten Values from Leach Liquors: U.S. Patent 2,963,343, Dec. 6, 1960.

Slatin, Harvey L., Electrolytic Production of Refractory Multivalent Metals: U.S. Patent 2,960,451, Nov. 15, 1960.

Ervin, Guy, Jr., and Others (assigned to Norton Company, Worcester, Mass.), Process for the Extraction of Relatively Pure Chromium, Molybdenum, and Tungsten: U.S. Patent 2,923,672, Feb. 2, 1960.

Wernlund, Christian J. (assigned to E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.), Electrodeposition of Molybdenum: U.S. Patent 2,943,029, June 28, 1960.

Marvin, Orrin F. (assigned to A. E. Butterfield, Tucson, Ariz., and A. K. Swann, Evansville, Ind.), Method for the Recovery of Uranium, Selenium, and Molybdenum: U.S. Patent 2,949,399, Aug. 16, 1960.

Jeffee, Robert I. (assigned to Kennecott Copper Corp., New York, N.Y.), Titanium-Molybdenum Alloys with Compound Formers: U.S. Patent 2,938,789, May 31, 1960.

Nickel

By Joseph H. Bilbrey, Jr.,[1] and Ethel R. Long [2]

INCREASED RESEARCH and development in exploration, processing, uses, and markets for nickel marked the year 1960. The 108,000 tons of nickel used in the United States in 1960 was slightly below the quantity used in 1959. The decrease resulted mainly from a lessened demand by the steel industry. On the other hand, free-world consumption rose to a record 258,000 tons, 20 percent more than in 1959, as the smaller demand by United States consumers was more than offset by increased demand in Western Europe, where more nickel was used in stainless steel, electroplating, and other industries. Substantially increased production of nickel in New Caledonia, Japan, and Canada, together with nickel from the U.S. Government Defense Production Act inventory supplied the 1960 free-world demand. U.S. nickel production also increased, reaching the equivalent of 13 percent of domestic consumption.

During 1960 because of difficulties with the Cuban Government the U.S. Government-owned plant at Nicaro and the Freeport Nickel Co. plant at Moa Bay, Cuba, each with an estimated annual capacity of 25,000 tons of nickel, were closed. The International Nickel Company of Canada, Ltd., announced that by the middle of 1961 it would approach its goal of 37,500 tons of nickel a year from its new plant at Thompson, Manitoba, which the company planned to open in 1961.

TABLE 1.—Salient nickel statistics

(Short tons)

	1951–55 (average)	1956	1957	1958	1959	1960
United States:						
Mine production	----------	7,392	12,900	13,490	13,374	14,079
Plant production:						
Primary [1]	1,295	6,722	10,070	11,740	11,606	14,303
Secondary	8,916	14,860	12,037	7,411	9,438	9,431
Imports for consumption	119,000	143,000	140,000	90,000	[2] 112,000	103,000
Exports	12,315	44,526	13,415	14,032	13,073	54,109
Consumption	99,719	127,578	122,466	79,017	112,661	108,159
Stocks Dec. 31: Consumer [3]	8,668	12,672	25,282	13,339	14,125	11,369
Price cents per pound	56½–64½	64½–74	74	74	74	74
World: Production	221,000	285,000	315,000	[2] 247,000	[2] 314,000	358,000

[1] Comprises metal from domestic ore, imported concentrate, and nickel recovered as a byproduct of copper refining.
[2] Revised figure.
[3] Excludes scrap.

LEGISLATION AND GOVERNMENT PROGRAMS

The Government did not make any new contracts to purchase nickel in 1960. In January, the Office of Civil and Defense Mobilization authorized the sale from Defense Production Act (DPA) inventory

[1] Commodity specialist, assisted technically by Isaac E. Weber, Division of Minerals.
[2] Statistical clerk, Division of Minerals.

of 19 million pounds of electrolytic nickel. About 12 million pounds of this was disposed of in 1960. In addition, about 23.7 million pounds of nickel from the DPA inventory was used in settlement of U.S. Government contracts. The General Services Administration agreed to sell to the Bureau of the Mint 500,000 pounds of nickel cathodes from DPA inventory, approximately the Mint's requirements for 1 year.

The Federal Register of August 2, 1960, contained notice of the disposal of about 314 short tons of arsenical nickel ore and approximately 1,400 short tons of nickel speiss from the strategic stockpile.

As of December 31, 1960 the DPA inventory of nickel was 125,365,000 pounds, 28 million pounds less than at the end of 1959. The inventory was reduced by sales of Nicaro nickel oxide sinter and electrolytic nickel and withdrawals under contract settlements arranged in 1959; it was increased by receipts of ferronickel from Hanna Nickel Smelting Co.

DOMESTIC PRODUCTION

Primary Nickel.—Domestic mine output of nickel contained in ore was 14,079 short tons, 5 percent more than in 1959. Hanna Nickel Smelting Co. treated 876,690 dry short tons of ore, averaging 1.51 percent nickel, from its nearby Riddle (Oreg.) deposit, to produce 24,364 tons of ferronickel, containing 11,114 tons of nickel. Output of nickel in ferronickel was 7 percent higher than in 1959.

National Lead Co. produced a pyrite concentrate containing nickel and cobalt from lead ore, and its refinery at Fredericktown, Mo., produced 11 percent more nickel than in 1959.

Freeport Nickel Co., Port Nickel, La., refinery produced 1,773 tons of nickel in 1960 from Cuban concentrate, demonstrating the feasibility of the process. The refinery, which was to produce 25,000 tons of nickel annually, closed in mid-year because of Cuban Government restrictions and prohibitive taxes.

In addition, refineries at Carteret and Perth Amboy, N.J., Laurel Hill, N.Y., El Paso, Tex., and Tacoma, Wash., recovered 623 tons of nickel in the form of sulfate, as a byproduct of copper refining. Shipments from these refiners contained 559 tons of nickel. Refined nickel salts (chiefly sulfate), containing 3,816 tons of nickel, were produced in the United States in addition to the nickel sulfate recovered as a byproduct of copper refining. Total refined salts production was 4,439 tons (nickel content), and shipments to consumers contained 4,342 tons of nickel.

TABLE 2.—Nickel produced in the United States

(Short tons, nickel content)

	1951-55 (average)	1956	1957	1958	1959	1960
Primary:						
Byproduct of copper refining	614	623	502	502	493	623
Domestic ore and imported concentrate	(1)	6,099	9,568	11,238	11,113	13,680
Secondary	8,916	14,860	12,037	7,411	9,438	9,431

1 11 tons produced in 1953, 192 tons in 1954, 3,356 tons in 1955.

Secondary Nickel.—In 1960, 9,400 tons of nickel was recovered from nonferrous scrap in the United States, the same as in 1959.

Nickel recovered from ferrous nickel-base scrap is not included in the secondary-nickel tables. Ferrous nickel-base alloys are those in which the metal of highest percentage is nickel, but which contain so much iron, chromium, cobalt, or other constituents of ferrous alloys that they must be classed as ferrous alloys. Examples are inconel and nichrome. Both nonferrous and ferrous nickel-base alloys may be used as alloying ingredients in ferrous alloys, but ferrous nickel-base alloys cannot be used to make nonferrous alloys.

Consumption of nonferrous nickel-base scrap increased 10 percent to 15,300 tons, compared with 13,900 tons in 1959, because of greater use of unalloyed nickel and nickel residues.

CONSUMPTION AND USES

Nickel consumption was 4 percent less than in 1959. The quantity used in stainless steels was 28 percent of total consumption; that in other steels, 14 percent. Quantities used were 7 and 16 percent less, respectively, than in 1959. Nonferrous alloys consumed 25 percent of the nickel used, 4 percent more than in 1959. Nickel used in high-temperature and electrical-resistance alloys was 4 percent below 1959, and the quantities used in manufacturing magnets and catalysts were 24 percent and 10 percent, respectively, below 1959. The electroplating industry, however, used 8 percent more nickel than in the previous year with the adoption of new plating techniques to improve quality.

The International Nickel Company, Inc., announced it would make individual market studies on the use of stainless steel in 20 industries in the United States to help expand demand in existing or new markets. A comprehensive article on the marketing of nickel was published.[3]

TABLE 3.—Nickel recovered from nonferrous scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

Kind of scrap	1959	1960	Form of recovery	1959	1960
New scrap:			As metal	1,379	1,274
Nickel-base	2,370	3,015	In nickel-base alloys	2,356	1,955
Copper-base	1,498	1,396	In copper-base alloys	2,750	2,458
Aluminum-base	360	342	In aluminum-base alloys	509	481
Total	4,228	4,753	In ferrous and high-temperature alloys[1]	1,036	1,130
			In chemical compounds	1,408	2,133
			Grand total	9,438	9,431
Old scrap:					
Nickel-base	4,692	4,151			
Copper-base	363	402			
Aluminum-base	155	125			
Total	5,210	4,678			
Grand total	9,438	9,431			

[1] Includes only nonferrous nickel scrap added to ferrous and high-temperature alloys.

[3] Clarke, K. H. J., The Marketing of Nickel: Canadian Mining and Metallurgical Bull., February 1960, pp. 99–106.

TABLE 4.—Stocks and consumption of new and old nickel scrap in the United States in 1960

(Short tons, gross weight)

Class of consumer and type of scrap	Stocks, Jan. 1	Receipts	Consumption			Stocks, Dec. 31
			New	Old	Total	
Smelters and refiners:						
Unalloyed nickel	223	875	573	309	882	216
Monel metal	346	1,360	280	1,015	1,295	411
Nickel silver [1]	684	3,496	452	2,823	3,275	905
Miscellaneous nickel alloys	11	5,249	9	5,231	5,240	20
Nickel residues	175	32	8	136	144	63
Total	755	7,516	870	6,691	7,561	710
Foundries and plants of other manufacturers:						
Unalloyed nickel	943	3,860	3,483	819	4,302	501
Monel metal	133	638	36	609	645	126
Nickel silver [1]	[2] 3,018	6,897	7,205	90	7,295	2,620
Miscellaneous nickel alloys	38	382		380	380	40
Nickel residues	958	1,995	1,792	571	2,363	590
Total	2,072	6,875	5,311	2,379	7,690	1,257
Grand total:						
Unalloyed nickel	1,166	4,735	4,056	1,128	5,184	717
Monel metal	479	1,998	316	1,624	1,940	537
Nickel silver [1]	[2] 3,702	10,393	7,657	2,913	10,570	3,525
Miscellaneous nickel alloys	49	5,631	9	5,611	5,620	60
Nickel residues	1,133	2,027	1,800	707	2,507	653
Total	2,827	14,391	6,181	9,070	15,251	1,967

[1] Excluded from totals because it is copper-base scrap, although containing considerable nickel.
[2] Revised.

TABLE 5.—Nickel (exclusive of scrap) consumed in the United States, by forms

(Short tons)

Form	1951–55 (average)	1956	1957	1958	1959	1960
Metal	73,476	96,403	94,765	61,768	87,751	87,399
Oxide powder and oxide sinter	15,849	20,742	17,049	13,007	20,710	19,392
Matte	8,981	8,875	9,047	3,309	2,899	17
Salts [1]	1,413	1,558	1,605	933	1,301	1,351
Total	99,719	127,578	122,466	79,017	112,661	108,159

[1] Figures do not cover all consumers.

PRICES

Domestic prices of nickel were unchanged during 1960. Electrolytic nickel was quoted at 74 cents per pound, duty included, f.o.b. Port Colborne, Ontario; nickel oxide sinter sold at 69.6 cents per pound, nickel content, packaged, f.o.b. port of entry; Cuban nickel oxide was 69 cents per pound, nickel content, f.o.b. Philadelphia. Nickel sulfate was quoted at 28 cents per pound, in bags, carlots, delivered.

TABLE 6.—Nickel (exclusive of scrap) consumed in the United States, by uses

(Short tons)

Use	1951–55 (average)	1956	1957	1958	1959	1960
Ferrous:						
Stainless steels	23,666	32,883	26,986	23,039	32,249	30,086
Other steels	17,195	17,413	15,882	14,510	18,342	15,331
Cast irons	4,223	5,819	5,534	3,851	4,857	4,605
Nonferrous [1]	30,981	35,840	33,449	18,048	25,606	26,567
High-temperature and electrical-resistance alloys	7,783	11,373	9,837	7,435	10,518	10,095
Electroplating:						
Anodes [2]	10,582	15,952	23,354	7,693	14,644	15,847
Solutions [3]	918	1,074	1,131	734	883	970
Catalysts	1,430	2,001	2,113	1,165	1,712	1,545
Ceramics	284	425	358	354	373	365
Magnets	720	933	902	636	1,028	778
Other	1,937	3,865	2,920	1,552	2,449	1,970
Total	99,719	127,578	122,466	79,017	112,661	108,159

[1] Comprises copper-nickel alloys, nickel silver, brass, bronze, beryllium alloys, magnesium and aluminum alloys, monel, inconel, and malleable nickel.
[2] Figures represent quantity of nickel used for production of anodes, plus cathodes used as anodes in plating operations.
[3] Figures do not cover all consumers.

TABLE 7.—Nickel (exclusive of scrap) in consumer stocks in the United States, by forms

(Short tons)

Form	1951–55 (average)	1956	1957	1958	1959	1960
Metal	6,192	9,684	21,082	10,608	9,567	9,009
Oxide powder and oxide sinter	1,615	1,976	3,037	2,464	4,334	2,143
Matte	436	424	787	3	24	7
Salts	425	588	376	264	200	210
Total	8,668	12,672	25,282	13,339	14,125	11,369

FOREIGN TRADE [4]

Imports.—The United States imported 103,000 tons of nickel contained in metal, oxide powder, oxide sinter, slurry, and matte—8 percent below 1959. Canada provided 70 percent; Cuba, 16 percent; and Norway, 13 percent of imports. The International Nickel Company, Inc., processed Canadian matte and slurry, containing 463 tons of nickel at its Huntington, W. Va., plant.

Exports.—A total of 54,109 tons of nickel-bearing materials was exported, an increase of 314 percent over 1959. Nickel in scrap was the main item. Shipments to Japan were 22 percent of the total; to Sweden, 19 percent; to West Germany, 14 percent; to Italy and the United Kingdom, 12 percent each; and to Canada, 11 percent.

[4] Figures on U.S. imports and exports (unless otherwise indicated), compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 8.—U.S. imports for consumption of nickel products, by classes

(Short tons)

Class	1951-55 (average)	1956	1957	1958	1959	1960
Ore and matte	13,017	12,820	13,177	4,574	4,071	184
Metal (pigs, ingots, shot, cathodes, etc.)[1]	89,545	106,534	99,787	62,793	[2] 82,888	79,662
Oxide powder and oxide sinter	26,680	[3] 32,955	[3] 37,080	29,622	[4] 30,062	[4] 24,584
Slurry [5]	([6])	37	211	260	[2] [4] 839	[4] 4,477
Refinery residues [7]	354	1,946		211		
Scrap [1]	622	1,078	410	271	619	135
Total: Gross weight	130,218	155,370	150,665	97,731	[2] 118,479	109,042
Nickel content (estimated)	119,000	143,000	140,000	90,000	[2] 112,000	103,000

[1] Separation of metal from scrap on basis of unpublished tabulations.
[2] Revised figure.
[3] Figures for 1956 include, but for 1957 exclude, 1,524 tons received from Cuba in December 1956 but not included in figures of Bureau of the Census until 1957.
[4] Adjusted by Bureau of Mines.
[5] Nickel-containing material in powders, slurry, or any form, derived from ore by chemical, physical, or any other means, and requiring further processing to recover nickel or other metals.
[6] Not provided for in import schedule before July 1, 1956.
[7] Reported to Bureau of Mines by importers.

Source: Bureau of the Census.

On October 29, 1959, the Bureau of Foreign Commerce, U.S. Department of Commerce, announced less-restrictive export controls on nickel scrap to certain destinations.

Tariff.—The duty of 1¼ cents a pound on refined nickel was unchanged; nickel ore, oxide powder and sinter, matte, slurry, and residues entered duty free.

On November 15, 1960, the U.S. Tariff Commission issued its Tariff Classification Studies, Explanatory and Background Materials, on Schedule 4—Chemicals and Related Products and Schedule 6—Metals and Metal Products. These reports to the President and to the Chairmen of the Committee on Ways and Means of the House and the Committee on Finance of the Senate, pursuant to Title I of the Customs Simplification Act of 1954, are a comprehensive study of U.S. laws prescribing the tariff status of imported articles, and a proposed revision and consolidation of those laws to eliminate anomalies and to simplify the determination and application of tariff classifications.

WORLD REVIEW

Estimated world output of nickel was a record 358,000 tons, an increase of 14 percent over 1959. The estimated free-world output was 290,000 tons, 16 percent greater than in 1959. Of this quantity Canada produced 74 percent; New Caledonia, 15 percent; Cuba (before September 20, 1960), 5 percent; and the United States, 4 percent.

NORTH AMERICA

Canada.—Canada produced a record of 214,774 tons of nickel—an increase of 15 percent over 1959.

The International Nickel Company of Canada, Ltd. (Inco), delivered 175,940 tons of nickel in all forms to consumers, the most deliveries on record and 11 percent more than in 1959. The Inco deliveries included 25,705 tons of nickel acquired from the U.S. Govern-

TABLE 9.—U.S. imports for consumption of new nickel products, by countries

(Short tons)

Country	Metal		Oxide powder and oxide sinter			
	1959	1960	1959		1960	
	Gross weight	Gross weight	Gross weight	Nickel content	Gross weight	Nickel content
North America:						
Canada	[1] 79,700	66,216	9,416	7,057	7,396	5,548
Canal Zone	2	------	------	------	------	------
Cuba	------	------	[2] 20,646	[2] 18,348	[2] 17,188	[2] 15,390
Total	[1] 79,702	66,216	[2] 30,062	[2] 25,405	[2] 24,584	[2] 20,938
Europe:						
Austria	4	------	------	------	------	------
France	(3)	3	------	------	------	------
Germany, West	------	33	------	------	------	------
Netherlands	(3)	------	------	------	------	------
Norway	2,848	13,092	------	------	------	------
Portugal	5	------	------	------	------	------
United Kingdom	329	318	------	------	------	------
Total	3,186	13,446	------	------	------	------
Grand total	[1] 82,888	79,662	[2] 30,062	[2] 25,405	[2] 24,584	[2] 20,938

Country	Slurry and other [4]				Ore and matte			
	1959		1960		1959		1960	
	Gross weight	Nickel content	Gross weight	Nickel content	Gross weight	Nickel content	Gross weight	Nickel content
North America:								
Canada	453	[2] 115	1,246	324	4,071	2,780	184	139
Cuba	[1,2] 386	[1,2] 182	[2] 3,231	[2] 1,555	------	------	------	------
Total	[1,2] 839	[1,2] 297	[2] 4,477	[2] 1,879	4,071	2,780	184	139

[1] Revised figure.
[2] Adjusted by Bureau of Mines.
[3] Less than 1 ton.
[4] Nickel-containing material in powder, slurry, or any form, derived from ore by chemical, physical, or any other means, and requiring further processing to recover nickel or other metals.

Source: Bureau of the Census.

ment or its suppliers, which was sold at the same price at which it was acquired.

Inco mined 16,768,000 short tons of ore at Sudbury, which was 9 percent more than in 1959 and another record. The company continued to operate the Creighton, Frood-Stobie, Garson, Levack, and Murray mines in the Sudbury district. Inco began developing the Clarabelle open pit in the Clarabelle and Lady MacDonald Lakes area southwest of its Murray mine, and production was scheduled to begin in 1961 to replace some of the tonnage from other mines, particularly the Frood open pit, which is approaching exhaustion. Inco continued development at the Crean Hill mine and planned to start producing in early 1961.

One shaft at the Creighton mine reached a depth of 6,750 feet, the company's deepest working, and is to be used temporarily for development and preliminary ore production from the lower levels of the mine. Inco's proved ore reserve on December 31, 1960, was

TABLE 10.—U.S. exports of nickel products, by classes

Class	1958		1959		1960	
	Short tons	Value	Short tons	Value	Short tons	Value
Ore, concentrate, and matte	10	$1,485			1	$4,326
Nickel and nickel-alloy metals in ingots, bars, rods, and other crude forms	11,957	13,721,729	5,707	$9,678,331	9,835	16,839,376
Nickel and nickel-alloy metal sheets, plates, and strips	863	2,320,857				
Nickel and nickel-alloy metal scrap	(1)	(1)	6,111	2,289,042	42,633	10,289,245
Nickel and nickel-alloy semifabricated forms, not elsewhere classified	563	2,491,121	519	2,313,625	644	2,321,654
Nickel-chrome electric-resistance wire except insulated	154	678,426	139	597,559	235	969,261
Nickel catalysts	485	1,022,945	597	1,161,911	761	1,240,236
Total	14,032	20,236,563	13,073	16,040,468	54,109	31,664,098

[1] Before Jan. 1, 1959, scrap was included with nickel and nickel-alloy metals in ingots, bars, rods and other crude forms.

Source: Bureau of the Census.

290,273,000 tons, a sharp increase over the 264,864,000 tons of the preceding year. The reserve included 25 million tons of ore at the Thompson mine, Manitoba.

At Copper Cliff, Ontario, work was proceeding on a new plant for fluid-bed roasting of nickel sulfide. The iron ore recovery plant, also at Copper Cliff, was to be tripled by 1963 at a cost of $50 million. The expansion will introduce economies by treating large quantities of nickeliferous pyrrhotite, normally processed in the Copper Cliff nickel smelter.

The Inco project at Thompson, Manitoba, made good progress. The refinery was expected to begin operating in early 1961 and to be producing at the full rate of 37,500 tons a year of nickel by midyear.

Inco spent $4.4 million on exploration in Manitoba during 1960. This included underground exploration of the Thompson mine and surface drilling in the Thompson-Moak Lake area. About $3 million was spent in the Sudbury district to find new ore bodies and extend known occurrences. A new shaft was to be sunk north of Copper Cliff to explore at depth the geological formation known as the Copper Cliff offset. Approximately $1.5 million was spent on exploring nickel occurrences in Northern Ontario, Quebec, Saskatchewan, and Northwest Territories of Canada, and in Africa, Australia, Greece, Guatemala, the South Pacific Islands, and the United States.[5]

Falconbridge Nickel Mines Ltd., delivered 32,501 tons of nickel, an increase of 11 percent over the preceding record of 1959. The Norduna Emtwo mine delivered 150,000 tons of ore of a somewhat better grade than in the preceding year. Falconbridge milled 2,362,000 tons of ore—an increase of 18 percent over 1959. Ore reserves totaled 46,089,100 tons, with an average nickel content of 1.46 percent, about the same as at the end of 1959.

Marbridge Mines Ltd., jointly owned by Marchant Mining Co. Ltd., and Falconbridge, was formed to bring into production the La

[5] The International Nickel Company of Canada, Ltd., Annual Report 1960, pp. 7–16.

TABLE 11.—World production of nickel by countries [1] [2]

(Short tons)

Country [1]	1951–55 (average)	1956	1957	1958	1959	1960
North America:						
Canada [3]	151,672	178,515	187,958	139,559	186,555	214,774
Cuba:						
Content of oxide	10,490	16,062	22,245	19,782	19,658	[4] 12,547
Estimated content of slurry—U.S. imports					200	1,600
United States:						
Byproduct of copper refining	614	623	502	502	493	623
Recovered nickel in domestic ore refined	[5] 1,186	6,099	9,568	11,238	11,113	11,907
Total	163,962	201,299	220,273	171,081	218,019	241,451
South America:						
Brazil (content of ferronickel)	[6] 34	70	90	80	85	[6] 160
Venezuela (content of ore)	[7] 1	12	35	42	29	[6] 30
Total	35	82	125	122	114	[6] 190
Europe:						
Albania (content of nickeliferrous ore) [6]				1,000	1,800	2,700
Finland:						
Content of nickel sulfate	[6] 119	164	89	125	92	126
Content of concentrates					324	2,465
Germany, East (content of ore) [8]	[7] 110	110	110	110	110	110
Greece (content of nickeliferrous ore)		386	565	265		
Poland (content of ore) [9]	[10] 943	1,321	1,400	1,488	1,405	[6] 1,400
U.S.S.R. (content of ore) [11]	41,600	52,000	55,000	58,000	60,000	64,000
Total [6]	42,800	54,000	57,200	61,000	63,700	70,800
Asia: Burma (content of speiss)	195	127	74	367	159	81
Africa:						
Morocco: Southern zone (content of cobalt ore) [6]	132	142	94	204	266	280
Rhodesia and Nyasaland, Federation of: Southern Rhodesia (content of ore)	4	45	73	4		24
Union of South Africa (content of matte and refined nickel)	1,860	3,624	4,562	[12] 2,200	[6] 2,900	[6] 3,200
Total	1,996	3,811	4,729	2,408	3,166	3,504
Oceania: New Caledonia (recoverable) [13]	11,620	25,569	32,359	12,345	28,810	42,300
World total (estimate) [1]	221,000	285,000	315,000	247,000	314,000	358,000

[1] A small quantity of nickel is also produced in Bolivia, Iran, and the Republic of Korea, but estimates for these countries are not included in the world total.
[2] This table incorporates some revisions.
[3] Comprises refined nickel and nickel in oxide produced, and recoverable nickel in matte exported.
[4] Exclusive of unknown tonnage produced and stored at Nicaro since September 20, 1960.
[5] Average for 1953–55.
[6] Estimate.
[7] One year only, as 1955 was first year of reported production.
[8] Estimate, according to annual issues of Minerais et Metaux, except 1960.
[9] According to the United Nations Statistical Yearbook, except 1960 estimate.
[10] Average for 1954–55.
[11] Estimate, according to the 47th annual issue of Metal Statistics (Metallgesellschaft), except 1959 and 1960 estimates.
[12] Revised estimate based on local sales and exports.
[13] Comprises nickel content of matte and ferronickel produced in New Caledonia plus estimate of recoverable nickel in ore exported. Mine production (nickel content of ore) was as follows: 1951–55 (average), 16,050 tons; 1956, 32,500 tons; 1957, 47,700 tons; 1958, 15,600 tons; 1959, 36,200 tons, and 1960, estimated 58,400 tons.

Compiled by Augusta W. Jann, Division of Foreign Activities.

Motte Township nickel property of Marchant Mining, 20 miles north of Malartic, Quebec. The company planned to mine 300 tons of ore per day financed by Falconbridge. The ore will be beneficiated by Canadian Malartic Gold Mines Ltd., which has a mill in the area, and the concentrate will be processed by Falconbridge.[6]

[6] Falconbridge Nickel Mines Ltd., Thirty-second Annual Report 1960, pp. 6–8.

Sherritt Gordon Mines Ltd., mined and milled 1,151,000 tons of ore from its Lynn Lake, Manitoba, mine—an increase of 17 percent over 1959. Nickel production from its refinery at Fort Saskatchewan, Alberta, from Lynn Lake and purchased concentrates amounted to 11,629 tons, 6 percent less than in 1959. In addition, the refinery produced 3,850 tons of nickel on a toll basis, compared with 142 tons in the preceding year. The ore reserve at the end of 1960 was 14.3 million tons; the grade of nickel averaged 0.92 percent. Higher grade ore was found in the new ore body at Lynn Lake, about ½ mile below the surface. Sherritt Gordon Mines Ltd., was seeking to establish markets for such specialty products as nickel strip, rod, and wire; ultrafine (below 5 microns) nickel powders; spherical nickel powder in various size ranges; and certain alloys difficult to produce by conventional methods.[7]

An estimated 2,350 tons of nickel was produced in the Northwest Territories by North Rankin Nickel Mines Ltd. Concentrate was shipped to the Sherritt Gordon refinery.

Nickel Mining and Smeltering Corp. continued its development work on the Gordon Lake nickel property, 55 miles northwest of Kenora, Ontario. The indicated reserve was reported to be enough to support a 500-ton-a-day operation.

Faraday Uranium Mines Ltd., spent $625,000 exploring a nickel deposit at Gordon Lake. Under an amended agreement with Nickel Mining & Smelting Corp., the company had until the end of 1961 to decide whether production was warranted. To finance additional exploration, Canadian Nickel Co., an exploration subsidiary of Inco, purchased $500,000 worth of Nickel Mining & Smelting Corp. first mortgage bonds from Faraday Uranium Mines. In return, Canadian Nickel Co. would have the first refusal over a 10-year period on a smelter contract, should results at the Gordon Lake property warrant production.[8]

Giant Nickel Mines Ltd., Choate, British Columbia, shipped 15,476 tons of bulk nickel-copper concentrate valued at $1,905,000 from Vancouver to Sumitomo Metal Mining Co., Japan, beginning in May.[9]

St. Stephen Nickel Mines, Ltd., suspended operations at its property in Charlotte County, New Brunswick.[10]

Consolidated Marbenor Mines, Ltd., and National Malartic Gold Mines, Ltd., actively explored their jointly owned nickel property near Waboden, Manitoba, 40 miles south of Inco's Thompson mine. Drilling over a 1,300-foot length to a depth of 800 feet indicated 2.0 to 2.5 million tons of ore containing 0.90 percent nickel.[11]

Conwest Exploration Co. planned an extensive test of the McVittie-Graham Mining Co., Ltd., property, 16 miles west of Sudbury and

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[7] Sherritt Gordon Mines Ltd., Annual Report 1960, pp. 3–6.

[8] Northern Miner (Toronto), Faraday Proposes New Financing Deal for Nickel Mining: Vol. 46, Dec. 15, 1960, p. 13; Inco Subsidiary Aids Development of Nickel Mining: Vol. 46, Dec. 15, 1960, p. 1: Ratify Financing for Nickel Mining: Vol. 46, Dec. 29, 1960, p. 9.

[9] Northern Miner (Toronto), Giant Nickel Mines Makes Shipment: Vol. 46, Nov. 17, 1960.

[10] Northern Miner (Toronto), U.S. Seeks Indictment of St. Stephen Nickel Officials, Promoters: Vol. 46, Aug. 25, 1960.

[11] Northern Miner (Toronto), Marbenor, National Nickel Prospect Is Looking Lively: Vol. 46, Oct. 13, 1960, pp. 1, 9.

east of the Crean Hill (Inco) mine. Early drilling results were good.[12]

Cuba.—In 1960, the U.S. Government-owned plant at Nicaro, Oriente Province, produced 976 tons of oxide powder (averaging 78 percent nickel plus cobalt) and 13,049 tons of oxide sinter (averaging 90.32 percent nickel plus cobalt) from 1,279,800 tons of ore. The contained nickel plus cobalt in the products totaled 12,547 tons. The Nicaro plant closed at the end of September, following harassment and confiscatory taxes levied by the Cuban Government. Previously the Cuban Government bid $5.3 million for the plant, which was valued at about $110 million. The offer was rejected.[13] The plant was officially intervened by the Cuban Government on October 24, 1960. Cuba included nickel among its exports to the U.S.S.R., Poland, China, and Rumania.

Because of Cuban Government restrictions and prohibitive taxes, the Freeport Nickel Co. suspended operations at its Moa Bay plant on April 1, 1960. Before the shutdown, the plant employed about 1,500 Cubans.[14] The Moa Bay nickel facilities were seized by the Cuban Government in August 1960. The Freeport Nickel Cuban facilities and its refinery in Louisiana, which also closed, represented an investment of about $100 million. A wholly owned subsidiary of Freeport Nickel Co., Nicaro Nickel Co. in Cuba, which engaged in selling ore to the U.S. Government-owned Nicaro Nickel plant, was nationalized under a Cuban Government decree published in the Cuban Official Gazette of October 24, 1960.[15]

On August 17, 1960, under Law No. 867, Cuba established a Cuban Mining Institute (Institute Cubano de Mineria) as a dependency of the Industrialization Department of the National Institute of Agrarian Reform (INRA). The law centralized in the newly established Institute all the functions of research, planning, exploitation, exploration, processing, and commercialization of minerals, which the "free initiative and activity of private enterprise have not properly developed." [16]

Dominican Republic.—The Minera y Beneficiadora Falconbridge Dominicana C. por A., a majority-owned subsidiary of Falconbridge Nickel Mines, Ltd., expected to complete and begin to operate its pilot plant for treating Dominican laterite ores in 1961.[17]

Puerto Rico.—The Federal Bureau of Mines placed on open-file a report on Puerto Rican nickel deposits. [18]

SOUTH AMERICA

Peru.—The Government of Peru suspended all mining concessions in the districts of Macusani and Ayapata, Department of Puno, reserving the area for further exploration. The action was based on

[12] Northern Miner (Toronto), McVittie Cuts Nickel-Copper: Vol. 46, Dec. 22, 1960, p. 1.
[13] Oil, Paint and Drug Reporter, Nicaro Nickel Works Shut in Face of Cuba Ultimatum: Vol. 178, Oct. 3, 1960, p. 3.
[14] Chemical and Engineering News, Freeport Closes Shop in Cuba: Vol. 38, Mar. 14, 1960, p. 23.
[15] Freeport Sulphur Co., Annual Report, 1960, pp. 6–8.
[16] U.S. Embassy, Havana, Cuba, State Department Dispatch 580, Sept. 12, 1960, pp. 1–5.
[17] Falconbridge Nickel Mines, Ltd., Annual Report, 1960, p. 9.
[18] Bureau of Mines, Nickel Content of Individual Samples Included in Composites of Enriched Zone Material (as Reported in Appendix of Bureau of Mines Report of Investigations 5532, "Nickel-Cobalt-Iron-Bearing Deposits in Puerto Rico"): Open-file rept. 11 pp.

reports in the last quarter of 1960 that nickel and other mineral deposits existed in the area.[19]

Venezuela.—Decree 217 by the Venezuelan Government, dated February 5, 1960, provided that the whole of Venezuela is a National Reserve Zone for the exploration and exploitation of nickel ore.[20] Venezuela also revoked the nickel mining concessions, which covered 7,410 acres and were acquired in 1946 and 1952 by Meridional de Minas, S.A. (subsidiary of the International Nickel Company of Canada, Ltd.), for failure to establish commercial exploitation under terms of the law.[21]

EUROPE

Finland.—Outokumpu Oy, the Finnish Government copper-mining corporation, produced 319,000 tons of nickel-copper ore at Kotalahti, the only mine in Finland producing nickel in 1960. Concentrate amounted to 39,750 tons containing 2,465 tons of nickel. Nickel sulfate production was 126 tons.

Greece.—Sizable deposits of nickeliferous iron ore were located at Euboea, Lokris, and Skyros. They were reported to be comparable to deposits in Cuba.[22]

Norway.—Falconbridge Nikkelverk, A/S, of Kristiansand S., Norway, a subsidiary of Falconbridge Nickel Mines, Ltd., increased its production of nickel to 33,000 tons.

ASIA

Japan.—Nickel ore imports in 1960 were 1,042,000 short tons, mainly from New Caledonia. This quantity was an increase of 31 percent over 1959 imports.[23] Japan produced 6,121 tons of pure nickel, compared with 5,760 tons in 1959; ferronickel produced was 58,790 tons, 60 percent more than in 1959.

The Customs Deliberation Council of the Japanese Government decided to apply the Tariff Quota system to the import of metallic nickel, to become effective October 1961. Domestic production of nickel was to be limited to 6,000 tons a year. The Japanese Government was to formulate a demand-supply program for each year. Under this program, excess demand over domestic production is to be imported duty free. The following duties are to apply to imports in excess of 1,000 tons: Year 1961–62 at 350,000 yen a ton (US$980); 1963–64 at 300,000 yen a ton (US$840); 1965 and thereafter, at 200,000 yen a ton (US$560).[24] The object of the Tariff Quota system is to help speed up rationalization of the Japanese nickel industry so that the price of nickel can be reduced in line with world prices.[25]

Pakistan.—An estimated 50 million tons of laterite ore occurs in the Ziarat area of the Quetta region, according to the Geological Survey of Pakistan.[26]

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[19] U.S. Embassy, Lima, Peru, State Department Dispatch 526, Mar. 1, 1961, p. 12.
[20] U.S. Embassy, Caracas, Venezuela, State Department Dispatch 662, Feb. 10, 1960, p. 1.
[21] Engineering and Mining Journal, vol. 161, October 1960, pp. 175–176.
[22] U.S. Embassy, Athens, Greece, State Department Dispatch 415, Nov. 8, 1960, p. 2.
[23] Japan Metal Bulletin, Feb. 21, 1961.
[24] Japan Metal Bulletin, Dec. 3, 1960.
[25] Japan Metal Bulletin, Dec. 6, 1960.
[26] World Mining, vol. 13, September 1960, p. 79.

Philippines.—The advantages of starting the Surigao Nickel Iron project instead of the Nassco Integrated Steel project approved by the Philippine Government were discussed.[27]

Turkey.—Geologists of the Turkish Mining Research Institute discovered nickel deposits on the Samsun-Dag and Kirha-Dag mountains, south of Izmir near the River Meander.[28]

OCEANIA

New Caledonia.—Production of nickel ore in New Caledonia was 2,493,000 tons, an increase of 64 percent over 1959. Ore exported was 1,071,000 tons, up 23 percent. Société le Nickel, with its new installation at Pointe Doniambo, increased production of nickel in the form of matte and ferronickel to 24,100 tons, 84 percent above the 1959 figure.

TABLE 12.—Production of nickel matte and ferronickel by Société le Nickel

(Short tons)

Product	1959	1960
Matte:		
Gross weight	9,954	14,930
Nickel content	7,655	11,496
Ferronickel:		
Gross weight	21,406	48,504
Nickel content	5,424	12,610

Source: New Caledonia Mining Service.

TABLE 13.—Exports of nickel ore and nickel products from New Caledonia

(Short tons)

Product	1959	1960
Ore:		
Gross weight	871,529	1,071,524
Nickel content	20,786	25,315
Matte:		
Gross weight	8,942	16,051
Nickel content	6,877	12,359
Ferronickel:		
Gross weight	19,804	49,458
Nickel content	5,025	12,859

Source: New Caledonia Mining Service.

TECHNOLOGY

The research program of the Federal Bureau of Mines included investigating the nickeliferous laterite resources of northwestern California, new methods of recovering and separating nickel and cobalt from lateritic ores, recovering nickel from laterites by sulfatization, and producing high-purity nickel. Some work was done on refining nickel and cobalt in a fused-salt bath and on recovering nickel from high-temperature alloy scrap. The Bureau of Mines published a re-

[27] Mining Newsletter (Philippines), Surigao Laterite Exploitation Versus Nassco's Integrated Steel Project: September–October 1960, pp. 24–25.
[28] Canadian Mining Journal, vol. 81, No. 11, November 1960, p. 125.

port on a rotary kiln process to produce an iron product containing 3 to 7 percent nickel from Cuban laterite and serpentine ores.[29]

An article describing operations at the new Cuban plant of Freeport Nickel was published.[30]

Inco described its procedure for separating copper from nickel in nickel-copper matte based on laboratory studies and pilot-plant developments.[31]

The Hanna Nickel Smelting Company application of the Ugine process at Riddle, Oreg., for producing ferronickel containing 45 to 46 percent nickel was described.[32]

A detailed description of the new Doniambo smelter in New Caledonia, which produced ferronickel containing 24 to 27 percent nickel plus cobalt, was published.[33]

General Electric Co. announced a new vacuum-melted iron, nickel, and cobalt alloy, Fernico-5, with thermal expansion properties close to alumina. The new alloy will permit users to take advantage of the high-strength, high-heat resistance, and insulating properties of alumina in metal-to-ceramic seals in electron tubes, thermionic energy convertors, capacitors, switchgear, and high-temperature circuits.[34]

Aluminum Company of America developed aluminum-iron-nickel alloys capable of withstanding the deteriorating effect of high-purity water at 700° F. An alloy of 4.8 percent iron, 7 percent nickel, and 88.2 percent aluminum was found to give the best results.[35]

Electro-Alloys Division, American Brake Shoe Co., produced an alloy with a nominal composition of 26 percent chromium, 35 percent nickel, 0.5 percent carbon, 0.7 percent magnesium (max.), and 1.6 percent silicon, strengthened and stabilized with cobalt and tungsten for service up to 2,300° F.[36]

United States Steel Corp. demonstrated that vessels made from quenched and tempered 9-percent-nickel steel, not stress relieved after welding, were as safe as stress relieved vessels when used for storing cryogenic (low temperature) liquids at minus 320° F. The alloy can be used for large containers suitable for transporting low-temperature liquids and for storing liquefied gases.[37]

General Electric Co. developed Astroloy, a nickelbase type alloy for use at 1,900° F. The nominal composition of the alloy is 0.5 percent carbon, 4.5 percent alumium, 3.5 percent titanium, 5 percent molybdenum, 15 percent chromium, 15 percent cobalt, 0.05 percent silicon, 0.05 percent manganese, and 0.03 percent boron. Astroloy is a vacuum-melted precipitation-hardening alloy suitable for jet engine parts for supersonic flight and other advanced propulsion systems.[38]

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[29] Mahan, W. M., Producing Nickel-Bearing Iron From Cuban Ores in a Batch Rotary Kiln: Bureau of Mines Rept. of Investigations 5638, 1960, 21 pp.

[30] Carlson, E. T., and Simons, C. S., Acid Leaching Moa Bay's Nickel: Jour. Metals, vol. 12, Mar. 1960, pp. 206–213.

[31] Sproule, K., Harcourt, G. A., and Renzoni, L. S., Treatment of Nickel-Copper Matte: Jour. Metals, vol. 12, March 1960, pp. 214–219.

[32] Coleman, E. E., and Vedensky, D. N., Ferro-Nickel Production in Oregon: Jour. Metals, vol. 12, March 1960, pp. 197–201.

[33] Thurneyssen, C. G., Szczeniowski, J., and Michel, F., Ferro-Nickel Smelting in New Caledonia: Jour. Metals, vol. 12, March 1960, pp. 202–205.

[34] G.E. Develops Low-Thermal Alloy for Ceramic Seals: Missiles and Rockets, vol. 6, June 13, 1960, p. 44.

[35] Journal of Metals, vol. 12, August 1960, p. 600.

[36] Journal of Metals, vol. 12, August 1960, p. 600.

[37] American Metal Market, Nine-Nickel Alloy Cuts Costs in Handling Cryogenic Gases: Vol. 67, Nov. 4, 1960, p. 9.

[38] Metal Progress, Astroloy—A Superalloy for 1900° F. Use: Vol. 78, December 1960, pp. 94–97.

A comprehensive review of nickel and high-nickel alloys as materials of construction was published.[39]

Linde Co., Division of Union Carbide Corp., developed a process for producing spherical powders from nickel and Nichrome in a particle size range of 20 to 150 microns, suitable for making sintered bodies of controlled porosity.[40]

Nickel strip was being produced from powder by Metals for Electronics, Inc., Hamden, Conn.[41]

Loma Machine Manufacturing Co., New York, N.Y., announced a low-cost horizontal compacting mill with horizontal edge control suitable for producing nickel strip.[42]

Carbonyl Metal Products Division, Budd Company, Philadelphia, produced duplicates of master models by decomposing nickel carbonyl and depositing a coherent layer of nickel on the heated surface of the pattern. The method is suitable for forming dies, patterns, core boxes, die castings, permanent molds, and shell molds.[43]

The National Bureau of Standards developed a technique for producing nickel-aluminum-alloy coatings that can protect metals from oxidation at temperatures up to 1,000° C. The coatings provide suitable protection for steel, nickel, and molybdenum.[44]

The Department of Scientific and Industrial Research, and the British Non-Ferrous Metals Research Association, London, England, sponsored an inquiry into the losses of nickel and chromium during electroplating as part of the study of the problem of treating industrial effluents.[45]

The Defense Metals Information Center, Battelle Memorial Institute, Columbus, Ohio, published technical reports on physical properties of some nickel-base alloys[46] and design information on nickel-base alloys for aircraft and missiles.[47] It also reported on recent developments in nickel-base superalloys.[48]

Patents were issued on recovering nickel from ores,[49] separating nickel from cobalt,[50] electrolytic recovery of nickel,[51] electro and electroless plating of nickel,[52] nickel coating by decomposition of nickel carbonyl,[53] various alloys,[54] nickel catalysts,[55] and electromagnetic prospecting.[56]

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[39] Marron, A. J., Nickel and High Nickel Alloys: Ind. Eng. Chem., vol. 52, November 1960, pp. 943–946.

[40] Metal Progress, Spherical Powders Made in Inert Atmosphere: Vol. 78, September 1960, p. 66.

[41] Steel, Nickel Strip Rolled from Powder: Vol. 147, Nov. 28, 1960, p. 84.

[42] American Metal Market, New Mill Produces High-Quality Nickel Strip from Powder: Vol. 67, Dec. 29, 1960.

[43] Metal Progress, Carbonyl Nickel, New Idea for Dies and Patterns: Vol. 77, June 1960, p. 66.

[44] Couch, D. E., and Connor, J. H., Nickel-Aluminum Alloy Coatings Produced by Electrodeposition and Diffusion: Jour. Electrochem. Soc., vol. 107, April 1960, pp. 272–276.

[45] Harris, E. P., A Survey of Nickel and Chromium Recovery in the Electroplating Industry: Inf. Div., Dept. Sci. and Ind. Res., London, England, August 1960, p. 44.

[46] Langston, M. E., and Lund, C. H., Physical Properties of Some Nickel-Base Alloys: Defense Metals Inf. Rept. 129, OTS PB 151086, May 20, 1960, 146 pp.

[47] Favor, R. J., Roberts, D. A., and Achbach, W. P., Design Information on Nickel-Base Alloys for Aircraft and Missiles: Defense Metals Inf. Center Rept. 132, OTS PB 151090, July 20, 1960, 151 pp.

[48] Wagner, H. J., Recent Developments in Superalloys: Defense Metals Inf. Center Memorandum 64, OTS PB 161214, Sept. 8, 1960, 14 pp.

[49] Donaldson, J. W., and Davis, H. F., Jr. (assigned to Quebec Metallurgical Industries, Ltd.), Method for Treating Nickel Sulfide Ore Concentrates: U.S. Patent 2,934,428, Apr. 26, 1960.

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[50] Bare, C. B., and Horst, R. J. (assigned to Bethlehem Steel Co.). Use of SO_2 in Ammonia Leaching Mayari Ore: U.S. Patent 2,928,732, Mar. 15, 1960.
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[51] Renzoni, L. S., and Barker, W. V. (assigned to The International Nickel Company, Inc.), Electrolytic Recovery of Nickel: U.S. Patent 2,966,407, Dec. 27, 1960.
[52] Lee, W. G., and Browar, E. (assigned to General American Transportation Corp.), Process of Chemical Nickel Plating of Amphoteric Elements and Their Alloys: U.S. Patent 2,928,757, Mar. 15, 1960.
Hinderina de Minjer, C., and Brenner, A. (assigned to the United States of America as represented by the Secretary of Commerce), Electroless Deposition of Nickel: U.S. Patent 2,929,742, Mar. 22, 1960.
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[53] Cummins, O. J. (assigned to Union Carbide Corp.), Method of Increasing Electrical Resistance of Gas Plated Nickel Coatings and Resulting Article: U.S. Patent 2,921,871, Jan. 19, 1960.
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Franklin, A. W., and Barber, J. B. (assigned to The International Nickel Co., Inc.), Titanium-Hardened Nickel-Cobalt-Iron Alloys: U.S. Patent 2,941,882, June 21, 1960.
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Nitrogen Compounds

By Richard W. Lewis [1] and Betty Ann Brett [2]

ANNUAL capacity of the domestic atmospheric nitrogen industry in 1960 was estimated at 5.5 million short tons compared with 5.3 million tons in 1959. Production in 1960 rose to a new high, 7 percent above 1959, and was about 87 percent of estimated capacity. Coking plants supplied nearly 200,000 tons, NH_3 content, as byproducts.

TABLE 1.—Salient nitrogen-compounds statistics [1]

(Thousand short tons)

	1951–55 (average)	1956	1957	1958	1959	1960
United States:						
Production of ammonia, NH_3 content	2,481	3,433	3,791	3,945	4,591	4,878
Imports for consumption of nitrogen compounds, gross weight	1,809	1,494	1,480	1,374	1,509	1,233
Exports of nitrogen compounds, gross weight	350	1,038	1,218	704	747	623
Consumption of nitrogen compounds, nitrogen equivalent, for years ended June 30	2,233	2,756	3,015	3,263	3,748	4,001
World: Production of nitrogen compounds, nitrogen equivalent, for years ended June 30	6,972	9,506	10,221	11,397	12,438	13,590

[1] This table incorporates some revisions.

DOMESTIC PRODUCTION

Anhydrous ammonia production continued its upward trend to another record, 7 percent above that of 1959.

U.S. Industrial Chemicals Co., a division of National Distillers & Chemicals Corp., increased ammonia production capacity at its plant at Tuscola, Ill., by 17 percent to 70,000 tons per year.

Armour & Co. announced a $60 million expansion program for Armour Agricultural Chemical Co. Plans included constructing a nitrogen plant at Sheffield, Pa., and a phosphate plant in Florida. The nitrogen plant will produce ammonia, nitric acid, urea, nitrogen solutions, ammonium nitrate, and other ammonia derivatives.

Expanded ammonia facilities of the W. R. Grace & Co. plant at Memphis, Tenn., were expected to be completed in 1961.

Solar Nitrogen Chemicals expanded its ammonia, urea, nitric acid, and ammonium nitrate facilities at Lima, Ohio. In addition, construction was started on a $15 million plant east of Joplin, Mo., for the production of anhydrous ammonia, urea, and related products.

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.

TABLE 2.—Major nitrogen compounds produced in the United States [1]

(Short tons, NH_3 content)

Compound	1951–55 (average)	1956	1957	1958	1959	1960 [2]
Anhydrous ammonia: Synthetic plants [3]	2,421,010	3,378,362	3,732,562	3,878,778	4,519,705	4,817,704
Aqua ammonia:						
Synthetic plants [3]	39,032	36,723	40,683	50,933	56,177	45,126
Coking plants	20,902	17,681	17,341	14,902	14,710	14,884
Total	59,934	54,404	58,024	65,835	70,887	60,010
Ammonium sulfate:						
Synthetic plants [3]	212,990	282,712	268,963	281,467	282,106	224,904
Coking plants	229,669	227,737	234,497	165,228	160,028	162,971
Total	442,659	510,449	503,460	446,695	442,134	387,875
Ammonium nitrate [3] [4]	708,913	927,587	1,099,053	1,097,064	1,214,410	1,318,631
Ammonium chloride [3]	9,919	9,448	7,464	7,078	8,133	(5)
Diammonium phosphate: Coking plants	(5)	6,067	9,689	10,581	12,093	11,878

[1] This table incorporates some revisions.
[2] Preliminary figures.
[3] Data from Bureau of the Census Current Industrial Reports.
[4] Nitrate nitrogen—also calculated to NH_3.
[5] Data not available.

A contract was awarded to Chemical Construction Corp. for the design and construction of an $11 million, 350-ton-per-day ammonia plant at Tampa, Fla., for the U.S. Phosphoric Products Division, Tennessee Corp. Plans included an ammonia synthesis converter.

The Dow Chemical Co. planned to expand production of anhydrous ammonia in its Freeport, Tex., plant to 115,000 short tons per year and to build a new ammonia plant at Plaquemine, La.

SunOlin Chemical Co. placed on stream a new 73,000-ton-per-year urea plant at North Claymont, Del. Both prilled and crystalline urea were produced using an improved Montecatini recycling process.

California Spray-Chemical Corp. opened its new $5 million fertilizer plant at Kennewick, Wash. Facilities consisted of three units: A high-pressure nitric acid unit with a daily capacity of 150 tons of nitric acid on a 100-percent basis but produced at a 57-percent concentration; an ammonium nitrate unit with a daily capacity of 150 tons of fertilizer-grade prilled ammonium nitrate; and a mixed-fertilizer section. The firm also announced plans for the construction of a $22 million mixed-fertilizer plant at Fort Madison, La. Production plans called for 300 tons per day of anhydrous ammonia, 150 tons of prilled ammonium nitrate, and 600 tons of mixed fertilizers.

Cooperative Farm Chemicals Assn. at Lawrence, Kans., placed on stream a new $1.25 million nitric acid plant with a daily capacity of 120 tons.

American Cyanamid Co. closed its nitroglycerin plant at Grafton, Ill., but planned to remain in the industrial explosive field with ammonium nitrate plants at Springville, Utah, and New Castle, Pa.

Air Reduction Co. Inc. began expanding its facilities at Acton, Mass., to increase production of liquid nitrogen from 75 to 130 tons a day.

Southern Nitrogen Co. Inc. acquired the anhydrous ammonia distribution and application facilities of Millhaven Sales Corp. of southeast Georgia.

Hercules Powder Co. purchased the Nitroform Agricultural Chemical Co. of Woonsocket, R.I.

General Services Administration accepted the $2.6 million bid of the Smith-Douglas Co., Inc., Norfolk, Va., for the Government ammonia plant in San Jacinto, Tex.

A $4 million expansion program by St. Paul Ammonia Products will increase the nitrogen capacity of its Pine Bend plant to 111,000 tons per year.

Valley Nitrogen Producers Inc. completed a new $10 million plant near Helm, Calif. Daily production capacity was 150 tons of anhydrous ammonia and 200 tons each of ammonium nitrate and ammonium phosphate.

CONSUMPTION AND USES

A total of 4 million tons of contained nitrogen was consumed in the crop year ending June 30, 1960, an increase of about 7 percent above the 1958–59 year. Agriculture continued as the leading consumer of nitrogen compounds. The principal nitrogen fertilizer materials in the order of importance in 1959–60 were: Anhydrous ammonia; ammonium nitrate; nitrogen solutions; ammonium sulfate; and aqua ammonia.

The use of ammonium nitrate for field-compounded explosives increased in 1960 but at a lesser rate than in 1959.

Approximately 700,000 short tons of urea was consumed during 1960; about 600,000 tons in fertilizer and feed compounds and the remainder for industrial uses.

Liquid fertilizers containing nitrogen were more in demand during 1960, increasing about 5 percent above 1959, whereas use of the solid fertilizers remained steady.

PRICES

The price of anhydrous ammonia increased $4 per ton during 1960. Prices for ammonium nitrate and urea were lowered, with the reduction on industrial urea amounting to 21 percent. Other commodity prices remained the same.

FOREIGN TRADE [3]

Imports of nitrogen compounds for consumption in 1960, in gross weight, were 18 percent lower than in 1959. Shipments of all compounds imported were less than in the previous year except those of urea and crude potassium nitrate, which increased 29 and 19 percent, respectively.

Exports were 16-percent less (gross weight basis) than in 1959. Ammonium sulfate represented the largest export item and comprised 38 percent of the total gross weight of nitrogenous exports.

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[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 3.—Price quotations for major nitrogen compounds in 1960

(Per short ton)

Compound	Jan. 4	Dec. 26	Effective date of change
Chilean nitrate, port, warehouse, bulk	$44.00	$44.00	
Sodium nitrate, synthetic, domestic, carlots, works, crude, bulk	44.00	44.00	
Ammonium sulfate, coke ovens, bulk	32.00	32.00	
Cyanamide, fertilizer-mixing grade, 21 percent N, granular, Niagara Falls, Ontario, bagged	57.00	57.00	
Ammonium nitrate, fertilizer grade 33.5 percent N:			
Canadian, eastern, carlots, shipping point, bags	68.00	64.00	Aug. 1
Western, domestic, works, bags	68.00	[1] 67.00	Oct. 3
Anhydrous ammonia, fertilizer, tanks, works	88.00	[2] 92.00	Oct. 3
Ammonium-nitrate-dolomite compound, 20.5 percent N, Hopewell, Va., bags	48.00	48.00	
Urea:			
Industrial, 46 percent N, bags, carlots, ton lots, delivered Eastern	125.00	98.00	Nov. 7
Agricultural, 45 percent N, bags, carlots, 30-ton minimum delivered Eastern	103.00	100.00	Nov. 7

[1] Quoted at $64 per ton from Aug. 1 to Oct. 3.
[2] Quoted at $84 per ton from Aug. 1 to Oct. 3.

Source: Oil, Paint and Drug Reporter.

TABLE 4.—U.S. imports for consumption of major nitrogen compounds

Year and compound	Short tons
1959:	
Industrial chemicals: Anhydrous ammonia	53
Fertilizer materials:	
Ammonium nitrate mixtures containing 20 percent or more nitrogen	341,037
Ammonium phosphates	215,707
Ammonium sulfate	217,473
Calcium cyanamide	58,400
Calcium nitrate	68,849
Nitrogenous materials, n.e.s.:	
Organic	[1] 23,050
Inorganic and synthetic	22,440
Potassium nitrate, crude	473
Potassium-sodium nitrate mixtures, crude	[2] 36,468
Sodium nitrate	461,765
Urea, n.e.s	[1] 63,733
Total	1,509,448
1960:	
Fertilizer materials:	
Ammonium nitrate containing over 32 percent nitrogen	[3] 172,316
Ammonium nitrate mixtures containing 32 percent and less nitrogen, including ammonium nitrate-calcium carbonate mixtures, except solutions	[3] 73,273
Ammonium phosphates	119,937
Ammonium sulfate	211,351
Calcium cyanamide	44,100
Calcium nitrate	62,023
Nitrogen solutions	[3] 50,174
Nitrogenous materials, n.e.s.:	
Organic	2,303
Other synthetic	[3] 41,475
Potassium nitrate, crude	[2] 565
Potassium-sodium nitrate mixtures, crude	[2] 18,702
Sodium nitrate	355,112
Urea, n.e.s	82,134
Total	1,233,465

[1] Revised figure.
[2] Adjusted by Bureau of Mines.
[3] Owing to changes in classification data not strictly comparable to earlier years.

Source: Bureau of the Census.

TABLE 5.—U.S. exports of major nitrogen compounds

(Short tons)

Compound	1959	1960
Industrial chemicals:		
Ammonia, anhydrous, and chemical-grade aqua (ammonium content)	24,411	14,692
Ammonium nitrate	6,783	2,449
Fertilizer materials:		
Ammonium nitrate	81,934	36,942
Ammonium phosphates and other nitrogenous phosphatic-type fertilizer materials	69,071	107,371
Ammonium sulfate	399,675	237,309
Anhydrous ammonia and aqua (ammonia content)	59,606	93,968
Nitrogenous chemical materials, n.e.c	39,399	63,219
Urea	64,574	66,380
Sodium nitrate	1,571	1,040
Total	747,024	623,370

Source: Bureau of the Census.

WORLD REVIEW

NORTH AMERICA

Canada.—Construction of a $17 million nitrogen plant by Brockville Chemicals Ltd., near Maitland, Ontario, was started and scheduled for completion in May 1961. The plant was designed to produce anhydrous ammonia, nitric acid, ammonium nitrate, and nitrogen solutions.[4] The second urea plant in Canada was completed for Consolidated Mining & Smelting Co. of Canada, Ltd., late in 1960 at Turner Side near Calgary, Alberta, at a cost of $5 million. The plant raised the urea capacity in Canada to 102,000 tons a year.[5] Sherritt Gordon Mines, Ltd., at Fort Saskatchewan, Alberta, doubled the capacity of its ammonium sulfate recovery works.[6]

TABLE 6.—World production and consumption of nitrogen, years ended June 30

(Thousand short tons)

Year	Production [1]	Consumption [1]	
		In agriculture	In industry
1955–56	9,506	7,705	1,493
1956–57	10,221	8,502	1,595
1957–58	11,397	9,295	1,793
1958–59	12,438	10,322	1,965
1959–60	13,590	11,335	2,276

[1] Estimate.

Source: British Sulphate of Ammonia Federation, Ltd.

El Salvador.—A $10 million fertilizer plant with a capacity of 400 tons per day was planned for the production of highly concentrated

[4] Oil, Paint and Drug Reporter, Nitrogen Chemicals Unit Is Progressing in Ontario: Vol. 178, No. 19, Oct. 31, 1960, p. 5.
[5] Chemical Trade Journal and Chemical Engineer (London), Canada's Second Urea Plant: Vol. 146, No. 3788, Jan. 8, 1960, p. 92.
[6] Precambrian-Mining in Canada (Winnipeg), Sherritt-Gordon Mines Report Sales, Profit Take Jump: Vol. 33, No. 6, June 1960, p. 52.

nitrogen, phosphorus, and potassium fertilizer. Units for producing nitric acid and ammonium nitrate were included in the facility.[7]

Mexico.—The Mexican Government declared that any firm wishing to start production of liquid or gaseous nitrogen in Mexico would be allowed reductions from 50 to 100 percent in import duty on the necessary material. Also, certain reductions would be allowed on income tax, import tax, and stamp duty.[8] Two new ammonia plants, one at Salamanca and the other at Minatitlan, were planned. The additional ammonia capacity was reportedly enough to meet Mexico's nitrogenous fertilizer needs for the next 10 years.[9]

TABLE 7.—World production and consumption of fertilizer nitrogen compounds, years ended June 30, by principal countries

(Thousand short tons of contained nitrogen)

Country	Production			Consumption		
	1956–57	1957–58	1958–59 [1]	1956–57	1957–58	1958–59 [1]
Australia	25	28	28	32	40	38
Austria	148	173	170	42	44	47
Belgium	256	286	325	97	98	107
Brazil	6	6	11	36	36	36
Canada	212	243	----------	41	63	----------
Ceylon	----------	----------	----------	28	22	41
Chile	284	284	----------	32	----------	----------
Denmark	----------	----------	----------	106	109	116
Egypt	29	35	38	127	173	195
Finland	23	24	31	48	45	47
France	497	562	614	444	539	530
Germany:						
East	331	337	353	248	247	----------
West	987	1,155	1,157	581	625	633
Greece	----------	----------	----------	62	69	78
India	89	90	90	182	203	283
Indonesia	----------	----------	----------	28	26	31
Israel	11	14	15	13	16	17
Italy	404	451	602	301	296	324
Japan	860	973	1,093	650	693	754
Korea, Republic of	----------	----------	----------	175	158	166
Mexico	14	14	----------	159	152	154
Netherlands	363	419	434	214	230	230
Norway	236	241	249	50	50	50
Peru	48	19	15	52	35	32
Philippines	9	9	15	14	17	22
Portugal	26	15	33	52	58	73
Spain	51	55	63	189	205	312
Sweden	36	41	37	99	94	98
Switzerland	12	13	15	12	13	15
Taiwan	20	25	33	92	124	107
Union of South Africa	15	19	24	26	32	37
United Kingdom	368	382	386	339	347	379
United States	2,270	2,360	2,675	2,065	2,233	2,586
Yugoslavia	5	6	7	36	64	84
World total [2]	8,025	8,730	9,645	7,440	7,970	8,818

[1] Preliminary figures.
[2] Exclusive of U.S.S.R.; includes quantities for minor producing and consuming countries not listed above.

Source: Converted and rounded from United Nations Food and Agriculture Organization.

[7] Fertiliser and Feeding Stuffs Journal (London), El Salvador's New Fertiliser Plant: Vol. 53, No. 1, July 13, 1960, p. 21.
[8] Chemical Age (London), Mexican Government's Offer to Nitrogen Producers: Vol. 83, No. 2136, June 18, 1960, p. 1015.
[9] Chemical Trade Journal and Chemical Engineer (London), Synthetic Ammonia Projects: Vol. 147, No. 3823, Sept. 9, 1960, p. 561.

SOUTH AMERICA

Chile.—The Nebraska nitrate mine of the Cía. Salitrera de K Tarapacá y Antofagasta, which had been worked at a loss for some time, was closed.[10] Chile's largest producer of natural nitrate, Companhia Salitrera Anglo-Lautaro, started a multimilliondollar modernization program.[11]

TABLE 8.—Chile: Exports of nitrate in 1960, by countries

(Thousand short tons)

Destination	Quantity	Destination	Quantity
Australia and New Zealand	9	Peru	15
Belgium	10	Spain	71
Brazil	48	Sweden	19
Denmark	18	United Kingdom	8
Egypt	54	London, in transit	26
France	72	United States	379
Germany, West	21	Yugoslavia	16
India	10	Other countries	29
Japan	17		
Netherlands	33	Total	855

Colombia.—A new company, Cía. Organizadora de Industrias de Abonos y Productos Quimicos Ltda., was formed by Colombian, U.S., and West German interests to build a $12 million chemical plant in Cartagena, Colombia. Ammonia and nitric acid produced will supply a proposed fertilizer works at Aproqui.[12]

Peru.—A chemical fertilizer plant designed and built by Montecatini, Soc. Generale per l'Industria Mineraria e Chimica for Fertilizantes Sinteticos S.A., Lima, Peru, went on stream at Callao. Annual production capacity was 20,000 tons of ammonia, 15,000 tons of ammonia sulfate, and 54,000 tons of nitric acid.[13]

EUROPE

Belgium.—A series of strikes in Belgium seriously affected the 1960 nitrogen production.[14] However, output was slightly above that of 1959.

Bulgaria.—A urea plant with an annual production capacity of 10,000 tons was to be erected at the Stalin Chemical combine. Also planned was a urea plant to produce between 20,000 and 25,000 tons at the Slarasgora Nitrogen works.[15]

Czechoslovakia.—Nitrogenous fertilizer production totaled 148,900 short tons in 1959, an increase of 25 percent over 1958.[16]

Denmark.—A Norwegian firm and two Danish firms formed a Danish subsidiary, Dansk-Norsk Kvaelstoffabrik I/S, to construct a

[10] Chemical Age (London), Chile Closing Nitrate Mine: Vol. 83, No. 2133, May 28, 1960, p. 886.
[11] World Mining, Chile's Largest Natural Nitrate Producer Modernizes Plants: Vol. 13, No. 7, June 1960, p. 21.
[12] Chemical Age (London), Colombia to Have Large Fertiliser Plant: Vol. 83, No. 2128, Apr. 23, 1960, p. 687.
[13] Chemical Age (London), Montecatini Build Peru Fertiliser Plant: Vol. 83, No. 2123, Mar. 19, 1960, p. 496.
[14] Nitrogen (London), Western Europe: No. 9, January 1961, p. 19.
[15] Chemical Age (London), Urea Plants Planned For in Bulgaria: Vol. 83, No. 2116, Jan. 30, 1960, p. 210.
[16] Nitrogen (London), Rise in Czech N Fertiliser Production: No. 9, January 1961, p. 38.

large nitrogen plant at Grenaa, Jutland. The plant was expected to produce about 75,000 tons of ammonium nitrate and 10,000 tons of liquid ammonia in 1963.[17]

Finland.—A plant was constructed to produce 20 tons per day of concentrated nitric acid for Typpi Oy of Oulo, Finland.[18]

France.—A 280,000-ton-per-year nitrogenous fertilizer plant was planned to go on stream in 1962 near Nantes. It was to be built by Société Chimique de la Grande Parcisse at Donges.[19] Péchiney, Compagnie de Produits Chimiques et Electro-Metallurgiques Péchiney and Compagnie de Saint-Gobain formed a new company, Produits Chimiques Péchiney-Saint-Gobain, to erect new plants and gradually take over the entire chemical products operations of both companies in France. Each company holds half an interest.[20] Nitrogen output and capacity in France increased in 1959 with a production total of 747,000 ton N equivalent, 12 percent more than in 1958. This trend was expected to continue.[21]

Germany, East.—Piesteritz Nitrogen Works was to double its nitrogen capacity to 22,000 short tons by 1961. Leuna-Werk Walter Ulbricht, which produced about 90 percent of East Germany's total nitrogenous fertilizer requirements, planned new plants for urea and ammonium nitrate production.[22]

Germany, West.—Synthetic ammonia production in 1960 totaled 1.4 million tons of nitrogen equivalent, an increase of 6 percent compared with 1959. Domestic consumption showed the same percentage increase but exports declined by 12 percent.[23] Union Rheinische Braun-Kohlen Kraftstoff AG, Wesseling, West Germany, began construction of a unit near Cologne for the annual production of 25,000 tons of urea.[24]

Italy.—Italy became the sixth largest nitrogen-producing country and in 1959–60 produced approximately the same tonnage as France. Italy was a large exporter in 1959–60, shipping more than 40 percent of its production.[25] Augusta Petrolchimica completed its new ammonia plant at Priolo, Sicily. Capacity of the plant was 36,000 tons per year.[26]

Norway.—Norsk Hydro-Elektrisk Kvoelstofaktieselskab, Norway's largest industrial undertaking in the electrochemical field, produced annually 1.5 million tons of 50 different products. Most of the tonnage consisted of nitrogenous materials. Nitrogen was produced in 1960 at the rate of 250,000 tons per year.[27] In 1960 the company

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[17] Foreign Commerce Weekly, Large Nitrogen Factory To Be Built at Jutland: Vol. 64, No. 15, Oct. 10, 1960, p. 17.
[18] Chemical Trade Journal and Chemical Engineer (London), Nitric Acid in Finland: Vol. 147, No. 3823, Sept. 9, 1960, p. 567.
[19] Chemical Age (London), Nitrogenous Fertilisers in France: Vol. 84, No. 2139, July 9, 1960, p. 67.
[20] Chemistry and Industry (London), Agreement Between Péchiney and Saint-Gobain: No. 18, Apr. 30, 1960, p. 490.
[21] Nitrogen (London), Western Europe: No. 9, June, 1960, p. 15.
[22] Chemical and Engineering News, International Briefs: Vol. 38, No. 3, Jan. 18, 1960, p. 65.
[23] Nitrogen (London), Western Europe—West Germany: No. 10, March 1961, p. 22.
[24] Chemical Age (London), Second Urea Producer for West Germany: Vol. 84, No. 2153, Oct. 15, 1960, p. 632.
[25] Nitrogen (London), Italy Now the Sixth Largest Producer of Nitrogen in the World: No. 9, January 1961, pp. 1–10.
[26] Chemical Age (London), Petrolchimica Complete Priolo Ammonia Plant: Vol. 83, No. 2140, July 16, 1960, p. 109.
[27] Fertiliser and Feeding Stuffs Journal, Norsk Hydro's Progress: Vol. 53, No. 1, July 13, 1960, pp. 13–15.

planned another ammonia plant, this one to use waste gases from the Norwegian State ironworks at Mo. A plant for production of ammonium sulfate also was proposed.[28]

Poland.—A new 1,350-ton-per-day nitrogen fertilizer plant was planned in the Pulav district of Lublin Province. Completion was scheduled for late in 1965.[29]

Portugal.—An agreement was signed between Montecatini of Italy and Uniao Fabril do Azoto of Portugal for construction of a 40,000-ton-per-year urea plant at Labradio.[30]

Rumania.—A 100,000-ton-per-year plant to produce ammonium nitrate was reported under construction at the Fagaras chemical plant in Transylvania.[31]

Spain.—Nitrogen fertilizer output in 1960 increased 35 percent over the 1959 production.[32] Plans were made to build a 220-ton-per-day urea plant at Cartagena by Refineria de Petroleos de Escombreras S.A. (Repesa) of Spain.[33] Spanish production of fertilizers was planned to reach a total of 1,475,000 tons per year by 1964 which would satisfy domestic demands.[34]

U.S.S.R.—Three urea plants were planned for construction in the U.S.S.R. by Werkspoor, a Dutch firm. The firm claimed the plants will be the largest in the world.[35] Russia's seven-year plan ending in 1965 required tripling of the 1958 output of mineral fertilizer.[36]

United Kingdom.—A 75,000-ton-per-year ammonia plant was placed in production by Shell Chemical Co. Ltd. at Shell Haven, Essex, England.[37] Imperial Chemical Industries (ICI), Ltd., suppliers of over 70 percent of the total quantity of nitrogenous fertilizer sold in the United Kingdom, announced plans for new developments at its Severnside Works, the cost of which will eventually total $250 million or more. Included in the plan was a new 100,000-ton-per-year ammonia plant and related plants for urea and fertilizer to cost $28 million. This stage of the development was scheduled for completion in 1963.[38] A second unit to concentrate dilute nitric acid by the magnesium nitrate method was constructed at ICI Nobel Division, Ardeer plant.[39]

ASIA

China.—China's output of fertilizers was only 10 percent of estimated requirements. The Business and Defense Services Administration, U.S. Department of Commerce, estimated in 1960 that the fertilizer facilities in production and under construction represented

[28] Commercial Fertilizer, Norway: Vol. 100, No. 2, February 1960, p. 37.
[29] Chemical Engineering, CPI News Briefs—Poland: Vol. 67, No. 23, Nov. 14, 1960, p. 268.
[30] Chemical Age (London), New Unit in Portugal to Produce Urea: Vol. 83, No. 2134, June 4, 1960, p. 920.
[31] Chemical Age (London), Ammonium Nitrate Project in Rumania: Vol. 83, No. 2118, Feb. 13, 1960, p. 288.
[32] U.S. Embassy, Madrid, Spain, State Department Dispatch 490: Mar. 6, 1961, p. 9.
[33] Chemical Age (London), Urea Plants for Spain: Vol. 83, No. 2115, Jan. 23, 1960, p. 172.
[34] Foreign Trade (Ottawa), Fertiliser—Spain: Vol. 113, No. 2, Jan. 16, 1960, p. 20.
[35] Chemical Engineering, Industrial News—U.S.S.R.: Vol. 67, No. 17, Aug. 22, 1960, p. 174.
[36] Commercial Fertilizer, Soviets Plan to Triple Mineral Fertilizer Output: Vol. 100, No. 5, May 1960, pp. 23–24.
[37] Farm Chemicals, New Ammonia Plant Serves U.K. Markets: Vol. 123, No. 5, May 1960, pp. 58–60, 62.
[38] Commercial Fertiliser Around the Map—England: Vol. 100, No. 6, June 1960, p. 40.
[39] Chemical Age (London), I.C.I. Nobel Build Second Unit To Concentrate Nitric Acid by Magnesium Nitrate: Vol. 83, No. 2135, June 11, 1960, p. 947.

a total capacity of 7 million tons, of which 5 million tons were nitrogeneous fertilizers.[40] The first stage of a large new synthetic ammonia fertilizer plant project in Lanchow (northwest China) was completed.[41]

India.—Sahu Chemicals ammonium chloride plant at Varanasi, Uttar Pradesh, began operating in mid-1960. The Nangal Fertilizers plant at East Punjab went on stream late in 1960. A urea plant at Neyveli, Madras, was under construction and expected to begin production in 1961–62, and plans were underway to establish plants at Rourkela, Orissa, and Trombay in Maharashtra.[42] The plant at Trombay near Bombay is the first major fertilizer plant in India to be financed entirely by the U.S. Government. Planned annual capacity was 116,000 tons of ammonia, 105,000 of nitric acid, and 300,000 of nitrophosphate. The cost of the plant was said to be $58 million.[43]

Indonesia.—The Export-Import Bank of Washington, D.C., granted a loan of $33.2 million to the Republic of Indonesia to help finance the construction of a $43.2 million urea plant at Palembang, Sumatra, by the government-owned company, Srirvidjaja Fertiliser, Inc.[44]

Iran.—Construction of a $29 million nitrogenous fertilizer plant 20 miles north of Shiraz progressed during the year and was expected to be completed in October 1961.[45]

Iraq.—Following surveys by Russian advisers, Basra was selected as the site for a nitrogen fertilizer plant to be built with Russian aid.[46]

Israel.—Fertilisers & Chemicals Ltd. of Haifa began an expansion program to double its ammonia capacity to 20,000 tons per year and to develop more consumer products.[47] The same firm concludes a deal with a Greek fertilizer firm to build a $1 million ammonia storage facility. As part of the contract, the Israeli firm was to provide the Greek company with aqua ammonia during the construction period and anhydrous ammonia after its completion.[48]

Japan.—Because of strong European competition that resulted in financial losses on exported ammonium sulfate, an organization was contemplated to control exports and to cut production.[49]

Korea, Republic of.—The Chung-ju urea fertilizer plant, first of its kind in Korea, began production in February. The plant, an International Cooperation Administration aid project costing about $40 million, had a rated annual capacity of 85,000 tons of urea fertilizer.[50]

Pakistan.—Pakistan Industrial Development Corp. planned to build a new ammonium sulfate plant to be located on the Indus River near Sukkor.[51]

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[40] Oil, Paint and Drug Reporter, Fertlizer Output of the China Reds Can't Meet Needs: Vol. 177, No. 17, Apr. 18, 1960, pp. 7, 50.
[41] Chemical Age (London), New Plant for Fertilisers and Synthetic Fibers in China: Vol. 84, No. 2139, July 9, 1960, p. 68.
[42] Bureau of Mines, Mineral Trade Notes: Vol. 52, No. 2, February 1961, pp. 20–21.
[43] Commercial Fertilizer, Around the Map—India: Vol. 101, No. 6, December 1960, p. 40.
[44] Commercial Fertilizer, Around the Map—Indonesia: Vol. 100, No. 3, March 1960, p. 45.
[45] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 5, May 1960, p. 24.
[46] Chemical Trade Journal and Chemical Engineer (London), Nitrogen Fertiliser Factory for Iraq: Vol. 146, No. 3803, Apr. 22, 1960, p. 926.
[47] Chemistry and Industry (London), Israeli Chemical Expansion Continues: No. 44, Oct. 29, 1960, p. 1353.
[48] Chemical Week, Ammonia/Israel: Vol. 87, No. 18, Oct. 29, 1960, p. 26.
[49] Commercial Fertilizer, Around the Map—Japan: Vol. 101, No. 6, December 1960, p. 40.
[50] Fertiliser and Feeding Stuffs Journal, Korea's Urea Plant: Vol. 52, No. 13, June 29, 1960, p. 602.
[51] Commercial Fertilizer, Around the Map—Pakistan: Vol. 101, No. 6, December 1960, p. 40–41.

United Arab Republic (Syria Region).—Syria's first nitrogen plant was proposed for construction near Homs with technical and financial assistance from the U.S.S.R. Annual capacity was to be 45,000 tons, which could be increased later to 120,000 tons.[52]

AFRICA

Algeria.—A nitrogenous fertilizer plant was planned at Bone, Algeria, by the Société Algérienne de l'Azote. The plant's annual production was to be 60,000 tons of fixed nitrogen. Ammonia would be converted to ammonium sulfate and urea.[53]

Morocco.—Shell Oil Co. planned to build an $18 million ammonium phosphate plant at the Port of Safi.[54]

Rhodesia and Nyasaland, Federation of.—Plans and estimates were completed for a $25 million nitrogen plant in Salisbury by the African Explosives and Chemical Industries, Ltd.[55]

Union of South Africa.—African Explosives & Chemical Industries, Ltd., completed its new ammonia plant at Modderfontein near Johannesburg. The $28 million project, including a urea plant, increased existing Modderfontein ammonia capacity to about 160,000 short tons per year. Most of the output was used to produce 120,000 tons of urea annually.[56] A nitrogen-fixation plant was planned by South African Oil and Chemical Corp. for operation by the end of 1963.[57]

United Arab Republic (Egypt Region).—Demag-Elektrometallurgie, Duesburg, West Germany, began constructing a large water-electrolysis plant at Aswan, Egypt, to generate hydrogen for ammonia synthesis. Calcium ammonium nitrate fertilizer was to be the final product. When completed the plant was to be owned and operated by Egyptian Chemical Industries Co., a joint State and private enterprise.[58]

OCEANIA

Australia.—The ammonia plant at Ballarat, Victoria, was sold by the Australian Government to Imperial Chemical Industries of Australia and New Zealand Ltd.[59]

TECHNOLOGY

New granulation techniques for calcium nitrate were developed through extensive investigations conducted at the Dutch State Mines (Netherlands). The results of the investigation and a new prilling procedure were reported at a meeting of the Fertiliser Society in London.[60] The techniques and processes for the production of granu-

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[52] Commercial Fertilizer, Around the Map—Syria: Vol. 101, No. 2, August 1960, p. 76.
[53] Chemical Trade Journal and Chemical Engineer (London), Nitrogen Fertilisers Plant for Algeria: Vol. 147, No. 3824, Sept. 16, 1960, p. 623.
[54] Commercial Fertilizer, Around the Map—Morocco: Vol. 100, No. 6, June 1960, p. 40.
[55] Chemical Age (London), Nitrogen Plant for Rhodesia: Vol. 84, No. 2150, Sept. 24, 1960, p. 492.
[56] Mining Magazine (London), News Letters—Southern Africa: Vol. 103, No. 5, November 1960, p. 298.
[57] Chemical Trade Journal and Chemical Engineer (London), Nitrogen Plant for Sasol: Vol. 147, No. 3819, Aug. 12, 1960, p. 349.
[58] Chemical Engineering, Overseas Briefs—Egypt: Vol. 67, No. 9, May 2, 1960, p. 160.
[59] Chemical Age (London), I.C.I.A.N.Z. Buy Ammonia Plant in Australia: Vol. 83, No. 2121, Mar. 5, 1960, p. 410.
[60] Chemistry and Industry (London), Developments in Granulation Techniques: No. 7, Feb. 13, 1960, pp. 171–173.

lar ammonium nitrate as developed by the Société de l'Azote et Produits Chimiques du Marly (S.B.A.) were made available to other companies by licenses.[61]

Several articles were published on the Monsanto Chemical Co.'s computer-operated ammonia plant.[62]

Chemical Construction Corp. was said to have perfected a new, lower cost, more efficient process for producing urea.[63] A new Japanese urea process was reported,[64] with a 100-percent conversion efficiency claimed.[65] A new process for making urea was also announced by the Lion Oil Division, Monsanto Chemical Co.[66] An electronic device to detect small metallic pieces in bagged urea was marketed.[67]

A new process for concentrating nitric acid, developed in West Germany, was evaluated by engineers in the United States.[68]

The U.S. Atomic Energy Commission disclosed the possibility of a "chemonuclear reactor" which could make ammonium nitrate fertilizer out of air, water, and uranium.[69]

The University of California reported the development of a nitric acid-ammonium hydroxide process to make pulp from woodchips, sawdust, and other residues from logging operations and at the same time convert effluent to fertilizer.[70]

Research studies on silicon-nitrogen polymers which may be cross-linked to make resins, some having good commercial possibilities, were reported.[71]

A new synthetic fiber called U–Rylon made by Toyo Koatsu Industries Ltd., Japan, was considered to be a potential competitor of nylon. The fiber was made from a polycondensation product of mon-methylene diamine and urea.[72]

Bulk storage of anhydrous ammonia at atmospheric pressure gained increased acceptance in the United States in 1960. Vertical tanks for such storage were being fabricated of a special fine-grained steel.[73]

Techniques for using ammonium nitrate in field-compounded explosives were improved. A method was reported for hard-rock and wet-hole blasting.[74]

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[61] Chemical Age (London), S.B.A. Processes for Production of Granular Ammonium Nitrate: Vol. 84, No. 2141, July 23, 1960, pp. 135–136.

[62] Farm Chemicals, Computer "Runs" Ammonia Plant: Vol. 123, No. 11, November 1960, pp. 32, 41.

Agricultural Chemicals, Monsanto Demonstrates Computer-Controlled Ammonia Production: Vol. 15, No. 11, November 1960, pp. 78–79.

Chemical Engineering Progress, Closed-Loop Computer Control Called a Success: Vol. 56, No. 11, November 1960, pp. 76, 78.

[63] Agricultural Chemicals, Chemico Announces New Urea Production Process: Vol. 15, No. 12, December 1960, p. 82.

[64] Battelle Technical Review, Chemical Engineering—New Japanese Urea Process: Vol. 9, No. 7, July 1960, p. 397a.

[65] Chemical Age (London), 100-Percent Conversion Efficiency Claimed for Jap Urea Process: Vol. 83, No. 2113, Jan. 9, 1960, p. 82.

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[69] Agricultural Chemicals, Atomic Fertilizer Possible: Vol. 15, No. 6, June 1960, p. 83.

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[72] Chemical Trade Journal and Chemical Engineer (London), Japan Making Urea-Derived Fibre: Vol. 146, No. 3787, Jan. 1, 1960, p. 35.

[73] Chemical Trade Journal and Chemical Engineer (London), Bulk Ammonia Storage: Vol. 147, No. 3824, Sept. 16, 1960, p. 599.

[74] Mining Journal (London), A.N. Slurries for Hard Rock and Wet Hole Blasting: Vol. 254, No. 6509, May 20, 1960, pp. 578–579.

Perlite

By John W. Hartwell [1] and Victoria M. Roman [2]

PRODUCTION of crude perlite in the United States in 1960 was 13 percent less than in 1959. Expanded perlite production was 11 percent less.

DOMESTIC PRODUCTION

Crude Perlite.—Crude perlite was produced by 12 companies from 14 mines. One company in Arizona that mined perlite in 1959 did not operate during 1960.

Producers used 6 percent less crude perlite for their own expanding operations than in 1959, and the quantity sold by them to expanders was 3 percent less.

Nearly 298,000 short tons of crude ore was mined in New Mexico; this quantity was 15 percent less than in 1959, but it represented 77 percent of domestic output. Other States, in descending order of crude perlite production, were: Nevada, Arizona, California, Colorado, and Utah.

Expanded Perlite.—Perlite was expanded in 29 States by 60 companies at 87 plants. This was four more plants than in 1959 (three in California and one in Iowa). The greatest number of expanding plants were in California, 12; followed by Pennslyvania, 7; Texas, 6; New York, 5; and Illinois and New Jersey, 4 each.

Exploration for obsidian in the Glass Mountain area of eastern Siskiyou County, Calif., led to the discovery of a deposit of readily expansible perlite close to both rail and highway transportation.[3]

Perlite also was discovered in a new mineral area in the Mojave Desert, 33 miles southeast of Barstow, Calif.[4]

Allied Atomic Corp. of Imperial Beach, Calif., purchased 100 acres of perlite claims in Pershing County, Nev. Plans were made for processing the perlite for use in heavy construction work.

Early in 1960 a perlite deposit, estimated to contain 6 million tons, was discovered near Malad, Oneida County, Idaho. Oneida Perlite Corp. was formed to mine the ore. First shipments at the rate of 5,000 tons per month were made in November.

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[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.
[3] California Division of Mines, Mineral Information Service, The California Mineral Industry in 1960: Vol. 14, No. 3, March 1961, p. 6.
[4] California Mining Journal, Large Zirconium Deposit Reported in Cady Mountains, San Bernardino County: Vol. 29, No. 12, August 1960, p. 23.

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	
		Quantity	Value	Quantity	Value			Quantity	Value
1951-55 (average)	231	148	$1,153	56	$316	204	182	181	$9,472
1956	350	207	1,940	103	610	310	263	264	13,122
1957	422	194	1,730	107	832	301	249	245	12,511
1958	372	197	1,624	95	840	292	241	239	12,373
1959	443	221	1,846	104	891	325	276	273	[1] 14,187
1960	385	214	1,847	98	818	312	248	244	13,046

[1] Revised figure.

In April 1960 fire destroyed the Johns-Manville Perlite Corp. crushing plant at No Aqua, N. Mex. Near the end of the year a new $1 million fireproof mill with a 150,000-ton annual capacity was placed in operation. Nine silos stored 2,150 tons of processed perlite for shipment by truck to a blending and loading plant at Antonito, Colo.

TABLE 2.—Expanded perlite produced and sold by producers in the United States

(Thousand short tons and thousand dollars)

State	1959				1960			
	Quantity produced	Sold			Quantity produced	Sold		
		Quantity	Value	Average value per ton		Quantity	Value	Average value per ton
California	23	23	$1,422	$61.20	24	24	$1,395	$59.13
Florida	12	11	786	69.09	9	9	599	69.23
Kansas	1	1	43	74.35	1	1	43	76.70
Michigan	8	8	412	50.69	5	5	287	54.70
New Jersey	11	11	657	60.99	9	9	547	61.80
New York	21	21	[1] 995	[1] 48.32	18	18	886	48.11
Pennsylvania	18	18	1,090	59.20	17	17	1,092	62.65
Texas	26	26	1,427	55.31	23	23	1,343	57.50
Other Eastern States [2]	100	98	5,082	51.80	86	84	4,721	56.46
Other Western States [3]	56	56	[1] 2,273	[1] 40.54	56	54	2,133	39.42
Total	276	273	[1] 14,187	[1] 51.95	248	244	13,046	53.46

[1] Revised figure.
[2] Includes Illinois, Indiana, Maryland, Massachusetts, New Hampshire, North Carolina, Ohio, Tennessee, Virginia, and Wisconsin.
[3] Includes Arizona, Colorado, Iowa, Louisiana, Minnesota, Missouri, Nebraska, Nevada, New Mexico, Oregon, and Utah.

CONSUMPTION AND USES

The following end-use percentages for expanded perlite were reported by producers: Building-plaster aggregate, 60; concrete aggregate, 13; filter aids, 12; oil well cement, 4; insulation (loose fill), insulation (other), soil conditioning, 2 each; filter, paint additive, and wall board, 1 each; and miscellaneous uses, 2.

PRICES

The average value of crushed, cleaned, and sized perlite, sold to expanders, was $8.64 per short ton, f.o.b. producers' plants, compared with $8.37 in 1959. The average value of crude perlite used by prime producers in their own expanding operations was $8.31, compared with $8.55 in 1959. A weighted average price of these two categories of crude perlite was $8.54 in 1960, a 1-percent increase over 1959.

The average price of all expanded perlite sold in 1960 was $53.50 per ton, an increase of almost 2 percent over 1959.

FOREIGN TRADE

Crude perlite may be imported duty-free under paragraph 1719 of the Tariff Act of 1930. Expanded perlite has had a duty at 15 percent ad valorem since January 1, 1948.

WORLD REVIEW

Canada.—Perlite has not been mined in Canada since 1953 when 1,112 tons was produced and processed. Raw perlite was imported from the United States for processing and use.

Expanded perlite production in 1959 was 127,000 cubic yards valued at nearly CAN $1 million, a 3-percent decrease in volume and value since 1958. Eight plants were operating in 1959 in Ontario, Quebec, Manitoba, Alberta, and British Columbia.

In 1959, 81 percent of the expanded perlite was used in lightweight plaster, compared with 91 percent in 1958. Consumption in concrete aggregate was 13 percent in 1959 and 3 percent in 1958. Acoustical tile, plaster, oil-well cement, stucco admix, and horticulture used 6 percent in both years.[5]

Germany, West.—The mining companies of Otavi Minen and Eisenbahn-Gesellschaft, Frankfurt, planned to build a new perlite plant in Dorfprozelten. Planned capacity of the plant was not given.

Hungary.—A perlite grinding and expanding plant with a capacity of 4,000 tons per year was constructed at Palhaza. Increased capacity to 24,000 tons was planned for 1961 and 60,000 tons for 1963.

Plants for producing expanded perlite were exported by Hungary's export bureau. These plants had a capacity of 5 cubic meters of expanded perlite per hour.

Iceland.—A review of perlite deposits in Iceland and their possible commercial applications was published.[6]

TECHNOLOGY

A book on the geology of industrial rocks and minerals contained information on perlite. Data included description and location of

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[5] Wilson, H. S., Lightweight Aggregates 1959 (Preliminary): Canadian Min. Ind., Dept. Min. and Tech. Surveys, Ottawa, Rev. No. 27, 1959, pp. 1–6.

[6] Richer, Konrad [Perlite, with Special References to Icelandic Occurrences]: Ztschr. deut. geol. gesell., vol. 112, 1960, pp. 197–207; Chem. Abs., vol. 55, No. 6, Mar. 20, 1961, col. 5259f.

occurrences, chemical and physical properties, production, uses, and 25 references.[7]

Some perlite deposits in Utah were described; the properties, methods of processing, and uses of the ores were given. A map of the area locating the deposits was included.[8]

Perlite deposits in the No Aqua Mountains and near Cerro de la Olla, Taos County, N. Mex., were described. The geology of the deposits and the mining and milling processes of the plants owned by Johns-Manville Perlite Corp., Great Lakes Carbon Corp., U.S. Perlite Co., and United Perlite Corp. were given.[9]

The perlite deposits in the Leitendorf Hills near Lordsburg, N. Mex., were described briefly.[10]

The occurrences and descriptions of 14 perlite deposits in Washington were published.[11]

A patent was granted for a composition made of asphalt and expanded perlite which could be used in protecting metallic pipelines.[12]

A perlite insulation refractory was patented. The insulation material was made of bentonite and expanded perlite, mixed and shaped with a binder, which was fused by firing at 1,400° to 1,750° F.[13]

A process was patented for making insulating refractories from a mixture of alumina cement, uncalcined kyanite, and 10- to 25-percent minus 6-mesh, expanded perlite. Shapes made from this mixture could withstand temperatures up to 2,500° F.[14]

An improved cement mortar containing portland cement, expanded perlite, and other materials for use in grouting and setting clay tile and other masonry work was patented.[15]

A patent was granted on a method of making structural clay brick containing exfoliated vermiculite, expanded perlite, or expanded clay as an aggregate to give additional strength and controlled bulk density.[16]

Patents were granted for a plaster material containing coarse and fine grades of expanded perlite [17] and a process for making acoustical plaster using calcined gypsum and expanded perlite or similar lightweight aggregates.[18]

A process for grinding and air-classifying expanded perlite as an improved filter aid product was patented.[19]

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[7] Bates, R. L., Geology of Industrial Rocks and Minerals: Harper Brothers, New York, N.Y., 1960, pp. 50–58.

[8] Nackowski, M. P., and Levy, Enrique, Mineral Resources of the Delta-Milford Area: Univ. of Utah Bull. 101, vol. 50, No. 18, September 1959, pp. 82, 84–89.

[9] Schilling, J. H., Mineral Resources of Taos County, N. Mex.: State Bureau of Mines and Miner. Resources, Bull. 71, 1960, pp. 27, 106–110, 114.

[10] Flege, R. F., Geology of Lordsburg Quadrangle, Hidalgo County, N. Mex.: State Bureau of Mines and Miner. Resources, Bull. 62, 1959, pp. 29–30.

[11] Valentine, G. M., and Hunting, M. T., Inventory of Washington Minerals: Wash. Dept. of Conservation, Division of Mines and Geol., Bull. 37, vol. 1, pt. 1, 1960, pp. 82–83 (text); vol. 2, pt. 1, 1960, p. 61 (map).

[12] Czemski, F. C., and Ford, K. D. (assigned to Atlantic Refining Co., Philadelphia, Pa.), Composition for Protecting Metallic Structures: U.S. Patent 2,935,412, Mar. 5, 1960.

[13] Houston, H. H., and McCollum, L. S. (assigned to International Minerals & Chemical Corp., Chicago, Ill.), Perlite Insulation Material: U.S. Patent 2,956,893, Oct. 18, 1960.

[14] Renkey, A. L. (assigned to Harbison-Walker Refractories Co., Pittsburgh, Pa.), Insulating Refractory: U.S. Patent 2,963,377, Dec. 6, 1960.

[15] Wagner, H. B. (assigned to Tile Council of America, Inc., New York), High Temperature Portland Cement Mortars: U.S. Patent 2,959,489, Nov. 8, 1960.

[16] Robinson, G. C. (assigned to Zonolite Co., Evanston, Ill.), Structural Clay Products and Method of Making the Same: U.S. Patent 2,922,719, Jan. 26, 1960.

[17] Covert, K. B., and Brist, U. M. (assigned to Pabcor, Inc., Fredericksburg, Va.), Plastering Material: U.S. Patent 2,931,733, Apr. 5, 1960.

[18] Sucetti, G., Acoustical Composition: U.S. Patent 2,921,862, Jan. 19, 1960.

[19] Maxey, W. C., Method of and Apparatus for Continuously Processing Expanded Perlite: U.S. Patent 2,935,267, May 3, 1960.

A canister-type filter assembly for removing vapor and impurities from air was patented. The filter would be an absorbent material composed of loose expanded perlite.[20]

The use of a mixture of diatomite and expanded perlite in optimum proportions and particle size gradings as a filter aid was patented.[21]

Foreign patents were issued on a method of continuously producing a filter aid from crude perlite,[22] a clay brick suitable for insulation or loadbearing applications,[23] a type of kiln apparatus for producing expanded perlite,[24] the manufacture of gypsum board with a core composition containing a lightweight aggregate such as expanded perlite,[25] and a plasterboard made of gypsum and expanded perlite.[26]

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[20] Gruner, C. T. (assigned to General Motors Corp., Detroit, Mich.), Filter Device: U.S. Patent 2,922,488, Jan. 26, 1960.

[21] Leppla, P. W. (assigned to Great Lakes Carbon Corp., New York, N.Y.), Mineral Filter Aid Composition: U.S. Patent 2,956,016, Oct. 11, 1960.

[22] Maxey, W. C., Canadian Patent 592,650, Feb. 16, 1960.

[23] Burnett, W. H. (assigned to Wm. H. Burnett Trust), Canadian Patent 558,901, June 17, 1958.

[24] Ito, J., Japanese Patent 312, 1960.

[25] Taylor, J. B. (assigned to British Plaster Board Holdings, Ltd.), British Patent 832,256, Apr. 6, 1960.

[26] Scales, J. V., Australian Patent 225,418, Nov. 19, 1959.

Phosphate Rock

By Richard W. Lewis [1] and Gertrude E. Tucker [2]

THE UPWARD TREND in marketable production of phosphate rock in the United States, which started in 1958, continued in 1960 with an increase of 10 percent over the previous year. A new world production record of 40 million tons was established. This was an 8 percent increase over the 1959 figure. U.S. imports declined 8 percent while exports of phosphate rock (P_2O_5 content) surpassed 1 million tons, a gain of 35 percent.

TABLE 1.—Salient phosphate rock statistics
(Thousand long tons and thousand dollars)

	1951-55 (average)	1956	1957	1958	1959	1960
United States:						
Mine production	[1] 41,799	52,198	45,460	46,459	49,249	54,338
P_2O_5 content	[1] 5,277	5,752	5,315	5,805	6,048	6,552
Marketable production	12,286	15,747	13,976	14,879	15,869	17,516
P_2O_5 content	3,913	4,960	4,356	4,668	4,939	5,443
Value	$75,180	$97,922	$87,689	$93,693	$98,758	$117,041
Average per ton	$6.12	$6.22	$6.27	$6.30	$6.22	$6.68
Sold or used by producers	12,233	14,111	14,597	[2] 14,757	16,065	17,202
P_2O_5 content	3,898	4,432	4,564	[2] 4,616	5,014	5,352
Value	$75,058	$89,232	$91,718	[2] $92,842	$99,657	$115,363
Average per ton	$6.14	$6.32	$6.28	[2] $6.29	$6.20	$6.71
Imports for consumption [3]	109	110	110	108	140	129
Value	$2,420	$2,626	$3,090	$2,944	$3,421	$3,754
Average per ton	$22.25	$23.90	$28.21	$27.21	$24.45	$29.04
Exports [4]	1,920	2,685	3,010	2,694	3,048	3,994
P_2O_5 content	634	876	977	887	956	1,290
Value	$12,449	$15,649	$20,070	$18,060	$20,466	$26,632
Average per ton	$6.48	$5.83	$6.67	$6.70	$6.71	$6.67
Consumption, apparent [5]	10,422	11,536	11,697	[2] 12,171	13,157	13,337
World: Production	27,555	33,680	32,410	34,750	36,960	40,100

[1] Average for 1953-55.
[2] Revised figure.
[3] Data on P_2O_5 content not available.
[4] As reported to the Bureau of Mines by domestic producers.
[5] Measured by amount sold or used plus imports minus exports.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

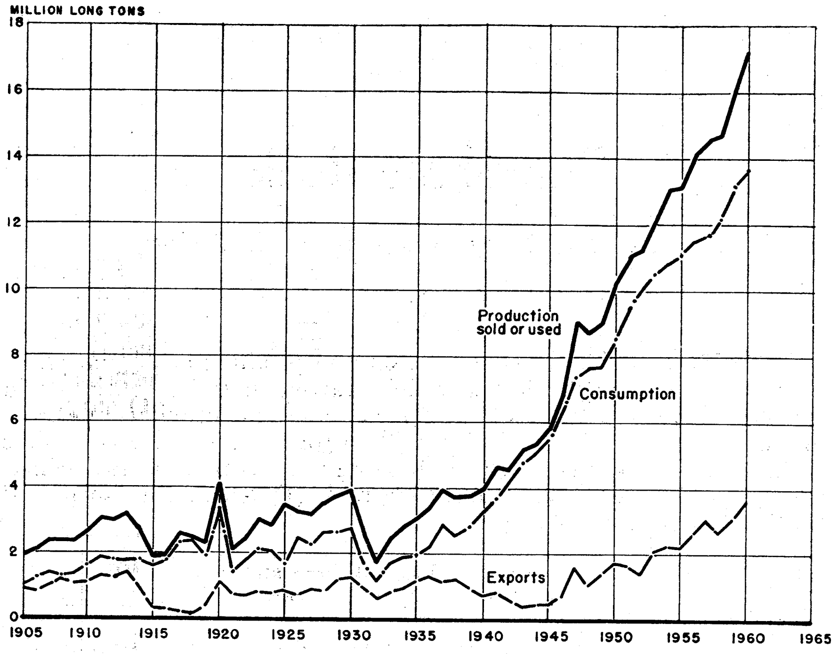

FIGURE 1.—Marketed production, apparent consumption, and exports of phosphate rock, 1905–60.

DOMESTIC PRODUCTION

All three of the phosphate rock producing areas increased production in 1960. Production in Florida, which produced 70 percent of the total domestic marketable rock, increased only 7 percent whereas production in Tennessee and the Western States increased 10 and 28 percent, respectively, over 1959.

A large amount of expansion took place in the phosphate industry of the Florida area in 1960. American Agricultural Chemical Co. began constructing a new washer plant 10 miles south of Pierce, Fla. Also, the company installed two high-efficiency air classifiers to separate fines from phosphate rock at its processing plant. As part of an air-pollution control project, American Cyanamid Co. installed a new $500,000 chain-mill with fans for blowing escaping fluorine gas into scrubbers where 70 percent of it is absorbed. In addition, a dust collector was planned for completion in 1961, which would reduce by 90 percent the amount of dust escaping into the atmosphere. Armour Agricultural Chemical Co. planned a new phosphate processing plant near Fort Meade, Fla.; a major part of a $60-million proposed expansion project.

Virginia-Carolina Chemical Corp. built a new diammonium phosphate plant in Polk County, Fla., a $10-million expansion of its superphosphate plant, and a new phosphate-rock flotation plant at Clear Springs. This company resumed production of elemental phosphorus at its Nichols plant, which had been closed since 1957. W. R. Grace & Co., Davison Chemical Division increased triple superphosphate productive capacity at least 25 percent. International Minerals & Chemical Corp. began constructing a phosphate-rock calcining plant at Bartow, which is scheduled for operation early in 1961. Construction of a phosphoric acid plant at Marseilles, Ill., by the National Phosphate Corp. was more than half completed in 1960. The plant was scheduled to use Florida phosphate rock to produce 54 percent P_2O_5 acid by the wet-process. Olin Mathieson Chemical Corp. let contracts for the construction of a $1.5-million phosphoric acid plant near Joliet, Ill. Swift & Co. planned a new phosphoric acid plant south of Bartow, Fla., to double its production. U.S. Phosphoric Products Division, Tennessee Corp. announced plans to expand its phosphate processing facilities 50 percent, to be completed in 1961 or early 1962.

TABLE 2.—Mine production of phosphate-rock ore in the United States, by States

(Thousand long tons)

Year	Florida		Tennessee [1]		Western States [2]		Total United States	
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content
1953–55 (average)	37,232	4,236	2,672	526	1,895	515	41,799	5,277
1956	47,250	4,530	2,524	576	2,424	646	52,198	5,752
1957	40,584	4,173	2,752	587	2,124	555	45,460	5,315
1958	41,084	4,556	3,003	625	2,372	624	46,459	5,805
1959	43,365	4,679	2,709	556	3,175	813	49,249	6,048
1960	48,007	5,023	2,931	636	3,400	893	54,338	6,552

[1] Includes brown rock, white rock in 1953–58, and blue rock in 1954–58.
[2] Includes Idaho, Montana, Utah, and Wyoming.

The Western phosphate-rock producers were keeping pace with the expanding industry. The Bunker Hill Co. completed a $2-million phosphoric acid plant at Sandpoint, Idaho, and construction was started on an addition to its phosphoric acid plant in Kellogg, Idaho. Anhydrous liquid phosphate will be produced in the latter plant by Bunker Hill exclusively for Collier Carbon & Chemical Corp., owners of the new facility. Monsanto Chemical Co. added 1,362 acres of phosphate land to its large holdings in the Soda Springs area of southern Idaho. The company also began constructing a plant to manufacture concentrated phosphoric acid at Addyston, Ohio. Monsanto will be the first commercial producer and shipper of bulk quantities of this concentrated acid. San Francisco Chemical Co. reported that its 600,000-ton-per-year phosphate concentrator near Vernal, Utah, started production in December 1960. J. R. Simplot Co. acquired the phosphate products facilities at Anaconda, Mont., and leased the phosphate rock properties at Conda, Idaho, from The Anaconda Company. Stauffer Chemical Co. planned a new phosphatic fertilizer plant at Vernal, Utah, which will be operating by the end of 1962. The company also announced that it was joining with Shell Chemical Co. and Western States Chemical Corp. to form a new fertilizer company and build a 50,000-ton-per-year plant to supply complex solid fertilizers for California. The plant would be located next to Stauffer Chemical Co.'s unit at Dominguez, Calif. It was reported that the Yuba Consolidated Industries, Inc., of San Francisco purchased leases on an estimated 120-million-ton phosphate-rock deposit near the Flaming Gorge Dam site in Utah.

TABLE 3.—Marketable production of phosphate rock in the United States, by States

(Thousand long tons)

Year	Florida [1]		Tennessee [2]		Western States [3] [4]		Total United States	
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content
1951–55 (average)	9,187	3,072	1,497	396	1,602	445	12,286	3,913
1956	11,822	3,910	1,685	438	2,240	612	15,747	4,960
1957	10,191	3,352	1,812	469	1,973	535	13,976	4,356
1958	10,851	3,593	1,903	495	2,125	580	14,879	4,668
1959	11,564	3,794	1,755	458	2,550	687	15,869	4,939
1960	12,321	4,052	1,939	506	3,256	885	17,516	5,443

[1] Salable products from washers and concentrators of land pebble and hard rock, and drier production of soft rock (colloidal clay).
[2] Salable products from washers and concentrators of brown rock, brown-rock ore (matrix) used directly, blue rock in 1954–58, and white rock in 1953–58.
[3] Mine production of ore (rock), plus a quantity of washer and drier production.
[4] Includes Idaho, Montana, Utah, and Wyoming.

In Tennessee, Hooker Chemical Corp. began construction of a $6.4-million expansion of its Columbia, Tenn., phosphate plant. The project included the addition of a third furnace to produce elemental phosphorus, which will increase the plant's capacity to 65,000 tons per year.

CONSUMPTION AND USES

Apparent consumption has set new records each year for over 20 years. The trend was followed again in 1960 with an increase of 1 percent over 1959.

The U.S. Department of Agriculture reported that 2,566,000 long tons of available P_2O_5 was consumed in fertilizer during the year ending June 30, 1960, less than a 1-percent increase over the preceding year.

Producers reported that 5,352,000 long tons (P_2O_5 content) of phosphate rock was sold or used in 1960. Of this total, 58 percent was used for agricultural and 18 percent for industrial products. The remainder was exported. Triple superphosphate tonnage (P_2O_5 content) increased 9 percent.

TABLE 4.—Phosphate rock sold or used by producers and apparent consumption in the United States

(Thousand long tons and thousand dollars)

Year	Sold or used		Apparent consumption
	Quantity	Value	Quantity
1951–55 (average)	12,233	$75,058	10,422
1956	14,111	89,232	11,536
1957	14,597	91,718	11,697
1958 [1]	14,757	92,842	12,171
1959	16,065	99,657	13,157
1960	17,202	115,363	13,337

[1] Revised figures.

TABLE 5.—Florida phosphate rock sold or used by producers, by kinds

(Thousand long tons and thousand dollars)

Year	Hard rock				Soft rock[1]			
	Rock	P_2O_5 content	Value		Rock	P_2O_5 content	Value	
			Total	Average per ton			Total	Average per ton
1951–55 (average)	81	28	$635	$7.85	81	17	$484	$5.95
1956	103	36	872	8.45	59	12	376	6.40
1957	80	28	682	8.59	56	12	401	7.15
1958	76	27	639	8.40	51	10	405	7.94
1959	76	27	649	8.54	56	11	443	7.91
1960	74	26	639	8.64	45	9	372	8.33

Year	Land pebble				Total			
	Rock	P_2O_5 content	Value		Rock	P_2O_5 content	Value	
			Total	Average per ton			Total	Average per ton
1951–55 (average)	8,986	3,014	$54,206	$6.03	9,148	3,059	$55,325	$6.05
1956	10,366	3,425	64,354	6.21	10,528	3,473	65,602	6.23
1957	10,508	3,467	66,863	6.36	10,644	3,507	67,946	6.38
1958	10,446	3,463	66,309	6.35	10,573	3,500	67,353	6.37
1959	11,628	3,837	71,771	6.17	11,760	3,875	72,863	6.20
1960	12,132	3,984	80,905	6.67	12,251	4,019	81,916	6.69

[1] Includes material from waste-pond operations.

TABLE 6.—Tennessee phosphate rock[1] sold or used by producers

(Thousand long tons and thousand dollars)

Year	Rock	P_2O_5 content	Value		Year	Rock	P_2O_5 content	Value	
			Total	Average per ton				Total	Average per ton
1951–55 (average)	1,579	418	$11,664	$7.39	1958	1,923	501	$13,160	$6.84
1956	1,663	434	12,792	7.69	1959	1,775	462	13,266	7.47
1957	1,778	459	11,857	6.67	1960	1,927	502	15,319	7.95

[1] Includes small quantity of Tennessee blue rock in 1954–58 and white rock in 1952–58.

TABLE 7.—Western States phosphate rock sold or used by producers

(Thousand long tons and thousand dollars)

Year	Idaho [1]				Montana [2]				Total			
	Rock	P_2O_5 content	Value		Rock	P_2O_5 content	Value		Rock	P_2O_5 content	Value	
			Total	Average per ton			Total	Average per ton			Total	Average per ton
1951-55 (average)	877	234	$3,571	$4.07	[3] 629	[3] 187	[3] $4,498	$7.15	1,506	421	$8,069	$5.36
1956	1,206	314	6,044	5.01	714	211	4,794	6.72	1,920	525	10,838	5.64
1957	1,418	374	6,589	4.65	[3] 757	[3] 224	[3] 5,326	7.04	2,175	598	11,915	5.48
1958	[4] 1,436	[4] 370	[4] 6,370	4.44	825	245	5,959	7.22	[4] 2,261	[4] 615	[4] 12,329	5.45
1959	1,590	400	6,625	4.17	940	277	6,903	7.34	2,530	677	13,528	5.35
1960	1,973	520	10,269	5.21	1,051	311	7,859	7.47	3,024	831	18,128	5.99

[1] Idaho includes Utah in 1951-52.
[2] Montana includes Utah in 1953-55, and Wyoming in 1951-60.
[3] Wyoming data published previously in Phosphate Rock chapters included as follows: 1951-55 (average): 63,000 long tons of rock, 20,235 tons of P_2O_5, valued at $421,000, for 1951-52; 1957: 182,000 long tons of rock, 58,000 tons of P_2O_5, valued at $1,197,000.
[4] Revised figure.

TABLE 8.—Phosphate rock sold or used by producers in the United States, by grades and States

(Thousand long tons)

Year and grade—B.P.L.[1] content (percent)	Florida		Tennessee		Western States		Total United States	
	Quantity	Percent of total	Quantity	Percent of total	Quantity	Percent of total	Quantity	Percent of total
1959:								
Below 60	81	1	1,468	83	1,647	65	3,196	20
60 to 66	2,513	21	[2] 307	[2] 17	[2] 883	[2] 35	556	4
68 basis, 66 minimum							[3] 2,626	[3] 16
70 minimum	1,601	14	(2)	(2)	(2)	(2)	2,122	13
72 minimum	2,128	18					2,128	13
75 basis, 74 minimum	3,470	29					3,470	22
77 basis, 76 minimum	1,967	17			(2)	(2)	1,967	12
Total	11,760	100	1,775	100	2,530	100	16,065	100
1960:								
Below 60	305	2	1,561	81	1,761	58	3,260	19
60 to 66			293	15			660	4
68 basis, 66 minimum	2,929	24	(2)	(2)	1,263	42	3,726	22
70 minimum	1,302	11	[2] 73	[2] 4			[4] 1,841	[4] 10
72 minimum	2,209	18					2,209	13
75 basis, 74 minimum	3,920	32					3,920	23
77 basis, 76 minimum	1,586	13					1,586	9
Total	12,251	100	1,927	100	3,024	100	17,202	100

1 Bone phosphate of lime, $Ca_3(PO_4)_2$.
2 Figures combined to avoid disclosing individual company confidential data.
3 Includes 77/76 grade rock in Western States.
4 Includes 72 grade rock in Western States.

TABLE 9.—Phosphate rock sold or used by producers in the United States, by uses and States

(Thousand long tons)

Year and use	Florida		Tennessee		Western States		Total United States	
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content
1959:								
Domestic:								
Agricultural:								
Ordinary superphosphate	4,294	1,492	(1)	(1)	(1)	(1)	4,474	1,549
Triple superphosphate [2]	3,459	1,132	90	28	473	151	3,842	1,254
Direct application to soil	598	186	70	21	(3)	(3)	668	207
Stock and poultry feed	351	110			(3)	(3)	351	110
Other [4]	51	17	12	3	3	1	66	21
Total agricultural	8,753	2,937	172	52	476	152	9,401	3,141
Industrial:								
Elemental phosphorus, ferrophosphorus, phosphoric acid	341	102	1,594	408	1,672	405	3,607	915
Other [5]			9	2			9	2
Total industrial	341	102	1,603	410	1,672	405	3,616	917
Exports [6]	2,666	836			382	120	3,048	956
Grand total	11,760	3,875	1,775	462	2,530	677	16,065	5,014
1960:								
Domestic:								
Agricultural:								
Ordinary superphosphate	4,000	1,350	(1)	(1)	(1)	(1)	4,270	1,436
Triple superphosphate [2]	3,538	1,160	114	36	817	258	4,199	1,368
Direct application to soil	528	163	64	19	(3)	(3)	592	182
Stock and poultry feed	285	90			(3)	(3)	285	90
Other [4]	34	11	6	1	6	2	46	14
Total agricultural	8,385	2,774	184	56	823	260	9,392	3,090
Industrial:								
Elemental phosphorus, ferrophosphorus, phosphoric acid	387	116	1,733	443	1,684	409	3,804	968
Other [5]			10	3	2	1	12	4
Total industrial	387	116	1,743	446	1,686	410	3,816	972
Exports [6]	3,479	1,129			515	161	3,994	1,290
Grand total	12,251	4,019	1,927	502	3,024	831	17,202	5,352

[1] Included with triple superphosphate.
[2] Includes rock for phosphoric acid (wet process).
[3] Included with "Other" agricultural.
[4] Includes phosphate rock used in calcium metaphosphate, fused tricalcium phosphate, nitraphosphate, fertilizer filler, and other applications.
[5] Includes phosphate rock used in pig iron blast furnaces, parting compounds, research, defluorinated phosphate rock, refractories, and other applications.
[6] As reported to the Bureau of Mines by domestic producers.

STOCKS

Producer's stocks at the end of 1960 were 9 percent higher than in 1959.

TABLE 10.—Producer stocks of phosphate rock, Dec. 31 [1]

(Thousand long tons)

Source	1959		1960	
	Rock	P_2O_5 content	Rock	P_2O_5 content
Florida	2,414	788	2,484	820
Tennessee [2]	246	69	258	74
Western States	[3] 754	[3] 208	986	262
Total	3,414	1,065	3,728	1,156

[1] As reported to the Bureau of Mines by domestic producers.
[2] Includes a quantity of washer-grade ore (matrix).
[3] Includes inventory adjustments.

PRICES

Prices for Florida land-pebble phosphate rock remained firm through June, as quoted by the Oil, Paint and Drug Reporter. The July 4, 1960 issue quoted a 50-cent-per-ton increase on all grades. Prices were again raised in November and were somewhat unsteady to the end of the year. Price variation was particularly noticeable on the 68/66 grade during November and December. The average increase in price for the year was about 12 percent.

On December 14, 1959, the Oil, Paint and Drug Reporter changed the quotations to price-per-short-ton from price-per-long-ton. Inadvertently, the prices listed for December 28 in table 11, page 843, Phosphate Rock chapter of the 1959 Minerals Yearbook, volume I, were not marked "per short ton".

Tennessee and Western States phosphate-rock prices were not quoted in the trade journals.

TABLE 11.—Prices of Florida land pebble, unground, washed, and dried phosphate rock, in bulk, carlots, at mine, in 1960

(Per short ton)

Grade (percent B.P.L.)	Jan. 4	Dec. 26	Grade (percent B.P.L.)	Jan. 4	Dec. 26
68/66	$4.798	$4.989-5.398	75/74	$6.628	$7.329-7.338
70/68	5.148	5.849-5.858	76/78	7.518	8.219-8.228
72/70	5.728	6.429-6.438			

Source: Oil, Paint and Drug Reporter.

FOREIGN TRADE[3]

Imports.—The total value of imported phosphate rock and phosphatic fertilizers in 1960 was $12.3 million, $7.3 million less than in 1959. Ammonium phosphate was again the highest valued import item but it was 45 percent lower than the preceding year. Only three items were imported in greater quantities in 1960: Normal superphosphate increased nine-fold, triple superphosphate, 7 percent, and dicalcium phosphate, 57 percent. Imports of ammoniated superphosphate dropped to less than a tenth of 1959 imports and guano to 13 percent of 1959 imports.

TABLE 12.—U.S. imports for consumption of phosphate rock and phosphatic fertilizers

Fertilizer	1959		1960	
	Long tons	Value	Long tons	Value
Phosphates, crude, not elsewhere specified	139,891	$3,420,818	129,290	$3,754,425
Superphosphates (acid phosphate):				
Normal (standard) [1]	128	7,716	1,112	27,431
Concentrated (treble) [2]	856	57,955	915	55,258
Ammoniated	2,733	223,893	237	17,182
Total superphosphates	3,717	289,564	2,264	99,871
Ammonium phosphates, used as fertilizer	192,596	13,633,209	107,087	7,464,663
Bone dust, or animal carbon and bone ash, fit only for fertilizer	14,111	887,938	8,225	533,280
Guano	[3] 13,340	1,162,309	1,794	162,021
Slag, basic, ground, or unground	237	6,665		
Dicalcium phosphate (precipitated bone phosphate) all grades	3,287	196,747	5,164	282,665

[1] Classified by the Bureau of the Census as: 1959, not over 25 percent P_2O_5 content; 1960, not over 22 percent P_2O_5 content.
[2] Classified by the Bureau of the Census as: 1959, over 25 percent P_2O_5 content; 1960, over 22 percent P_2O_5 content.
[3] Revised figure.

Source: Bureau of the Census.

Exports.—Japan continued to be the best foreign customer with Canada next. These countries received 34 and 20 percent of the exported phosphate rock, respectively. Canada was the major recipient of superphosphate (41 percent); followed by Brazil (13 percent), and Cuba (10 percent).

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 13.—U.S. exports of phosphate rock, by grades and countries

Grade and destination	1959		1960	
	Long tons	Value	Long tons	Value
Florida phosphate rock:				
North America:				
Bahamas			27	$864
Canada	281,357	$2,466,967	294,730	2,725,248
Costa Rica			187	2,079
Cuba	20,000	154,537	28,302	270,968
El Salvador			179	4,638
Mexico	48,553	318,739	70,897	475,646
South America:				
Argentina			2,034	20,280
Brazil	59,668	605,722	41,552	415,336
Chile	2,001	31,125	1,929	38,145
Colombia	2,295	34,369	1,303	14,530
Peru	11,033	100,811	13,453	121,068
Uruguay	10,047	105,050	17,257	177,085
Venezuela	237	3,884	89	2,066
Europe:				
Austria	4,939	39,315		
Czechoslovakia	5,987	53,883	16,505	148,549
Denmark	30,769	277,972	29,139	262,265
Finland			7,639	69,540
Germany:				
East			9,221	63,154
West	316,088	2,543,098	391,341	3,170,842
Greece	14,484	97,335	22,437	197,944
Ireland			15,806	142,261
Italy	204,867	1,781,091	548,934	4,475,267
Netherlands	199,348	1,730,038	192,390	1,676,188
Norway	798	8,187	8,685	77,837
Spain	115,070	1,039,174	125,598	1,161,976
Sweden	61,268	553,042	62,870	588,151
Switzerland			2,004	21,649
United Kingdom	200,742	1,592,682	274,024	2,321,403
Asia:				
Hong Kong	908	6,002		
India	11,287	112,863	28,485	284,867
Japan	1,124,337	8,363,094	1,437,102	10,906,517
Korea, Republic of	7,781	134,732	15,182	269,441
Laos	496	8,250		
Philippines	20,489	180,390	6,480	65,987
Turkey	26,491	176,132		
Viet-Nam	9,269	170,961	11,735	209,532
Africa: Union of South Africa	20,085	181,969	20,887	187,977
Total	2,810,694	22,871,414	3,698,403	30,569,300
Other phosphate rock:[1]				
North America:				
Canada	409,198	5,503,924	542,527	6,887,836
Costa Rica	259	3,221		
Cuba	268	3,870		
El Salvador	45	1,372	89	1,532
Mexico	559	25,558	34	915
South America:				
Brazil	1,479	15,187	3,002	30,079
Chile			986	15,630
Venezuela	4,009	64,745	1,250	37,500
Europe: Belgium-Luxembourg	12,714	104,254		
Asia: Viet-Nam	497	8,245		
Total	429,028	5,730,376	547,888	6,973,492
Grand total	3,239,722	28,601,790	4,246,291	37,542,792

[1] Includes colloidal matrix, sintered matrix, soft phosphate rock, and Tennessee, Idaho, and Montana rock.

Source: Bureau of the Census.

TABLE 14.—U.S. exports of superphosphates (acid phosphates), by countries

Destination	1959		1960	
	Long tons	Value	Long tons	Value
North America:				
Bahamas	174	$6,260	220	$8,577
Canada	166,760	5,583,192	169,621	6,037,060
Costa Rica	1,719	94,747	1,785	99,414
Cuba	31,134	1,257,628	43,693	1,618,822
Dominican Republic	9,814	640,923	3,748	257,371
El Salvador	295	20,140	400	28,275
Guatemala	68	3,857	54	2,585
Mexico	18,049	1,235,204	15,357	996,567
Nicaragua	53	3,412	5	236
Panama			167	11,300
Trinidad and Tobago	500	31,696	150	10,088
Other	319	19,732	44	3,029
South America:				
Argentina	140	10,000	310	18,765
Brazil	45,124	2,433,132	54,803	3,044,132
Chile	25,646	1,568,819	36,499	2,369,044
Colombia	769	50,151	4,168	279,102
Ecuador	256	15,695	250	17,286
Paraguay	18	1,800		
Peru	103	10,638	2,640	64,890
Venezuela	4,476	221,524	9,595	612,979
Other			99	6,786
Europe:				
Germany, West			206	11,088
Ireland			1,792	98,327
Netherlands			15,103	793,846
Sweden			10	624
Asia:				
Hong Kong			5,303	375,366
Indonesia	10	880	27	1,953
Korea, Republic of	104,405	6,127,141	36,525	2,116,353
Pakistan			11,351	792,000
Philippines	473	30,893	2,953	201,536
Viet-Nam	1,969	33,000	36	3,182
Other			5	462
Oceania: Trust Territory of the Pacific Islands			5	502
Africa:				
Libya			7	585
Rhodesia and Nyasaland, Federation of	357	8,400		
Total	412,631	19,408,864	416,931	19,882,132

Source: Bureau of the Census.

WORLD REVIEW

NORTH AMERICA

Canada.—Electric Reduction Co. of Canada Ltd. started constructing a $12-million plant at Port Maitland, Ontario for the production of triple superphosphate, phosphatic fertilizer solutions, and industrial phosphate. The phosphate rock will be supplied by International Minerals & Chemical Corp. from its Florida mines. The sulfuric acid was available locally. The new plant was expected to supply all of Canada's triple superphosphate demand plus about 5 percent of the U.S. market.[4] A new company, Grand Saguenay Mines and Minerals Ltd., was formed to explore and develop an iron-phosphate deposit in the Saguenay River area, about 15 miles from the aluminum plant at Arvida.[5]

[4] Chemical Age (London), New Erco Fertiliser Plant Will Meet Canadian Demand and Give Export Surplus: Vol. 84, No. 2151, Oct. 1, 1960, p. 544.
[5] Canadian Mining Journal (Quebec), New Company Develops Iron-Phosphate Area: Vol. 81, No. 1, January 1960, p. 114.

Mexico.—Hooker Mexicana, S.A., a wholly-owned subsidiary of Hooker Chemical Corp. started operating its new $1.2-million sodium tripolyphosphate plant at Lecheria, 15 miles from Mexico City. The plant also produced food-grade phosphoric acid and tetrasodium pyrophosphate. Capacity of the plant was 30,000 tons of sodium tripolyphosphate per year.[6]

Netherlands Antilles.—Aruba Exploration & Mining Co., Ltd. was established in January to develop the mineral resources of the island. The company concentrated its efforts on the phosphate-rock deposits.[7]

TABLE 15.—World production of phosphate rock by countries [1 2]

(Thousand long tons)

Country [1]	1951–55 (average)	1956	1957	1958	1959	1960
North America:						
United States	12,286	15,747	13,976	14,879	15,869	17,516
Netherlands Antilles (exports)	108	104	105	85	97	113
Total	12,394	15,851	14,081	14,964	15,966	17,629
South America:						
Brazil	[3] 30	44	82	144	246	[3] 246
Chile:						
Apatite	47	62	32	18	20	[3] 20
Guano	42	24	34	31	21	[3] 20
Peru (guano)	262	331	281	164	107	144
Venezuela	----------	30	146	----------	----------	----------
Total	381	491	575	357	394	[3] 430
Europe:						
Belgium	56	13	16	18	13	[3] 13
France	103	89	92	76	[3] 74	[3] 74
Spain	22	8	(4)	----------	(4)	----------
Sweden (apatite)	8	----------	----------	----------	----------	----------
U.S.S.R.:						
Apatite [3]	2,805	3,690	3,940	3,940	3,940	4,230
Sedimentary rock [3]	1,225	1,575	1,720	1,970	1,970	2,265
Total [1 4]	4,465	5,620	6,000	6,250	6,240	6,830
Asia:						
British Borneo (guano)	1	(4)	(4)	(4)	1	[3] 1
China [4]	120	150	200	300	500	600
Christmas Island (Indian Ocean) exports	341	341	336	374	487	[3] 490
India (apatite)	2	9	9	15	14	14
Indonesia	(4)	3	4	2	10	7
Israel	35	118	150	206	201	[3] 200
Jordan	61	205	258	289	332	356
Philippines (guano)	2	8	4	8	(4)	10
Viet-Nam, North:						
Phosphate rock	(5)	32	22	32	[3] 34	[4] 65
Apatite	(5)	23	65	137	138	[4] 400
Total [1 4]	620	910	1,080	1,390	1,750	2,170

See footnotes at end of table.

[6] Chemical and Engineering News, Hooker Returns to Mexico: Vol. 38, No. 29, July 18, 1960, pp. 68–70

[7] Bureau of Mines, Mineral Trade Notes: Vol. 51, No. 5, November 1960, pp. 48–49.

TABLE 15.—World production of phosphate rock by countries [1] [2]—Continued

(Thousand long tons)

Country [1]	1951-55 (average)	1956	1957	1958	1959	1960
Africa:						
Algeria	713	600	603	552	563	579
Malagasy Republic (Madagascar)	1	3	3	5	9	[3] 9
Morocco: Southern zone	4,562	5,435	5,480	6,236	7,050	7,354
Rhodesia and Nyasaland, Federation of: Southern Rhodesia					2	3
Senegal [7]	74	72	88	103	94	104
Seychelles Islands (exports)	7	4	6	17	6	[3] 6
South-West Africa (guano)	1		3		1	
Tunisia	1,907	2,044	2,035	2,243	2,150	2,068
Uganda	4	3	3	2	3	4
Union of South Africa	88	154	166	213	228	264
United Arab Republic (Egypt Region)	529	605	576	549	668	558
Total	7,886	8,920	8,963	9,920	10,774	10,949
Oceania:						
Angaur Island (exports)	119					
Australia	6	7	11	7	5	[3] 5
Makatea Island (French Oceania)	240	255	303	304	306	372
Nauru Island (exports)	1,163	1,333	1,105	1,234	1,192	[3] 1,378
Ocean Island (exports)	276	297	292	324	334	[3] 344
Total	1,804	1,892	1,711	1,869	1,837	[3] 2,100
World total (estimate) [1] [2]	27,555	33,680	32,410	34,750	36,960	40,100

[1] North Korea and Poland produce phosphate rock; but data of output are not available; estimates for these countries have been included in the total. A negligible amount is produced in Angola, British Somaliland, Jamaica, Japan, and Tanganyika.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Less than 500 tons.
[5] Data not available; estimate by senior author of chapter included in the total.
[6] Target.
[7] Includes calcium phosphate, production of which is reported in thousand long tons as follows: 1952-55 (average) 19; 1956, 7; 1957, 2; 1958, 1; 1959, 1; 1960, 0.5.

Compiled by Liela S. Price, Division of Foreign Activities.

SOUTH AMERICA

Brazil.—Fabrica de Fertilizantes de Araxa completed construction of a new fertilizer plant and began producing pulverized apatite.[8] Cia. de Superfosfatos e Produtos Quimicos planned to establish a plant in Capuava with an initial annual output of 40,000 tons of triple superphosphates and about 15,000 tons of phosphoric acid.[9] Important easily workable phosphate rock deposits were discovered at Olinda on land belonging to Cia. Paulista de Tecidos.[10]

Colombia.—Compania Quimica Industrial S.A. of Cali, Colombia, planned to build a plant to produce double and triple superphosphate near Puerto Berrio.[11]

Peru.—Compania de Minerales Industriales of Lima staked a large number of phosphate rock claims in the Sechura Desert in northwest Peru. Preliminary geological studies indicated that the deposit was one of the largest in the world.[12]

[8] Bureau of Mines, Mineral Trade Notes: Vol. 51, No. 4, October 1960, p. 39.
[9] Chemical Age (London), Brazilian Firm To Set Up Superphosphates Plant: Vol. 83, No. 2131, May 14, 1960, p. 808.
[10] Mining Journal (London), Mining Miscellany: Vol. 254, No. 6509, May 20, 1960, p. 583.
[11] World Mining, International News Latin America: Vol. 13, No. 7, June 1960, p. 54.
[12] World Mining, Large Phosphate Deposit Located in Peru Desert: Vol. 13, No. 12, November 1960, p. 56.

Venezuela.—The Venezuelan government planned to develop large phosphate deposits in the Lobatera region of Tachira State.[13]

EUROPE

Austria.—A plant to produce phosphoric acid was planned for erection at Krems.[14]

Germany, West.—Farbwerke Hoechst AG subsidiary, Knapsack-Griensheim AG of Knapsack, proposed the construction of a new 70,000-kw. phosphorus furnace to be completed late in 1961. The company had two furnaces producing 40,000 tons of elemental phosphorus annually.[15]

Ireland.—The first plant for making triple superphosphate began production in October at The Marina, Cork, operated by Goulding Fertilisers, Ltd.[16]

Albatross-Windmill Fertiliser Co., Ltd., awarded a contract to build an extension to its plant to add superphosphates to its products.[17]

Yugoslavia.—The construction of a 757,000-ton-per-year superphosphate plant at Prahovo was expected to be completed in 1961.[18]

ASIA

Burma.—Fertilizers & Chemical, Ltd. (Haifa, Israel) announced that it would build a $2-million superphosphate and sulfuric acid plant near Rangoon.[19]

India.—A contract was awarded by Adarsh Chemicals and Fertilisers, Ltd., for a sulfuric acid and a superphosphate plant to be built at Bombay.[20] The capacity to produce superphosphates in India increased about 6 percent in 1959, but production was 244,428 tons, 47 percent above that of 1958.[21]

Israel.—A flotation plant to upgrade Oron phosphate rock to more than 31 percent P_2O_5 began operating. In addition to the Oron deposits in the Negev Desert, there are three principal phosphate-rock fields in Israel: Ein Yahav, Hameishar, and Hor Hahar. The Negev Phosphates Co., Ltd., planned construction of its second phosphate plant at Ein Yahav, 100 kilometers from Eilat.[22] Fertilisers & Chemicals Ltd. of Haifa expanded its dicalcium phosphate plant, tripling output.[23]

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13 Agricultural Chemicals, To Work Phosphate Deposits: Vol. 15, No. 12, December 1960, p. 74.
14 Chemical Age (London), vol. 83, No. 2123, Mar. 19, 1960, pp. 495–496.
15 Chemical Age (London), 70,000 kw Phosphorus Furnace for Knapsack: Vol. 84, No. 2151, Oct. 1, 1960, pp. 543–544.
16 Chemical Trade Journal and Chemical Engineer (London), Fertilisers in Eire: Vol. 147, No. 3833, Nov. 18, 1960, p. 1173.
17 Commercial Fertilizer, Around the Map: Vol. 101, No. 6, December 1960, p. 40.
18 Chemical Trade Journal and Chemical Engineer (London), Superphosphate in Yugoslavia: Vol. 146, No. 3805, May 6, 1960, p. 1044.
19 Chemical Superphosphates, Sulfuric Acid/Burma: Vol. 86, No. 17, Apr. 28, 1960, p. 39.
20 Chemical Age (London), Chemico Will Build New Fertiliser Plant in India: Vol. 84, No. 2141, July 23, 1960, p. 129.
21 Bureau of Mines, Mineral Trade Notes: Vol. 52, No. 2, February 1961, p. 23.
22 Bureau of Mines, Mineral Trade Notes: Vol. 51, No. 3, September 1960, p. 35.
23 Agricultural Chemicals, Haifa Output Increased: Vol. 15, No. 11, November 1960, p. 71.

Lebanon.—A report described the phosphate-rock deposits in the Rift Valley area of southern Lebanon. Extensive exploration showed the beds ranged in thickness from a few inches to 10 feet, and in grade from 17 to 31 percent P_2O_5. The reserve in the northern part of the field containing 23 to 25 percent P_2O_5 was estimated at 4.8 million tons.[24]

Viet-Nam.—Production of about 50,000 tons of organic phosphate with a guano base was expected in 1960 in the Paracel Islands. A reserve of more than 20 million tons of this material was estimated.[25]

AFRICA

Algeria.—Plans were announced that an extensive phosphate-rock deposit at Djebel Onk in eastern Algeria was to be exploited. The plan included the construction of a 60-mile railroad, a processing plant to produce annually 800,000 tons of marketable phosphate rock, the development of a small petroleum field nearby to supply fuel for the plant, and the mining of the deposit by open-pit methods. The reserve of the deposit was estimated at 500 million to 1 billion tons, reportedly the largest in the world.[26]

Congo, Republic of the.—The government announced the discovery and survey of large deposits of carbonatite containing commercially interesting quantities of pyrochlore and apatite.[27]

Morocco.—The Bureau d'Etudes et de Participations Industrielles (BEPI) made extensive plans for a chemical complex to be built at Safi. The complex will be made up of three principal plants: The first, a "feeder" plant, will produce sulfuric acid and the phosphorous materials necessary for the production of fertilizer; the second will produce triple superphosphates; and the third, to be built with the aid of Royal Dutch-Shell, will produce ammonium phosphate fertilizer.[28]

Morocco withdrew from the French Comptoir des Phosphates de l'Afrique du Nord which had controlled all sales of phosphates from Morocco, Algeria, and Tunisia. Arrangements were completed for direct purchases of ore from Morocco with the Office Cherifien des Phosphates managing sales.[29]

Senegal.—Compagnie Sélégalaise des Phosphates de Taïba shipped 10,000 tons of phosphate to the Netherlands on August 10. This was the first commercial export of phosphate from the Republic.[30] Other exports totaling 79,000 tons followed. The capacity of the company's plant is 2,000 tons daily.

Tanganyika.—Examination of a large phosphate-rock deposit about 70 miles southwest of Arusha revealed an estimated reserve of 10 million long tons, 1 million of which can be easily developed by removing a thin overburden. New Consolidated Goldfields, Ltd., planned to process and market 50,000 tons annually in East Africa where at present phosphatic fertilizer is imported at high cost.[31]

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[24] U.S. Embassy, Ankara, Turkey, State Department Dispatch 710: May 4, 1960, pp. 1-15.
[25] Commercial Fertilizer, Viet-Nam, Phosphate From Paracels: Vol. 100, No. 1, January 1960, p. 50.
[26] Bureau of Mines, Mineral Trade Notes: Vol. 51, No. 4, October 1960, pp. 38-39.
[27] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 6, June 1960, p. 37.
[28] Economic News from Morocco, vol. 2, No. 9, October 1960, pp. 3-4, Morocco Embassy, Washington, D.C.
[29] Bureau of Mines, Mineral Trade Notes: Vol. 51, No. 2, August 1960, pp. 46-47.
[30] Foreign Commerce Weekly, Phosphate Shipped From Senegal for First Time: Vol. 64, No. 18, Oct. 31, 1960, p. 25.
[31] Bureau of Mines, Mineral Trade Notes: Vol. 51, No. 5, November 1960, p. 49.

TABLE 16.—**Algeria, Morocco, and Tunisia: Exports of phosphate rock by countries**

(Long tons)

Destination	1959	1960 [1]
North America: Canada		3,937
South America:		
Brazil	33,893	24,573
Chile		8,799
Uruguay	4,872	15,452
Europe:		
Austria	88,097	99,208
Belgium	578,756	627,680
Czechoslovakia	77,851	127,854
Denmark	216,662	223,913
Finland	84,052	98,273
France	1,681,587	1,717,558
Germany, West [2]	854,733	912,547
Greece	146,515	167,126
Ireland	128,762	155,590
Italy	1,095,902	886,061
Netherlands	486,697	506,915
Norway	85,622	64,175
Poland	258,388	295,177
Portugal	252,760	241,366
Rumania	10,147	
Spain	844,388	834,796
Sweden	230,168	254,287
Switzerland	23,641	31,593
United Kingdom	721,565	886,582
Yugoslavia	7,450	23,390
Asia:		
China	502,351	570,332
India	94,960	43,498
Indonesia	2,954	22,194
Japan	281,742	244,511
Taiwan	68,329	79,197
Turkey	17,484	28,979
Viet-Nam	7,381	10,925
Africa: Union of South Africa	357,394	413,974
Oceania: New Zealand	4,500	
Intercountry shipments [3]	466,001	408,462
Total	9,715,604	10,028,924
Algeria	548,462	516,156
Morocco: Southern Zone	7,046,449	7,533,559
Tunisia	2,120,693	1,900,232
Senegal		78,977

[1] Includes Senegal.
[2] May include East Germany.
[3] Trade between Algeria, Morocco, and Tunisia.

Compiled from Customs Returns of Algeria, Morocco, and Tunisia by Corra A. Barry, Division of Foreign Activities.

Togo, Republic of.—The development of the Akoumape phosphate-rock deposit was scheduled by the Compagnie Togolaise des Mines du Bénin. A railroad for the project was completed and other work was started. Reserves were estimated at 50 million tons.[32]

Tunisia.—Aktiebolaget Forenade Superfosfatfabriken of Sweden signed an agreement with the Tunisian government to build a $9.5-million triple superphosphate plant at Sfax.[33]

United Arab Republic (Egypt Region).—The Ministry of Industry stated that 100 million tons of phosphate rock had been located in the western desert of Egypt. It was further stated that work had begun expanding the phosphate-rock workings near Kosseir and that exploitation of phosphate rock had started on a new site in the Nile Valley between Edfu and Esna.[34]

[32] World Mining, International News, Africa: Vol. 22, No. 12, November 1960, p. 69.
[33] Bureau of Mines, Mineral Trade Notes: Vol. 51, No. 4, October 1960, p. 41.
[34] Mining Journal (London), Mining Miscellany: Vol. 255, No. 6538, Dec. 9, 1960, p. 662.

TABLE 17.—United Arab Republic (Egypt Region): Exports of phosphate rock by countries [1]

(Long tons)

Destination	1958	1959
Ceylon	37,008	70,708
Czechoslovakia	47,854	36,821
Finland	3,120	----------
Germany, West	21,230	[2] 6,998
Greece	33,468	7,779
India	52,674	63,396
Japan	152,061	[2] 139,637
Spain	57,787	102,563
Yugoslavia	11,379	2,736
Other countries	----------	11,005
Total	416,581	441,643

[1] This table incorporates some revisions.
[2] Detail shown by country of importation.

Compiled from Customs Returns of United Arab Republic (Egypt Region) by Corra A. Barry, Division of Foreign Activities.

TECHNOLOGY

Underground slurrying techniques were used experimentally in an effort to recover phosphate rock from deposits along the Pamlico River in North Carolina.[35]

A new phosphate-rock washer using a special hydrosizer was developed and construction was started at the Palmetto, Fla., location of American Agricultural Chemical Co. The facility was designed to give maximum recovery of phosphate rock.[36]

A new flotation process was developed by Smith-Douglass Co., Inc. engineers and was tested for an 8-month period. The test-run demonstrated that the process saved 30 percent in major equipment and 20 percent in operating cost while recovering 95 percent of the phosphate against an 85-percent recovery by previous methods. In the process, silica is floated first and then the phosphate. This is the reverse of other methods.[37]

A process for concentrating phosphate rock containing calcium carbonate by passing gaseous sulfur dioxide through a phosphate-rock slurry was patented by Negev Phosphates Co., Ltd.[38]

A patent was issued for an improved method of deoiling phosphate-rock concentrates from the primary cells in the double-flotation process.[39]

A new type of wet-scrubber unit for removing dust ejected into the air by phosphate-rock drying plants was installed at the Ridgewood, Fla., plant of W. R. Grace & Co. Davison Chemical Division. This was the first installation of a system of this type in the field. The wet scrubber followed a primary cyclone dust remover. It was stated that it eliminated almost all dust from the ejected gases.[40]

[35] Chemical Week, Technology Newsletter: Vol. 87, No. 12, Sept. 17, 1960, pp. 87–88.
[36] Oil, Paint and Drug Reporter, AAC Starts Construction of New Phosphate Washer: Vol. 177, No. 19, May 2, 1960, p. 47.
[37] Chemical Week, Flotation Switch Cuts Phosphate Costs: Vol. 87, No. 13, Sept. 24, 1960, pp. 75–76.
[38] Chemical Trade Journal and Chemical Engineer (London), Patents List, Concentrating Rock Phosphate: Vol. 147, No. 3821, Aug. 26, 1960, p. 478.
[39] Chapman, O. C., and Dean, A. W. (assigned to Virginia-Carolina Chemical Corp.), Process of Deoiling Phosphate Concentrate by Means of Immiscible Liquids: U.S. Patent 2,927,691, Mar. 8, 1960.
[40] Mining World, Precipitates—Central & Eastern: Vol. 22, No. 3, March 1960, p. 67.

Engineers of all eight phosphate-rock producing companies in the Polk-Hillsborough County phosphate area of Florida agreed on minimum design standards for settling area dams to be built in the future. The new standards were based on proven engineering practices, advice from U.S. Army Corps of Engineers, and other consultants.[41]

A new process for making mineral fertilizers from molten magnesium phosphate was claimed by the Kazakh Academy of Science, Institute of Chemistry (Moscow). The process smelts phosphorites in a cyclone furnace originally designed for smelting copper concentrates and it uses a magnesium trachinate salt as an additive.[42]

A method for producing monocalcium orthophosphate from crude tricalcium phosphate was patented which comprised of reacting the crude material with phosphoric acid (60–100 percent H_3PO_4).[43]

A new process was developed by Barrett Division, Allied Chemical Corp. for recovering gypsum from wet process phosphoric acid production. The recovered gypsum is comparable in quality with that produced from the highest purity rock and could be used for manufacturing wallboard.[44]

A plant to recover vanadium pentoxide from ferro-phosphorus slag reportedly was being designed by Minerals Engineering Co. at Salt Lake City, Utah. The undisclosed process uses elemental-phosphorus furnace slag and was stated to be the first attempt to produce high-purity vanadium pentoxide from Western phosphatic ores.[45]

A new process for producing granular diammonium phosphate was developed by the Tennessee Valley Authority.[46]

A magnesium ammonium phosphate fertilizer that will not burn or injure roots or foliage was developed by the W. R. Grace & Co. as well as a ferrous ammonium phosphate which was stated to be equally effective in some forestry applications.[47]

L. Light and Co., Ltd. reportedly produced both red and white phosphorus with a minimum purity of 99.999 percent.[48] American Agricultural Chemical Co. announced a new product, said to be the purest grade of elemental phosphorus that has been produced commercially.[49]

Starch phosphates were in pilot-plant production by American Maize-Products Co. of Hammond, Ind. The firm contemplated building a plant to produce 60,000 pounds of starch phosphates per week. Possible uses for these products were: Thickener for frozen foods; a taconite-ore binder; an ingredient in adhesives, drugs, and cosmetics; and a substitute for gum arabic, locust bean gum, and carboxymethyl cellulose.[50]

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[41] Mining World, What's Going on in Mining Central: Vol. 22, No. 12, November 1960, p. 65.
[42] Chemical Week, Processes: Vol. 87, No. 13, Sept. 24, 1960, p. 81.
[43] Vickey, R. C. (assigned to Horizons, Inc.), Production of $Ca(H_2PO_4)_2$: U.S. Patent 2,914,380, Nov. 24, 1959.
[44] Chemical Age (London), Recovery of By-Product Gypsum From Phosphoric Acid: Vol. 83, No. 2131, May 14, 1960, pp. 807–808.
[45] Chemical Week, Technology Newsletter: Vol 86, No. 19, May 17, 1960, p. 67.
[46] Agricultural Chemicals, New TVA Process Developed: Vol. 15, No. 9, September 1960, p. 86.
[47] Chemical Age (London), Two New Metal Ammonium Phosphate Compounds from Grace: Vol. 84, No. 2161, Dec. 10, 1960, p. 998.
[48] Chemical Trade Journal and Chemical Engineer (London), Ultra-Pure Phosphorus: Vol. 147, No. 3826, Sept. 30, 1960, p. 726.
[49] Farm Chemicals, Ultra-Pure Phosphorus Marketed by the Ounce: Vol. 123, No. 3, March 1960, p. 54.
[50] Chemical Week, Technology Newsletter: Vol. 86, No. 26, June 25, 1960, pp. 77–78.

An improved method of direct analyses for available phosphorus in fertilizers was accepted by the Association of Official Agricultural Chemists.[51]

Monsanto Chemical Co. introduced developmental quantities of six new flame retardants for resin systems. These compounds were made from phosphorus chlorides and bromides combined with aldehydes and trialkyl phosphites. It was claimed that these compounds provided a way to impart flame resistance to polystyrene, polyolefins, acrylics, and polyesters without damaging the desirable resin properties. Hooker Chemical Corp. produced in commercial quantities, triphenylphosphite-derived compounds for mixing into new types of stabilizer systems to retard oxidation in polyvinyl and polyolefin resins.[52]

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[51] Chemical and Engineering News, Research & Technology Concentrates: Vol. 38, No. 42, Oct. 17, 1960, p. 49.

[52] Chemical Engineering, New Organophosphorus Chemicals Kindle Hopes for Big Markets: Vol. 67, No. 20, Oct. 3, 1960, pp. 33–35.

Platinum-Group Metals

By J. P. Ryan [1] and Kathleen M. McBreen [2]

LOWER INDUSTRIAL demand, reflecting the downturn in the Nation's business, and unusual price stability characterized the platinum-group-metal industry in 1960. Domestic consumption of platinum-group metals declined only moderately from the record high of 1959, but net imports dropped sharply. Mine production rose substantially, but refinery output of secondary metals dropped from the peak of 1959.

The U.S.S.R. continued its orderly selling of platinum and palladium in world markets at prices only slightly below U.S. official prices, and this policy contributed to price stability. For the first time since 1946, rhodium of Soviet origin was imported by the United States.

World production of platinum-group metals rose moderately to about 1.2 million ounces, principally because of the sharp increase in Canada's output, which was the highest in 18 years. Output from the Union of South Africa, based on an increase in the scale of operations at Rustenburg Platinum Mines, Ltd., was estimated to have advanced moderately.

The virtual completion of productive facilities at the Thompson nickel-mining project of The International Nickel Company of Canada, Ltd. (Inco), in northern Manitoba, Canada, brought a substantial increase in the company's productive capacity and potential output of byproduct platinum-group metals. Initial production was scheduled to begin early in 1961.

LEGISLATION AND GOVERNMENT PROGRAMS

The regulations established under the Defense Materials System by Business and Defense Services Administration of the U.S. Department of Commerce, governing the flow of raw materials to defense agencies, continued to apply to platinum-group metals. Purchase orders for materials needed in national defense work continued to have priority rating over unrated commercial business orders.

All platinum-group metals through the semifabricated stage required a validated license for export to Soviet-bloc countries.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

Exploration for platinum-group metals was eligible for 50-percent financial assistance under the program of the Office of Minerals Exploration (OME); no projects were active in 1960.

DOMESTIC PRODUCTION

Domestic mine production of platinum-group metals, derived from platinum placers in Alaska and gold placers in California and recovered as byproducts in refining gold and copper ores, increased about 50 percent to 23,600 ounces. Total refinery production of new platinum-group metals from both domestic and foreign sources rose 4 percent over last year to 51,240 ounces, with increases in the output of palladium, iridium, osmium, and rhodium more than offsetting lower output of platinum and ruthenium. Nearly 40 percent of the new metals recovered came from domestic sources.

Secondary platinum-group metals recovered by refiners, chiefly from scrap, sweeps, and outmoded jewelery, aggregated 76,900 ounces, about 44 percent less than the quantity so recovered in 1959. All metals of the platinum group shared in the drop. In addition to the secondary metals recovered, large quantities of platinum-group metals in the form of wornout catalysts, spinnerets, laboratory ware, and other used equipment were received from industry for reworking or refining on toll. Refiners delivered at least 763,000 ounces of such metals in 1960 compared with 538,000 ounces in 1959.

Domestic ores and secondary materials furnished about 13 percent of domestic requirements of platinum-group metals in 1960.

TABLE 1.—Salient platinum-group metals statistics

	1951–55 (average)	1956	1957	1958	1959	1960
United States:						
Mine production [1]..troy ounces..	28, 967	21, 398	18, 531	14, 359	15, 485	23, 609
Value	$2, 240, 453	$1, 884, 487	$1, 428, 642	$740, 583	$913, 736	$1, 485, 439
Refinery production:						
New metal.....troy ounces..	56, 810	58, 650	47, 228	48, 195	49, 321	51, 243
Secondary metal.....do.....	61, 370	106, 269	87, 521	81, 514	135, 996	76, 857
Imports for consumption..do.....	660, 943	1, 033, 877	682, 013	670, 431	1, 010, 333	680, 646
Exports (except manufactures) troy ounces..	33, 696	42, 072	40, 354	47, 368	31, 405	65, 149
Stocks Dec. 31:						
Refiner, importer, dealer troy ounces..	401, 772	564, 533	507, 189	493, 426	495, 851	515, 750
Consumption..........do.....	576, 562	858, 912	744, 025	689, 693	896, 403	775, 214
World: Production..........do.....	870, 000	1, 110, 000	1, 320, 000	890, 000	[2]1, 010, 000	1, 190, 000

[1] From crude platinum placers and byproduct platinum-group metals recovered largely from domestic gold and copper ores.
[2] Revised figure.

CONSUMPTION AND USES

Domestic consumption of platinum-group metals, as indicated by sales to consuming industries, was 775,200 ounces, about 14 percent below the record high of 1959. The fall off in industrial consumption, which extended to all metals of the platinum group, reflected decreased demand for these metals principally because of the general decline in business activity. Although increased quantities of platinum-

TABLE 2.—New platinum-group metals recovered by refiners in the United States, by sources

(Troy ounces)

Year and source	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1951-55 (average)	44,843	6,068	3,006	1,138	1,029	726	56,810
1956	50,516	4,389	2,476	500	363	406	58,650
1957	37,109	4,031	2,693	1,349	1,056	990	47,228
1958	35,409	5,913	3,146	1,014	1,229	1,484	48,195
1959:							
From domestic sources:							
Crude platinum; Gold and copper refining	9,791	4,179	767	103	83	92	15,015
From foreign crude platinum	27,505	3,346	933	388	847	1,287	34,306
Total	37,296	7,525	1,700	491	930	1,379	49,321
1960:							
From domestic sources:							
Crude platinum; Gold and copper refining	10,232	8,274	810	118	769	163	20,366
From foreign crude platinum	24,899	1,362	1,865	885	1,688	178	30,877
Total	35,131	9,636	2,675	1,003	2,457	341	51,243

TABLE 3.—Secondary platinum-group metals recovered in the United States

(Troy ounces)

Year	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1951-55 (average)	28,975	28,270	1,026	315	1,085	1,699	61,370
1956	60,916	37,774	1,751	447	3,246	2,135	106,269
1957	49,022	31,294	1,406	398	3,014	2,387	87,521
1958	36,426	38,883	1,223	335	2,639	2,008	81,514
1959	58,945	68,279	1,188	361	5,631	1,592	135,996
1960	38,861	35,465	914	279	953	385	76,857

group metals were absorbed by chemical industries and for dental and medical uses, these gains failed to offset declines in other industrial categories. Consumers in the United States absorbed nearly two-thirds of the 1960 world production of platinum-group metals.

Platinum sales declined 11 percent as increased demand from electrical industries was more than offset by lower demand from other principal consuming industries. Chemical, petroleum, and glass industries absorbed 51 percent of the platinum sold; electrical and electronic industries took 33 percent; jewelry and decorative uses took 10 percent; and dental and medical uses took 5 percent of total sales.

Sales of palladium were 15 percent lower than in 1959 principally because of the sharp drop in demand from electrical and electronic equipment manufacturers, which absorbed about two-thirds of the total palladium sold. The fall off in electrical and jewelry sales more than offset increased sales for chemical, petroleum refining, and dental and medical uses, which accounted for 18, 1, and 9 percent of total sales, respectively.

Sales of minor platinum-group metals—iridium, osmium, rhodium, and ruthenium—dropped 19 percent to 36,400 ounces. About half of the total metals sold were used in the chemical and glass industries, 22 percent for jewelry and decorative uses, 19 percent for electrical, and 2 percent for dental and medical uses. Rhodium comprised about two-thirds of the total sales of these metals.

The principal industrial uses of the platinum-group metals were based on such properties as high resistance to chemical corrosion, especially at high temperature, superior catalytic activity, and good electrical conductivity. Platinum-group-metal catalysts continued to be used extensively in many highly specialized chemical processes including ammonia oxidation and the production of nitric acid, production of hydrogen peroxide by the anthraquinone process, synthesis of hydrocyanic acid from methane and ammonia, synthesis of waxes, and the synthesis of acetaldehyde acetylene. Platinum-group metals were widely used as catalysts in petroleum refining and the production of high-octane gasoline involving such reforming processes as cracking, isomerization, hydrogenation, dehydrogenation, and sulfur removal, or combinations of these processes. Platinum-group-metal catalysts also were used extensively in the pharmaceutical industry for producing many antibiotics and vitamins.

Increased quantities of platinum were used as anodes in electrochemical processes, including the production of hydrogen peroxide and perchlorates. Substantial quantities of platinum and platinum alloys continued to be used in such specialized equipment as thermocouples, resistance thermometers, laboratory apparatus, equipment for

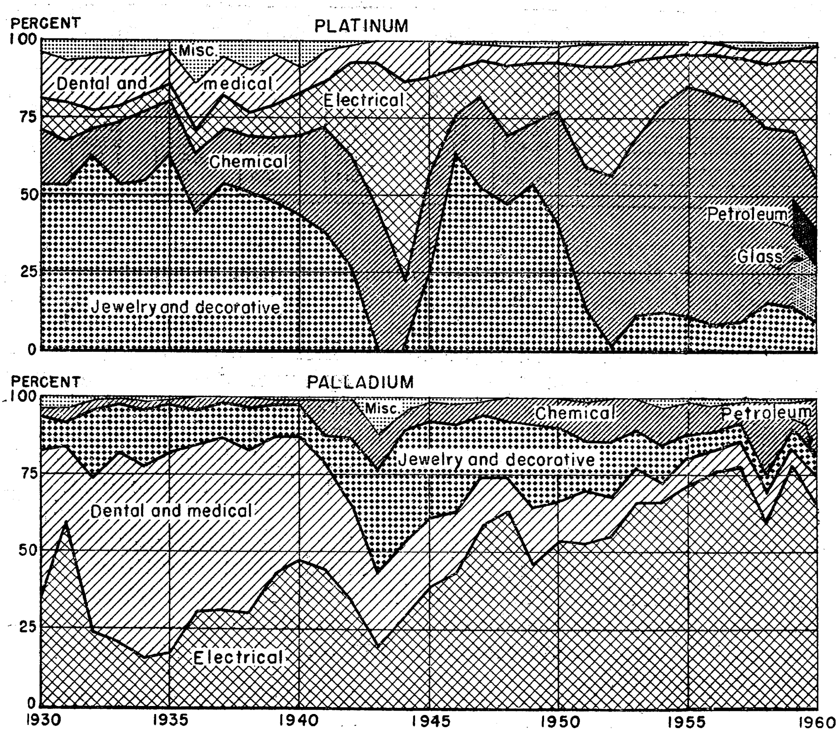

FIGURE 1.—Sales of platinum and palladium to various consuming industries in the United States, 1930–60, as percent of total.

melting special glass and making glass fiber, furnace-heating elements, spinnerets for extruding synthetic fiber, spark-plug electrodes, temperature-limiting fuses, and other applications involving service at elevated temperatures or under corrosive conditions. Large quantities of platinum-group metals and alloys were used in fabricating a wide variety of electrical contacts, dental and medical devices, jewelry, and other decorative products.

The minor platinum-group metals—iridium, rhodium, osmium, and ruthenium were used principally as alloying elements to improve the properties of the more abundant platinum and palladium by increasing their hardness, tensile strength, and resistance to heat and corrosion. Rhodium electroplate was widely used in jewelery, reflectors, electrical contacts, decorative tableware, and other equipment where its attractive color, brightness, and tarnish-resistance are outstanding.

TABLE 4.—Platinum-group metals sold to consuming industries in the United States

(Troy ounces)

Year and industry	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total	Percent of total
1959:								
Chemical	80,107	42,394	637	496	12,023	1,330	136,987	15
Petroleum	44,327	603			45		44,975	5
Glass	82,997		20		8,375		91,392	10
Electrical	84,837	374,080	2,010	37	5,649	538	467,151	52
Dental and medical	15,379	31,291	319	6	138	936	48,069	5
Jewelry and decorative	50,096	34,113	4,357	20	4,407	1,560	94,553	11
Miscellaneous	5,747	5,590	165	220	176	1,378	13,276	2
Total	363,490	488,071	7,508	779	30,813	5,742	896,403	100
1960:								
Chemical	71,253	73,854	810	550	7,705	1,496	155,668	20
Petroleum	35,645	5,300	2		33		40,980	5
Glass	59,390	6	49		8,273		67,718	9
Electrical	106,903	271,560	1,802	31	4,163	970	385,429	50
Dental and medical	15,898	38,617	234	2	83	575	55,409	7
Jewelry and decorative	32,666	23,336	3,165	1	4,175	753	64,096	8
Miscellaneous	2,828	1,552	106	204	183	1,041	5,914	1
Total	324,583	414,225	6,168	788	24,615	4,835	775,214	100

Rhodium combined with chromium and silicon to form a multilayer coating was used effectively to protect tungsten wires against oxidation at temperatures up to 3,000° F. for periods up to 20 minutes.

Palladium brazing alloys found wider use for joining various components in high-temperature service where high resistance to oxidation, good strength, and creep properties are essential. These alloy systems include palladium-silver-manganese, palladium-nickel, and palladium-copper-silver. Palladium brazing alloys also were used in constructing nuclear fuel elements and for sealing stainless steel containers in which fuel cans are removed from the reactor.[3]

[3] Betteridge W., and Rhys, D. W., Modern Industrial Uses of the Platinum Metals: Metal Ind. (London), vol. 97, No. 9, Aug. 26, 1960, pp. 163–166; No. 10, Sept. 2, 1960, pp. 183–185; No. 11, Sept. 9, 1960, pp. 203–205.

STOCKS

Domestic refiners and dealers reported total working stocks of platinum-group metals on hand, in process, or in transit at yearend of 515,800 ounces, about 4 percent more than at the end of 1959. The U.S. Department of Agriculture, Commodity Credit Corporation (CCC), reported 548,100 ounces of palladium and 15,000 ounces of ruthenium in the supplemental stockpile at the end of the year. No platinum-group metals were acquired in 1960 under the CCC program to barter surplus agricultural products for metals and minerals.

TABLE 5.—Refiner, importer, and dealer stocks of platinum-group metals in the United States, December 31

(Troy ounces)

Year	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1956	353,778	163,730	13,248	4,092	17,764	11,921	564,533
1957	306,988	154,005	13,272	4,420	18,998	9,506	507,189
1958	295,274	151,572	10,548	4,241	20,883	10,908	493,426
1959	290,691	158,706	11,127	4,218	20,720	10,389	495,851
1960	260,916	204,345	11,473	4,225	26,547	8,244	515,750

PRICES

Reflecting lower demand and a general lack of speculative interest, price changes of platinum-group metals were relatively minor during the year. After some speculative demand in January, the official price of platinum, as published by E&MJ Metal and Mineral Markets, advanced from a range of $77–$80 a fine troy ounce to $82–$85 and remained virtually unchanged thereafter. Similarly, the price per ounce of palladium increased from $22–$24 to $24–$26 in January and was unchanged thereafter; rhodium also rose in the first month from $122–$125 to $137–$140 with no further change during the year. The price of iridium dropped from $75–$80 to $70–$75 in October; ruthenium prices also dropped in October from $55–$60 to $45–$50, increasing again to $55–$60 near the end of the year. Osmium remained unchanged at $70–$90.

Trading in platinum futures on the New York Mercantile exchange was essentially nominal, reflecting unusual price stability.

The price at which platinum was offered by the U.S.S.R. remained stable at about $2 below the official price of Canadian and South African platinum.

FOREIGN TRADE[4]

Imports.—U.S. imports of platinum-group metals aggregated nearly 681,000 ounces, about one-third less than in 1959. Net imports represented 80 percent of domestic requirements of these metals.

Imports of all metals of the platinum group except rhodium were substantially lower than in 1959. Rhodium imports rose 7 percent.

[4] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

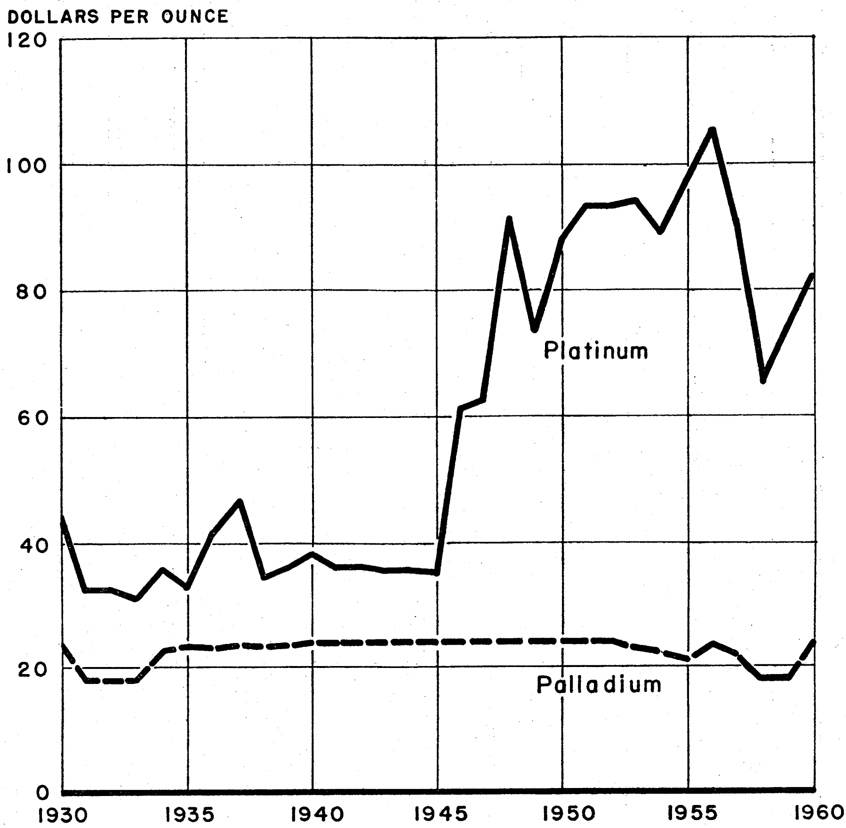

FIGURE 2.—Average price per ounce of platinum and palladium, 1930–60.

Imports from Canada and the United Kingdom, the leading exporters of platinum-group metals, dropped 22 percent and accounted for 55 percent of total U.S. imports. Imports from the U.S.S.R. and western European countries, which furnished most of the remainder, also declined sharply.

Exports.—Exports of platinum-group metals were 65,150 ounces compared with 31,400 ounces in 1959. Switzerland, United Kingdom, West Germany, France, and Canada were the largest buyers, taking more than 90 percent of all exports.

TABLE 6.—U.S. imports for consumption of platinum-group metals

Year	Troy ounces	Value (thousands)	Year	Troy ounces	Value (thousands)
1951–55 (average)	660,943	[1] $36,947	1958	670,431	$24,972
1956	1,033,877	[1] 57,755	1959	1,010,333	36,912
1957	682,013	[1] 35,783	1960	680,646	34,131

[1] Data known to be not comparable with years before 1954.

Source: Bureau of the Census.

TABLE 7.—U.S. imports for consumption of platinum-group metals (unmanufactured), by countries [1]

(Troy ounces)

Year and country	Unrefined material [2]				Refined metals						
	Ores and concentrates of platinum metals	Platinum grain and nuggets (including crude, dust and residues)	Platinum sponge and scrap	Osmiridium	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1959:											
North America:											
Canada		38,750			53,855	134,061	3,654		17,079	61	247,460
Cuba			535								535
Mexico			30			700					730
Total		38,750	565		53,855	134,761	3,654		17,079	61	248,725
South America:											
Colombia	503	31,498			3,424						35,425
Venezuela		161	4								165
Total	503	31,659	4		3,424						35,590
Europe:											
Czechoslovakia					1,536	33,577					35,113
France		2,476			5,625	59,408					67,509
Germany, West			772		2,000	2,522	60				5,354
Italy			118								118
Netherlands					12,332	34,508					46,840
Norway		1,800			4,565	6,225					12,590
Spain			613								613
Switzerland					25,495	160,553					186,048
U.S.S.R.					51,505	78,926					130,431
United Kingdom		3,078		2,112	100,187	100,005	4,058	1,223	12,263	14,618	237,544
Total		7,354	1,503	2,112	203,245	475,724	4,118	1,223	12,263	14,618	722,160
Asia:											
Japan			3,412			255					3,667
Lebanon			85								85
Total			3,497			255					3,752
Oceania: Australia			97	9							106
Grand total:											
Troy ounces	503	77,763	5,666	2,121	260,524	610,740	7,772	1,223	29,342	14,679	1,010,333
Value	$26,905	$5,447,330	$420,388	$75,711	$17,240,966	$9,373,802	$401,907	$64,664	$3,368,905	$491,900	$36,912,478

1960:											
North America:											
Canada	27	11			71,218	111,446	1,406		9,731	40	193,879
Mexico			41								41
Total	27	11	41		71,218	111,446	1,406		9,731	40	193,920
South America: Colombia	374	28,855	1,929		785						31,943
Europe:											
Czechoslovakia					3,239	3,700					6,939
France					1,248	1,618					2,866
Germany, West					5,576	1,011	14				6,601
Netherlands					11,618	5,483					17,101
Norway		190			3,395	1,830					5,415
Switzerland					6,821	111,962			2,090		120,873
U.S.S.R.					34,837	66,114			10,154		111,105
United Kingdom		1,282			99,570	64,672	2,833	277	9,747	3,957	182,338
Total		1,472			166,304	256,390	2,847	277	21,991	3,957	453,238
Asia:											
Japan			1,089								1,089
Lebanon						420					420
Total			1,089			420					1,509
Oceania: Australia			36								36
Grand total:											
Troy ounces	401	30,338	3,095		238,307	368,256	4,253	277	31,722	3,997	680,646
Value	$30,095	$2,200,830	$212,477		$18,917,141	$8,188,861	$283,055	$16,525	$4,126,336	$155,575	$34,130,895

[1] On the basis of detailed information received by the Bureau of Mines from importers, certain items recorded by the Bureau of the Census as "sponge and scrap" have been reclassified and included with "platinum refined metal" in this table.

[2] Bureau of the Census categories are in terms of metal content. It is believed, however, that in many instances gross weight is actually reported.

Source: Bureau of the Census.

TABLE 8.—U.S. exports of platinum-group metals, by countries [1]

Year and destination	Platinum (ore, concentrates, ingots, bars, sheets, wire, sponge, and other forms, including scrap)		Palladium, rhodium, iridium, osmiridium, ruthenium, and osmium (metal and alloys including scrap)		Platinum-group manufactures, except jewelry[2] (value)
	Troy ounces	Value	Troy ounces	Value	
1951-55 (average)	[3] 10,430	[3] $857,033	[3] 23,266	[3] $643,347	[3] $1,322,663
1956	[3] 23,823	[3] 2,383,443	[3] 18,249	[3] 634,293	[3] 2,489,260
1957	17,199	1,328,551	23,155	373,728	1,960,062
1958	35,075	1,233,350	12,293	379,375	2,102,566
1959:					
North America:					
Canada	3,914	197,322	7,999	137,699	1,997,389
Cuba	40	3,220	----	----	72,725
Guatemala	----	----	----	----	543
Mexico	525	47,711	349	5,857	118,409
Total	4,479	248,253	8,348	143,556	2,189,066
South America:					
Brazil	66	9,930	----	----	10,566
Chile	10	1,394	(4)	1,400	8,219
Colombia	86	2,852	----	----	1,996
Venezuela	202	15,000	211	3,910	11,690
Other	21	1,946	----	----	24,952
Total	385	31,122	211	5,310	57,423
Europe:					
France	30	2,448	----	----	----
Germany, West	539	34,876	2,425	112,900	4,400
Sweden	----	----	10	1,040	----
Switzerland	38	3,200	----	----	6,350
United Kingdom	9,877	579,718	1,046	41,032	31,932
Other	----	----	----	----	2,314
Total	10,484	620,242	3,481	154,972	44,996
Asia:					
India	62	9,508	----	----	1,155
Japan	3,028	233,451	717	84,655	3,353
Philippines	80	2,500	88	1,495	1,077
Other	42	1,719	----	----	4,933
Total	3,212	247,178	805	86,150	10,518
Africa	----	----	----	----	902
Oceania	----	----	----	----	2,950
Grand total	18,560	1,146,795	12,845	389,988	2,305,855
1960:					
North America:					
Canada	1,164	103,168	3,236	82,699	2,081,827
Cuba	299	29,131	40	958	2,476
Guatemala	----	----	12	300	----
Haiti	----	----	----	----	672
Mexico	393	41,328	1,667	43,095	124,019
Panama	6	562	----	----	----
Total	1,862	174,189	4,955	127,052	2,208,994
South America:					
Brazil	100	7,566	----	----	----
Chile	----	----	12	288	2,718
Colombia	10	850	185	5,250	8,671
Venezuela	4	864	84	2,164	3,955
Other	35	6,079	----	----	4,485
Total	149	15,359	281	7,702	19,829

See footnotes at end of table.

TABLE 8.—U.S. exports of platinum-group metals, by countries [1]—Continued

Year and destination	Platinum (ore, concentrates, ingots, bars, sheets, wire, sponge, and other forms, including scrap)		Palladium, rhodium, iridium, osmiridium, ruthenium, and osmium (metal and alloys including scrap)		Platinum-group manufactures, except jewelry[3] (value)
	Troy ounces	Value	Troy ounces	Value	
1960:					
Europe:					
Belgium-Luxembourg	10	$800	70	$14,640	$20,075
France	4,305	355,104	387	36,633	96,386
Germany, West	9,906	796,381	1,524	74,883	6,046
Switzerland	11,951	656,476	7,580	190,376	513,604
United Kingdom	19,135	1,075,066	69	4,141	57,936
Other	645	15,673			22,243
Total	45,952	2,899,500	9,630	320,673	716,290
Asia:					
India	158	13,616			
Japan	1,301	103,349	781	48,175	20,019
Philippines			5	312	5,478
Other	37	4,768			3,904
Total	1,496	121,733	786	48,487	29,401
Africa	38	757			1,502
Oceania					2,420
Grand total	49,497	3,211,538	15,652	503,914	2,978,436

1 Quantities are gross weight.
2 Beginning Jan. 1, 1952, quantity not recorded. Quantity, troy ounces: 1951—17,348.
3 Owing to changes in classification, data not strictly comparable with years before 1955.
4 Data not available.

Source: Bureau of the Census.

WORLD REVIEW

World output of platinum-group metals was estimated at 1.2 million ounces, about 18 percent higher than in 1959. The two leading producing countries, Canada and the Union of South Africa, continued to provide about 70 percent of the world output, and the U.S.S.R., most of the remainder.

Canada.—Canadian production of platinum-group metals increased 40 percent over 1959 to 460,320 ounces valued at $16.9 million, the highest output since the peak year of 1942. About 48 percent of the total output was platinum, and most of the remainder was palladium. Virtually all of the platinum-group metals were recovered as byproducts of smelting and refining nickel-copper ores of the Sudbury district.

The International Nickel Company of Canada, Ltd., the largest producer, operated five mines in the Sudbury district and commenced development of three others. Tonnage of ore mined was the highest on record. Development of the Thompson mine in Manitoba, which will increase the company's output of platinum-group metals, neared completion, and the mine was scheduled to begin production early in 1961. The company increased capacity and improved process efficiency at its Acton, England, refinery during the year.

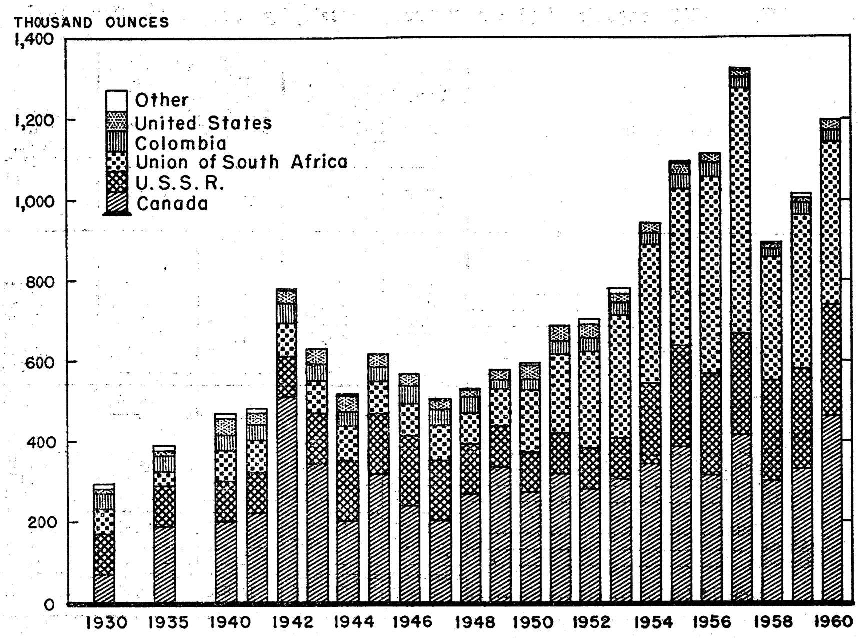

FIGURE 3.—World production of platinum-group metals, 1930, 1935, 1940–60.

Falconbridge Nickel Mines, Ltd., Canada's second largest platinum-group metal producer, operated six mines in the Sudbury district and commenced development of its large Stratcona deposit.

Colombia.—Output of platinum-group metals in Colombia was estimated at 28,900 ounces, about 9 percent less than in 1959.

South America Gold & Platinum Co., the leading producer, reported an output of 19,213 ounces of fine platinum compared with 14,838 fine ounces in 1959. The company operated six dredges throughout the year and handled 20.6 million cubic yards of gravel. The reserve of developed gravel at yearend was 64.4 million cubic yards, with an estimated recoverable content of 20 cents per cubic yard combined gold and platinum, compared with 55.8 million cubic yards with a recoverable content equivalent to 21.9 cents per cubic yard in 1959.[5]

Union of South Africa.—Based on the increase in operations reported by the chairman of Rustenburg Platinum Mines, Ltd., one of the world's two leading producers, the output of platinum-group metals in South Africa was estimated at 400,000 ounces, an increase of about 7 percent over 1959 production. Although Rustenburg does not disclose its production figures, the chairman stated at the company's annual meeting that the scale of operations at the company's mines increased during the year in conformity with the policy of maintaining adequate stocks of refined metals to surges in demand. The chairman further stated that mine production during the current fiscal year exceeded sales, that stocks were beginning to build up to the desired

[5] South American Gold & Platinum Co., Forty-fourth Annual Report 1960, p. 4.

TABLE 9.—World production of platinum-group metals [1]

(Troy ounces)

Country	1951-55 (average)	1956	1957	1958	1959	1960
North America:						
Canada:						
Platinum: Placer and from refining nickel-copper matte	147,639	151,357	199,565	146,092	150,382	221,832
Other platinum-group metals: From refining nickel-copper matte	178,386	163,451	216,582	154,366	177,713	238,489
United States: Placer platinum and from domestic gold and copper refining	28,967	21,398	18,531	14,359	15,485	23,609
Total	354,992	336,206	434,678	314,817	343,580	483,930
South America: Colombia: Placer platinum (U.S. imports)	33,843	32,947	24,267	19,619	31,498	28,855
Europe: U.S.S.R.: Placer platinum and from refining nickel-copper ores [2]	185,000	250,000	250,000	250,000	250,000	275,000
Asia: Japan:						
Palladium from refineries	130	218	233	240	341	1,396
Platinum from refineries	738	483	354	442	472	564
Iridium from refineries	[3] 9	15	3,215	643	----------	----------
Total	877	716	3,802	1,325	813	1,960
Africa:						
Congo, Republic of the (formerly Belgian): Palladium from refineries [4]	35	160	325	161	----------	----------
Ethiopia: Placer platinum	206	244	248	180	68	189
Sierra Leone: Placer platinum (exports)	----------	----------	5	8	----------	----------
Union of South Africa:						
Platinum-group metals from platinum ores	288,498	484,574	603,704	[2] 300,000	[2] 375,000	[2] 400,000
Osmiridium from gold ores	6,551	6,696	5,361	[5] 5,262	5,352	[2] 5,000
Total	295,290	491,674	609,643	305,611	380,420	405,189
Oceania:						
Australia:						
Placer platinum	8	18	17	22	----------	[2] 2
Placer osmiridium	36	26	66	42	3	
New Guinea	6	9	14	28	18	[2] 20
Total	50	53	97	92	21	[2] 22
World total (estimate) [1]	870,000	1,110,000	1,320,000	890,000	1,010,000	1,190,000

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of roundin where estimated figures are included in the detail.
[2] Estimate.
[3] 1 year only, as 1955 was 1st year of production reported.
[4] Includes platinum.
[5] Sales.

Compiled by Augusta W. Jann, Division of Foreign Activities.

levels, and that the rate of output was constantly being reviewed in the light of probable sales requirements.

The new reduction plant at Rustenburg, the third such plant, was brought into operation in June 1960 and operated satisfactorily. The company planned to keep this plant in operation, regardless of any further cutback in the overall rate of production. The operation of each of the three available plants at a rate less than its capacity would result in a higher metallurgical efficiency than that which would be obtained by closing one plant and operating the other two at a high rate of throughput.

With regard to the company's production and sales policy, the chairman stated:

> * * * We expect that the violent upward surges which have characterised the platinum market in the past will to some extent be controlled by virtue of Rustenburg's considerable stocks and potential productive capacity. These should assist in avoiding the recurrence of the critical shortages of platinum which have previously occurred from time to time. * * *

U.S.S.R.—Although the U.S.S.R. has been one of the world's three major producers of platinum-group metals, it publishes virtually no data on its output. Most of the 1960 Soviet output of platinum-group metals probably was recovered as a byproduct of the Noril'sk and Petsamo-Monchegorsk nickel operations. Placer deposits in the Urals were believed to be largely depleted and probably furnished only a minor part of current Russian production. Although the U.S.S.R. continued to export large quantities of platinum-group metals to Western Europe and the United States, increased quantities of these metals were probably being absorbed by Soviet industries.

TECHNOLOGY

Johnson, Matthey & Co., Ltd., announced the development of a stable platinum-plating solution from which exceptionally bright, heavy, and coherent deposits may be obtained. Known as DNS, the platinum-plating solution based on the complex sulfato-dinitrito-platinous acid ($H_2Pt(NO_2)_2SO_4$) can be used successfully on electrical components and on printed circuits. The platinum can be deposited directly on copper, brass, silver, nickel, aluminum, and titanium. For deposition on tin, zinc, cadmium, or steel, an undercoat of silver or nickel is necessary.[6] Best results are obtained at a platinum concentration of 5 grams per liter, current density of 5 amperes per square foot, and a bath temperature of 30° to 70° C.

A method of electrodepositing iridium from aqueous solution was developed to meet the requirement for high-temperature stable protective coatings in certain military applications. Bright tenacious iridium deposits were produced with a cathode efficiency of 12 percent, using a metal content of 10 grams per liter and a current density of 20 amperes per square foot at a temperature of 60° C.[7]

Chemical processes involved in reforming petroleum to produce high-octane fuels and petrochemicals using platinum catalysts were described in a British trade journal.[8] The economic use of platinum reforming catalysts involving activation, deactivation, and regeneration processes also was discussed and the principal catalyst manufacturing processes were briefly outlined.

A palladium-gold: iridium-platinum thermocouple with a high thermal e.m.f. was developed for use at temperatures up to 1,000° C.

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[6] Platinum Metals Review, vol. 4, No. 2, April 1960, pp. 56–58.
[7] Journal of the Electrochemical Society, vol. 107, No. 8, August 1960, p. 185C.
[8] Connor, H., Platinum Reforming Catalysts: Chemistry and Industry (London), No. 48, Nov. 26, 1960, pp. 1454–1472.

The thermocouple was reported to have much greater sensitivity than the well-known platinum: rhodium-platinum combinations.[9]

A new immersion-type rhodium plating solution provided a corrosion-resistant and easy-to-solder, printed, and etched rhodium circuit. Tests showed that a rhodium plate over copper resists 50 percent nitric acid solution in a 30-minute exposure.[10]

A method of plating molybdenum with a protective coating of iridium, involving intermediate treatment in strike baths of chromium and nickel and plating in a gold cyanide bath, was described in a patent.[11] The final plating consists of a 0.0005-inch layer of iridium from a bath comprising a molten alkali metal cyanide containing 5.3 to 6.7 grams of iridium per liter, at a temperature of 600° C. and a current density of 10 amperes per square foot.

A newly developed palladium-silver alloy having remarkable stability as well as hydrogen transfer rate, formed the basis of a new industrial process for separating and purifying hydrogen.[12] The ultrapure hydrogen obtained by diffusion through a silver-palladium membrane was used in powder metallurgy and in semiconductors and as rocket fuel.

The modern use of platinum catalyst in ammonia oxidation for nitric acid manufacture and the application of platinum metals in the catalytic reduction of oxides in fume elimination from a new acid plant were described.[13]

Researchers at Union Carbide Metals Co. laboratories discovered that a small amount of platinum metal attached to tantalum prevented hydrogen embrittlement of the tantalum in highly corrosive environments at elevated temperatures.[14] The technique is simple and effective and should expand the range of usefulness of tantalum in the chemical industry to meet the increasing demand for higher operating temperatures.

Over 100 patents were issued in the United States and the United Kingdom on industrial processes and applications involving the use of platinum-group metals. Most of the patents were for platinum metal catalysts used in reforming petroleum and its products and in hydrogenation and dehydrogenation processes for the manufacture of drugs and miscellaneous chemicals.[15] Several patents were issued on the use of platinum-group metals and alloys in electrical components, electrochemical equipment, and miscellaneous alloys for mate-

[9] Bennett, H. E., The Pallador Thermocouple: Platinum Metals Rev., vol. 4, No. 2, April 1960, pp. 66–67.

[10] Materials in Design Engineering, What's New in Materials: Vol. 52, No. 5, November 1960, p. 517.

[11] Withers, J. C., and Ritt, P. E. (assigned to Melpar, Inc., Falls Church, Va.), Plating of Iridium: U.S. Patent 2,929,766, Mar. 22, 1960.

[12] Hunter, J. B., New Hydrogen Purification Process: Platinum Metals Rev., vol. 4, No. 4, October 1960, pp. 130–131.

[13] Bell, B. H. J., Platinum Catalysts in Ammonia Oxidation: Platinum Metals Rev., vol. 4, No. 4, October 1960, pp. 122–126.

[14] American Metal Market, Study Tantalum With Platinum Attachment: Vol. 68, No. 13, Jan. 19, 1961, p. 14.

[15] Platinum Metals Review, vol. 4, Nos. 1–4, 1960.

rials of construction. A book[16] of general interest and articles[17] pertaining to the technology of platinum-group metals were published during the year.

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[16] McDonald, Donald, A History of Platinum, Johnson, Matthey & Co., Ltd., London, England, 1960, 254 pp.

[17] Rylander, P. N., Hydrogenations With Platinum Metal Catalysts: Engelhard Industries, Inc., Tech. Bull., vol. 1, No. 3, December 1960, pp. 93–97.

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Potash

By Richard W. Lewis[1] and Gertrude E. Tucker[2]

PRODUCTION of marketable potassium salts in the United States reached a new high of nearly 4.5 million short tons in 1960. Sales were 5 percent above those for 1959, but dropped below production for the first time in 3 years. The total value of sales also reached a record high of $85.5 million.

TABLE 1.—Salient potash statistics

(Thousand short tons and thousand dollars)

	1951–55 (average)	1956	1957	1958	1959	1960
United States:						
Production of potassium salts (marketable) ... quantity..	3,089	3,679	3,840	3,640	4,033	4,472
Approximate equivalent K_2O..do....	1,803	2,172	2,266	2,147	2,383	2,638
Value [1] ...	$67,456	$82,107	$84,612	$75,000	$80,393	$87,054
Sales of potassium salts by producers quantity..	2,970	3,572	3,625	3,954	4,191	4,412
Approximate equivalent K_2O..do....	1,732	2,103	2,137	2,336	2,476	2,602
Value at plant ...	$64,851	$79,768	$79,628	$81,577	$83,903	$85,470
Average per ton ...	$21.84	$22.33	$21.97	$20.64	$20.02	$19.37
Imports for consumption of potash materials ... quantity..	348	334	339	366	432	418
Approximate equivalent K_2O..do....	187	181	182	199	234	226
Value ...	$12,273	$12,018	$11,823	[2] $12,874	[2] $15,737	$15,461
Exports of potash materials..quantity..	132	398	467	507	572	833
Approximate equivalent K_2O..do....	74	226	234	254	337	491
Value ...	$6,207	$14,937	$17,506	$18,276	$18,496	$25,926
Apparent consumption of potassium salts [3] ... quantity..	3,186	3,508	3,497	3,813	4,051	3,997
Approximate equivalent K_2O..do....	1,845	2,058	2,085	2,281	2,373	2,337
World: Production (marketable):						
Approximate equivalent K_2O..do....	6,730	8,350	8,700	8,800	9,400	10,000

[1] Derived from reported value of "Sold or used."
[2] Revised figure.
[3] Measured by sold or used plus imports minus exports.

LEGISLATION AND GOVERNMENT PROGRAMS

The Department of the Interior ordered a withdrawal of some 9,445 acres of public lands near Moab, Utah, from oil and gas leasing for 10 years.[3] This made it possible for a large potash deposit in this area to be opened.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.
[3] Federal Register, Withdrawing Public Lands From Oil and Gas Leasing for Preservation and Development of Potash Deposits Belonging to the United States: Vol. 25, Sept. 3. 1960, p. 8548.

DOMESTIC PRODUCTION

The upward trend in production of marketable potassium salts in the United States continued in 1960, with an 11-percent increase above 1959.

New Mexico, California, and Utah remained the principal producing States, with New Mexico supplying 93 percent of the domestic output. Maryland and Michigan produced only small quantities.

Mine production from the Carlsbad area of New Mexico increased 8 percent. The calculated grade of crude salts mined was 18.85 percent K_2O equivalent, back to normal after a low of 18.58 percent in 1959.

The plant locations of potash-producing companies in the United States were the same as in 1957.[4] Farm Chemical Resources Development Co., completed one deep shaft east of Artesia, N. Mex.

Production of manure salts in the United States was about 13,800 tons, containing 3,300 tons K_2O equivalent, and came from Utah and New Mexico.

TABLE 2.—Production and sales of potassium salts in New Mexico

(Thousand short tons and thousand dollars)

Year	Crude salts [1]		Marketable potassium salts					
	Mine production		Production			Sales		
	Gross weight	K_2O equivalent	Gross weight	K_2O equivalent	Value [2]	Gross weight	K_2O equivalent	Value
1951–55 (average)	8,900	1,809	2,767	1,615	$59,922	2,661	1,551	$57,599
1956	11,941	2,305	3,384	1,997	75,122	3,279	1,931	72,802
1957	12,893	2,430	3,528	2,080	77,197	3,353	1,977	73,243
1958	12,224	2,309	3,355	1,978	69,106	3,650	2,157	75,343
1959	13,932	2,588	3,707	2,189	74,117	3,821	2,258	76,725
1960	15,071	2,841	4,138	2,440	80,023	4,092	2,412	78,707

[1] Sylvite and langbeinite.
[2] Derived from reported value of "Sold or used."

United States Borax & Chemical Corp. started construction of new facilities at its Carlsbad, N. Mex., location to produce high-purity muriate of potash.

Duval Sulphur & Potash Co. opened another ore body about 12 miles from its present potash plant in the Carlsbad area. Production was expected early in 1961.

American Potash & Chemical Corp. began an $11 million capital improvement program for its plant at Trona, Calif. When completed in mid-1961, the potash production capacity will be increased by about 25 percent.

A $3 million expansion of the Southwest Potash Corp. facilities near Carlsbad, N. Mex., begun during the year, was expected to be completed early in 1961.

International Minerals & Chemical Corp., Potash Division, Carls-

[4] Bureau of Mines, Minerals Yearbook: Vol. 1, 1957, p. 950.

bad, N. Mex., resumed mining on the 800-foot level, unworked since 1948, after exploration revealed a new area of commercial value.

Texas Gulf Sulphur Co. entered the potash business through the acquisition of a large high-grade potash deposit near Moab, Utah, from the Delhi-Taylor Oil Corp. Under the agreement between the two companies, Delhi-Taylor retained a 25-percent net profit interest in the property in addition to the receipt of $4.5 million over a 4½-year period. Texas Gulf Sulphur began constructing a $25 million mining and processing plant designed to produce over 1 million tons of muriate potash annually. The facilities were scheduled to be in production near the end of 1962. By the end of 1963 the commercial output capacity is expected to be more than 1.5 million tons annually. This extensive property is southwest of Moab, Utah, in the Cane Creek Anticline area.

CONSUMPTION AND USES

The apparent consumption of potassium salts in the United States for 1960 was about 50,000 short tons less than in the record year of 1959. The drop was thought to be chiefly due to adverse weather conditions in the Midwest. Illinois, with 217,224 tons (K_2O equivalent) was the leading State for deliveries; Indiana, Ohio, Georgia, and Florida

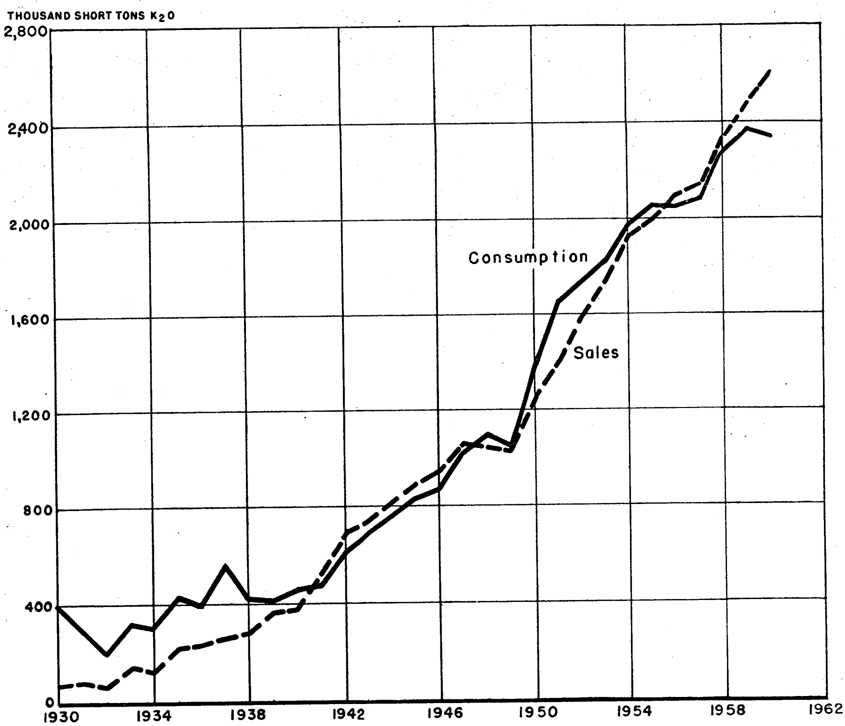

FIGURE 1.—Comparison of apparent domestic consumption of potash (K_2O) and sales of domestic producers of potash in the United States, 1930–60.

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followed in order. Deliveries to Virginia (among the five leaders in 1959) decreased by 17 percent in 1960. Deliveries do not necessarily correspond to consumption, however, since much of that delivered is used in mixed fertilizers and resold.

The consumption of high-purity muriate of potash for chemical use continued its slow but steady increase, with 1960 up 1 percent.

TABLE 3.—Deliveries of potash salts in 1960, by States of destination

(Short tons of K_2O)

State	Agricultural potash	Chemical potash	State	Agricultural potash	Chemical potash
Alabama	77,807	16,293	Nebraska	3,257	4
Arizona	1,334	96	Nevada		1,311
Arkansas	47,413	100	New Hampshire	49	40
California	20,399	7,792	New Jersey	31,881	2,019
Colorado	1,256	12	New Mexico	438	20
Connecticut	4,752	218	New York	37,455	63,637
Delaware	8,306	571	North Carolina	111,508	300
District of Columbia	502		North Dakota	3,137	
Florida	138,383	983	Ohio	160,947	4,444
Georgia	163,233	453	Oklahoma	6,644	549
Idaho	879		Oregon	5,549	190
Illinois	217,224	2,447	Pennsylvania	39,027	2,285
Indiana	177,502	2,480	Rhode Island	1,179	171
Iowa	70,045	342	South Carolina	60,235	
Kansas	2,328	615	South Dakota	639	
Kentucky	45,022	6,467	Tennessee	91,174	
Louisiana	21,528	540	Texas	61,868	6,778
Maine	13,162	76	Utah	156	108
Maryland	74,093	1,142	Vermont	2,142	
Massachusetts	14,517	95	Virginia	109,187	60
Michigan	69,178	674	Washington	8,041	63
Minnesota	68,202		West Virginia	1,150	11,000
Mississippi	41,092	48	Wisconsin	66,081	102
Missouri	58,299	1,543			
Montana	37	1	Total	2,138,237	136,069

Source: American Potash Institute.

STOCKS

Potash (K_2O) stocks held by producers increased 12 percent. These stocks on hand included material sold for delivery in the 1961 spring planting season which begins in February.

TABLE 4.—Stocks of potassium salts in the United States

(Thousand short tons)

Year	Number of producers	Stocks Dec. 31	
		Potassium salts	Equivalent potash (K_2O)
1951–55 (average)	10	373	219
1956	10	739	440
1957	11	939	560
1958	11	625	372
1959	11	464	277
1960	11	521	311

PRICES

The 1960–61 prices of domestic potash were restored approximately to the 1956–57 level.

Price lists were published by producers in April 1960 for shipments during the months indicated against contracts made prior to July 1, 1960. On quantities contracted after June 30, 1960, the above prices were increased by 2 cents per unit, in bulk.

All producers charged $5 per short ton extra for packing in 100-pound bags and reserved the right to adjust their prices to meet competition of other domestic producers.

TABLE 5.—Bulk prices for New Mexico potash [1]

(Cents per unit K_2O)

	1960			1961
	July–Aug.	Sept.–Oct.	Nov.–Dec.	Jan.–June
Standard muriate, 60 percent K_2O minimum	33	34	35	37.5
Granular muriate, 60 percent K_2O minimum	34	35	36	38.5
Sulfate of potash, 50 percent K_2O minimum	62.5	62.5–67.5	67.5	70.5
Mine Run salts, 20 percent K_2O minimum	17.65	17.65	17.65	17.65

[1] Quoted by producers, f.o.b. Carlsbad, in minimum 40-ton carlots.

TABLE 6.—Bulk prices for California potash [1]

(Cents per unit K_2O)

	1960			1961
	July–Aug.	Sept.–Oct.	Nov.–Dec.	Jan.–June
New improved muriate of potash, 60 percent K_2O minimum	41	42	43	45.5
Granular muriate of potash, 60 percent K_2O minimum	42	43	44	46.5

[1] Quoted by American Potash & Chemical Corp., carlots, f.o.b., Trona, Calif.

FOREIGN TRADE [5]

Imports.—Imports of muriate from France and Spain were higher than in 1959 by 15 and 22 percent, respectively. The tonnage of potassium sulfate imported from France increased 30 percent, but muriate and sulfate imports from West Germany were only 74 percent of those in 1959. Total imports of potassium salts from all countries was about 3 percent less.

East Germany withdrew from the U.S. muriate market in February 1959 but was replaced by the U.S.S.R. in 1960.

[5] Figures on U.S. imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census, and the American Potash Institute, Inc.

TABLE 7.—U.S. imports for consumption of potash materials[1]

Material	Approximate equivalent as potash (K_2O) (percent)	1959 Short tons	1959 Approximate equivalent as potash (K_2O) Short tons	1959 Approximate equivalent as potash (K_2O) Percent of total	1959 Value	1960 Short tons	1960 Approximate equivalent as potash (K_2O) Short tons	1960 Approximate equivalent as potash (K_2O) Percent of total	1960 Value
Used chiefly in fertilizers:									
Muriate (chloride)[2]	60	313,760	188,256	80.5	[3] $8,747,854	301,781	181,068	80.0	$8,578,896
Potassium nitrate, crude	40	473	189	.1	57,367	[4] 565	226	.1	[4] 68,459
Potassium-sodium nitrate mixtures, crude	14	[4] 36,468	[3] 5,106	2.2	[4] 1,406,976	[4] 18,702	2,618	1.2	[4] 802,429
Potassium sulfate, crude[2]	50	72,478	36,239	15.5	[3] 2,618,612	74,575	37,288	16.5	2,771,839
Other potash fertilizer materials	6	41	2	.0	1,622	12,584	755	.3	477,174
Total fertilizer		[3] 423,220	[3] 229,792	98.3	[3] 12,832,431	408,207	221,955	98.1	12,698,797
Used chiefly in chemical industries:									
Bicarbonate	46	12	5		2,681	34	16		5,942
Bitartrate:									
Argols	20	491	98		92,065	198	40		34,076
Cream of tartar	25	1,719	430		881,644	1,438	360		771,476
Carbonate	61	170	104		23,297	600	366		82,797
Caustic	80	695	556		177,398	666	533		136,660
Chlorate and perchlorate	36	526	189		130,104	464	167		108,945
Chromate and dichromate	40	2	(5)	1.7	654	2	(5)	1.9	648
Cyanide	70	[3] 731	[3] 512		410,864	887	621		448,587
Ferricyanide	42	308	129		187,128	336	141		202,358
Ferrocyanide	44	608	268		232,823	646	284		251,522
Nitrate	46	1,856	854		242,029	2,433	1,119		308,668
Permanganate	29	481	139		192,531	42	12		16,947
Rochelle salts	22	81	18		36,710	185	41		82,557
All other	50	1,332	666		294,581	1,383	692		311,215
Total chemical		[3] 9,012	[3] 3,968	1.7	[3] 2,904,509	9,314	4,392	1.9	2,762,398
Grand total		[3] 432,232	[3] 233,760	100.0	[3] 15,736,940	417,521	226,347	100.0	15,461,195

[1] Changes in Minerals Yearbook, 1959, p. 874, table 5, 1958 value should read as follows: Muriate (chloride) $7,187,591; potassium sulfate, crude, $2,453,591; total fertilizer, $10,725,863; grand total, $12,874,427.
[2] Quantities furnished by American Potash Institute, Inc.; values adjusted by Bureau of Mines.
[3] Revised figure.
[4] Adjusted by Bureau of Mines.
[5] Less than 1 ton.

Source: Bureau of the Census.

TABLE 8.—U.S. imports for consumption of potash materials, by countries[1]

(Short tons)

Year and country	Bitartrate: Argols or wine lees (20)[2]	Bitartrate: Cream of tartar (25)[2]	Caustic (hydroxide) (80)[2]	Chlorate and perchlorate (36)[2]	Cyanide (70)[2]	Muriate (chloride)[3] (60)[2]	Potassium nitrate, crude (40)[2]	Potassium sodium nitrate mixtures, crude (14)[2]	Potassium nitrate (saltpeter), refined (46)[2]	Potassium sulfate, crude[3] (50)[2]	All other[4]	Total: Quantity	Total: Value
1959:													
Canada	--	--	--	--	--	14,359	--	3	--	--	41	14,403	[5] $289,189
Chile	--	--	--	--	--	--	--	36,240	--	--	--	36,240	1,378,435
France	28	--	--	11	144	107,870	228	--	--	36,150	32	144,463	[5] 4,859,675
Germany:													
East	--	--	--	--	--	9,086	--	--	467	--	80	9,633	[5] 317,791
West	--	--	368	35	[5] 428	133,960	245	[6] 225	1,217	36,328	539	[5] 173,345	[5] 5,526,077
Italy	17	642	--	--	--	--	--	--	172	--	81	912	370,932
Netherlands	--	--	5	--	2	--	--	--	--	--	1,681	1,688	554,377
Portugal	446	--	--	--	--	--	--	--	--	--	--	446	82,415
Spain	--	327	--	--	--	48,485	--	--	--	--	--	48,812	[5] 1,409,740
Sweden	--	--	322	334	--	--	--	--	--	--	--	656	203,888
United Kingdom	--	750	--	3	146	--	--	--	--	--	392	1,291	567,705
Other countries	--	--	--	143	11	--	--	--	--	--	189	343	176,716
Total	491	1,719	695	526	[5] 731	313,760	473	[6] 36,468	1,856	72,478	3,035	[5] 432,232	[5] 15,736,940
1960:													
Chile[7]	--	--	--	--	--	--	--	18,420	--	--	5,311	23,731	994,973
France	82	--	15	13	219	124,395	96	--	--	47,147	4,394	176,361	5,956,124
Germany:													
East	--	--	--	--	--	--	--	--	388	--	88	476	91,087
West	--	43	428	38	474	98,777	469	280	1,798	27,428	3,894	133,629	4,614,050
Italy	--	538	--	--	--	--	--	--	240	--	169	947	378,336
Netherlands	--	5	48	--	--	--	--	--	7	--	1,117	1,177	388,583

See footnotes at end of table.

TABLE 8.—U.S. imports for consumption of potash materials, by countries [1]—Continued

(Short tons)

Year and country	Bitartrate: Argols or wine lees (20)[2]	Bitartrate: Cream of tartar (25)[2]	Caustic (hydroxide) (80)[2]	Chlorate and perchlorate (36)[2]	Cyanide (70)[2]	Muriate (chloride)[3] (60)[2]	Potassium nitrate, crude (40)[2]	Potassium sodium nitrate mixtures, crude (14)[2]	Potassium nitrate (saltpeter), refined (46)[2]	Potassium sulfate, crude [3] (50)[2]	All Other [4]	Total: Quantity	Total: Value
1960—Continued													
Spain		231				59,350					1	59,582	$1,751,739
Sweden			175	288								463	135,419
United Kingdom		621			105						673	1,399	501,630
U.S.S.R.						19,259						19,259	481,016
Other countries	116			125	89			2			165	497	168,238
Total	198	1,438	666	464	887	301,781	565	18,702	2,433	74,575	15,812	417,521	15,461,195

[1] Changes in Minerals Yearbook, 1959, p. 875, table 6, 1958 values should read as follows: France, $3,715,213; East Germany, $1,489,269; West Germany, $4,509,200; Spain, $988,478; total, $12,874,427.
[2] Figures in parentheses indicate, in percent, approximate equivalent as potash (K_2O).
[3] Quantities furnished by American Potash Institute, Inc.; values adjusted by Bureau of Mines.
[4] Approximate equivalent as potash (K_2O): 1959–60, 38 percent.
[5] Revised figure.
[6] Adjusted by Bureau of Mines.
[7] Potassium sodium nitrate mixtures, crude, include 2,400 tons ($97,560) credited by the Bureau of the Census to potassium nitrate, crude.

Source: Bureau of the Census.

Exports.—Potash exports amounted to 20 percent of sales in 1960 and were 46 percent higher than in 1959. Exports of potash for fertilizer to Europe were three times those of the previous year.

TABLE 9.—U.S. exports of potash materials, by countries

Destination	Fertilizer				Chemical			
	1959		1960		1959		1960	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
North America:								
Canada	73,286	$2,446,699	104,283	$3,148,901	7,431	$1,174,427	8,925	$1,270,454
Costa Rica	416	15,794	4	214	9	4,660	13	4,781
Cuba	9,792	390,069	28,558	895,610	59	18,982	60	19,585
Dominican Republic	1,344	49,795	4,866	169,785	7	3,480	4	1,106
El Salvador	-------	-------	95	5,580	16	3,600	2	1,530
Guatemala	15	1,917	-------	-------	46	13,606	13	3,121
Honduras	78	3,568	-------	-------	8	3,140	2	1,040
Mexico	16,158	566,273	13,453	366,252	845	162,431	583	142,620
Panama	10	1,601	10	536	17	6,340	3	3,327
Other	158	6,734	90	5,791	5	5,701	3	15,199
Total	101,257	3,482,450	151,359	4,592,669	8,443	1,396,367	9,608	1,462,763
South America:								
Argentina	-------	-------	282	8,597	53	22,061	155	40,224
Brazil	58,163	1,690,414	47,442	1,401,807	123	39,263	195	52,582
Chile	496	11,773	551	25,986	44	14,247	61	21,782
Colombia	66	2,270	1,128	36,076	90	20,932	151	37,655
Ecuador	390	44,709	-------	-------	21	4.786	30	8,509
Peru	259	11,540	165	9,100	6	8,332	6	4,726
Uruguay	68	3,508	-------	-------	11	2,159	8	3,961
Venezuela	1,057	33,642	275	9,580	151	45,904	94	27,742
Other	-------	-------	-------	-------	10	7,892	14	13,734
Total	60,499	1,797,856	49,843	1,491,146	509	165,576	714	210,915
Europe:								
Belgium-Luxembourg	3,308	78,401	4,500	117,350	556	32,237	29	16,707
Germany, West	-------	-------	-------	-------	167	65,408	77	32,723
Ireland	5,377	143,200	15,355	415,747	-------	-------	-------	-------
Italy	[1] 9,158	[1] 255,808	24,808	617,333	94	28,282	1,261	93,241
Sweden	-------	-------	2,204	66,307	1,047	66,161	639	44,875
United Kingdom	112	4,680	5,085	138,859	13	3,890	664	196,171
Other	-------	-------	-------	-------	37	16,734	185	98,392
Total	[1] 17,955	[1] 482,089	51,952	1,355,596	1,914	212,712	2,855	482,109
Asia:								
India	-------	-------	-------	-------	19	11,246	7	4,927
Japan	274,363	7,909,240	486,869	13,857,907	1	8,450	20	11,615
Korea, Republic of	2,330	111,202	1,911	86,456	-------	-------	1,222	54,726
Philippines	8,161	350,948	4,683	145,235	125	35,520	43	18,925
Taiwan	27,869	621,022	10,578	320,697	-------	-------	1	318
Other	55	4,235	10	1,172	16	30,335	56	26,541
Total	312,778	8,996,647	504,051	14,411,467	161	85,551	1,349	117,052
Africa:								
Union of South Africa	25,328	777,744	12,879	366,395	14	12,083	1,519	47,590
Other	-------	-------	72	3,141	2	2,978	1,004	27,691
Total	[2] 25,328	[2] 777,744	12,951	369,536	16	15,061	2,523	75,281
Oceania:								
Australia	12,656	306,917	2,465	73,706	615	118,755	323	69,575
New Zealand	29,528	658,200	42,900	1,214,280	-------	-------	(3)	300
Total	42,184	965,117	45,365	1,287,986	615	118,755	323	69,875
Grand total	560,001	16,501,903	815,521	23,508,400	11,658	1,994,022	17,372	2,417,995

[1] Revised figure.
[2] Minerals Yearbook, 1959, p. 876, Libya revised to none.
[3] Less than 1 ton.

Source: Bureau of the Census.

Sixty-two percent of U.S. exports of potash for fertilizer was shipped to Asia. Japan alone accounted for 60 percent of the exports. Exports to Japan increased 77 percent, but exports to all Asian countries declined in 1960.

WORLD REVIEW

Australia.—Lake Campion and the surrounding vicinity in Western Australia was reported to have significant reserves of alunite. A government-owned plant at the site formerly produced alumina and byproduct potassium salts.[6]

Canada.—International Minerals & Chemical Corp. continued work on its shaft near Esterhazy, Saskatchewan, in an effort to penetrate and seal the 300-foot-thick Blairmore quicksand stratum. This troublesome area, which consists of a mixture of sand, water, and mud under pressures up to 450 pounds per square inch, was first encountered at about the 1,200-foot level.

After several unsuccessful attempts to conquer the unstable Blairmore by using conventional methods, including grouting around the shaft to solidify the watery sands, a "tubbing" technique was proposed. Since this technique had never been used in North America, engineers from four German firms, who had experience with the tubbing method in European and African mines, were called in to help. The shaft lining operations were progressing successfully at the end of the year with completion expected early in 1961. Sinking the shaft 1,800 feet after penetrating the Blairmore stratum should be a routine matter, and the mine is expected to go into production in fiscal 1962. The total depth of the shaft was planned to be 3,400 feet.[7]

Continental Potash Corp. reconditioned its surface plant near Unity, Saskatchewan. The shaft was prepared for the penetration of the Blairmore sands zone.[8]

Potash Company of America, Ltd., with potash holdings near Saskatoon, Saskatchewan, merged with the parent company, Potash Company of America.[9] A Canadian firm contracted to grout the entire 3,400-foot shaft at an estimated cost of $900,000. The grouting was scheduled to be completed during the summer of 1961.[10]

France.—A loss in production of about 90,000 tons was expected at the potash mines in the Mulhouse, Alsace region as a result of a 30-day work slowdown.[11]

Germany, East.—A Seven-Year Plan was expected to raise the output of potash products from 1,528,000 tons in 1958 to 2,128,000 tons in 1965.[12]

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[6] World Mining, vol. 13, No. 10, September 1960, p. 80.

[7] U.S. Consulate, Winnipeg, Canada, State Department Dispatch 86: Mar. 30, 1961, pp. 2, 3.
Oil, Paint and Drug Reporter, IMC's Potash Project in Canada May Be Solid by 1962: Vol. 178, No. 19, Oct. 31, 1960, pp. 5, 47.

[8] Northern Miner (Toronto), Cont. Potash Shaft Ready for Sinking: Vol. 46, No. 50, Mar. 9, 1961, p. 22.

[9] Pit and Quarry, Potash Company of America Absorbs Canadian Subsidiary: Vol. 53, No. 2, August 1960, p. 124.

[10] Skillings' Mining Review, Potash Co. Grouting Shaft at Saskatoon, Sask.: Vol. 49, No. 27, Oct. 1, 1960, p. 20.

[11] Chemical Week, vol. 87, No. 22, Nov. 26, 1960, p. 104.

[12] Neue Zeit (Berlin) [Plans of Ferrous, Nonferrous, Potash Industries]: Oct. 28, 1959.

TABLE 10.—World production of potash (marketable, unless otherwise stated) by countries[1]

(Short tons, K_2O equivalent)

Country	1951-55 (average)	1956	1957	1958	1959	1960
North America:						
Canada	----------	----------	----------	----------	46,500	----------
United States	1,802,551	2,171,584	2,266,481	2,147,671	2,383,259	2,638,574
Crude (including brines)[2]	1,996,905	2,479,463	2,615,808	2,478,725	2,781,960	3,039,309
South America: Chile	10,559	9,930	8,339	9,811	15,482	[3]16,500
Europe:						
France	1,096,578	1,463,006	1,545,267	1,630,436	1,622,832	[3]1,686,500
Crude [2]	1,247,969	1,653,465	1,736,894	1,835,033	1,828,804	1,912,508
Germany:						
East [3]	1,502,000	1,598,000	1,653,000	1,700,000	1,764,000	1,764,000
Crude [2] [3]	1,734,000	1,840,000	1,900,000	1,960,000	2,028,000	2,028,000
West	1,554,023	1,823,221	1,862,904	1,886,052	2,026,046	2,179,267
Crude [2]	1,854,221	2,166,039	2,190,290	2,225,564	2,364,455	2,552,950
Italy	(4)	(4)	(4)	9,022	11,575	51,162
Poland	(4)	(4)	(4)	(4)	(4)	27,500
Spain	215,728	263,468	251,460	238,292	269,790	[3]298,000
U.S.S.R.[3]	547,000	983,600	1,040,000	1,100,000	1,160,000	1,212,500
Asia:						
Israel	2,756	31,000	50,000	67,100	72,000	108,000
Japan	325	474	[3]1,650	[3]1,900	[3]2,300	[3]2,200
Africa: Eritrea	683	----------	----------	450	----------	----------
World total (marketable) (estimate)[1]	6,730,000	8,350,000	8,700,000	8,800,000	9,400,000	10,000,000

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] To avoid duplication of figures, data on crude potash are not included in the total.
[3] Estimate.
[4] Data not available, estimate included in total.

Compiled by Helen L. Hunt, Division of Foreign Activities.

TABLE 11.—France: Exports of potash materials[1] by countries[2]

(Short tons)

Destination	1958	1959
North America:		
Canada	28,752	25,219
Cuba	5,751	5,557
Martinique	6,462	8,077
United States	104,212	147,812
South America:		
Brazil	18,743	19,988
Chile	2,296	5,191
Colombia	2,756	----------
Europe:		
Austria	34,721	32,771
Belgium-Luxembourg	214,218	173,767
Denmark	34,177	26,107
Finland	7,256	9,066
Greece	1,838	4,593
Ireland	43,174	48,977
Italy	66,241	61,783
Netherlands	163,642	148,661
Norway	16,807	13,627
Sweden	33,395	24,645
Switzerland	63,007	61,271
United Kingdom	268,781	242,814
Asia:		
Ceylon	23,255	37,238
India	6,073	14,465
Japan	187,210	201,148
Taiwan	9,039	10,947
Africa:		
Algeria	22,621	21,434
Morocco: Southern zone	10,340	3,127
Rhodesia and Nyasaland, Federation of	17,360	7,740
Tunisia	2,782	8,314
Union of South Africa	11,475	20,029
Oceania:		
Australia	34,276	20,508
New Zealand	22,361	24,999
Other countries	64,142	94,853
Total	1,527,163	1,524,728

[1] Figures include salts, carbonate, chloride, and nitrate of potash.
[2] This table incorporates some revisions.

Compiled from Customs Returns of France by Bertha M. Duggan and Corra A. Barry, Division of Foreign Activities.

TABLE 12.—West Germany: Exports of potash materials[1] by countries[2]

(Short tons)

Destination	1959	1960
North America:		
Canada	23,832	30,137
Cuba	12,142	6,634
Dominican Republic	6,940	----------
Mexico	2,206	----------
Puerto Rico	23,246	26,863
United States	171,602	115,628
South America:		
Brazil	16,941	37,004
Venezuela	4,510	5,887
Europe:		
Austria	44,142	53,985
Belgium-Luxembourg	135,718	159,148
Denmark	216,520	259,725
Finland	8,338	65,279
Greece	5,512	6,241
Ireland	27,967	24,643
Italy	38,466	45,846
Netherlands	169,315	212,627
Norway	3,048	5,713
Sweden	28,672	47,300
Switzerland	31,376	34,420
United Kingdom	230,551	278,047
Asia:		
Ceylon	13,943	8,238
India	7,057	12,138
Indonesia	9,062	9,522
Japan	141,132	142,448
Korea, Republic of	----------	10,472
Malaya, Federation of	9,075	10,719
Philippines	5,502	5,529
Taiwan	21,495	23,512
Africa:		
Rhodesia and Nyasaland, Federation of	15,065	19,457
Union of South Africa	20,709	22,045
Zanzibar	3,543	3,646
Oceania:		
Australia	30,230	20,799
New Zealand	28,461	21,670
Other countries	28,182	31,261
Total	1,534,500	1,756,583

[1] Data include crude salts, chloride, sulfate, magnesium sulfate, and beet ash.
[2] This table incorporates some revisions.

Compiled from Customs Returns of West Germany by Bertha M. Duggan and Corra A. Barry, Division of Foreign Activities.

Germany, West.—The Federal Cartel Office approved the formation of a cartel by the Association of German Potash Producers whereby the sale of all potassium salts produced in West Germany would be handled through a central body, Verkaufsgemeinschaft Deutscher Kaliwerke GmbH., based in Hanover.[13]

India.—Most of the potash required for agricultural use was imported by the State Trading Corp. through the Indian Potash Supply Agency. Consumption of potassic fertilizers in India during 1960 was estimated at 45,000 tons (K_2O equivalent) compared with 32,500 tons in 1959. Imports, however, dropped from 53,200 tons muriate (K_2O equivalent) in 1959 to 14,600 tons, because of high inventories carried over from 1959.[14]

Israel.—Dead Sea Works, Ltd., at Sodom, the only potash producer in Israel, did not achieve anticipated production because of an unusually cool summer that slowed solar evaporation. This led to plans for a shift to thermal evaporation.[15] An expansion program, planned to start in 1961 and continue over a 4-year period, was intended to increase annual potash production to 660,000 tons by the midsixties. A 30-mile dike was planned to cut off about one-tenth of the area of the Dead Sea at its southern section for use as a vast evaporation plant. This was to be the first construction stage. The earthern dike, estimated to cost about $22 million, was to be 26 feet high and 234 feet broad at its base.[16]

Italy.—The San Cataldo potash mine and the Campofranco processing plant of the Montecatini Co. began operations late in October

[13] Chemical Age (London), Federal German Potash Cartel Announced: Vol. 83, No. 2113, Jan. 9, 1960, p. 94.
[14] Bureau of Mines, Mineral Trade Notes: Vol. 52, No. 6, June 1961, p. 35.
[15] Bureau of Mines, Mineral Trade Notes: Vol. 51, No. 3, September 1960, p. 36.
[16] Mining Journal (London), vol. 255, No. 6538, Dec. 9, 1960, p. 662.

1960. The daily output of 3,000 tons of kainite from the mine was shipped by a 12-mile cableway to the plant, which had a 300,000-ton yearly capacity.[17]

Spain.—Potasa de Navarra, a new potash company, was formed to exploit some rich deposits discovered about 2 years before. Production of 50,000 tons (K_2O equivalent) per year was initially expected, with expansion to 200,000 tons within 6 to 8 years. The company is controlled by the Spanish National Institute for Industry.[18]

TABLE 13.—Spain: Exports of potash materials by countries

(Short tons)

Destination	1958	1959	1960 [1]
North America:			
Canada			5,952
United States	30,027	48,502	59,508
South America: Chile	10,803	3,968	
Europe:			
Belgium-Luxembourg	37,677	49,217	1,323
Denmark			43,715
France			10,086
Germany, West			11,023
Italy	20,332	26,802	48,913
Netherlands	15,052	16,105	17,417
Norway	60,561	53,174	56,935
Portugal	14,311	16,722	9,800
United Kingdom	58,237	66,411	69,513
Asia: Japan	44,093	44,864	34,302
Other countries	661		1,240
Total	291,754	325,765	369,727

[1] January to November, inclusive.

Compiled from Customs Returns of Spain by Bertha M. Duggan and Corra A. Barry, Division of Foreign Activities.

U.S.S.R.—It was reported that potassium salt reserves of 6.5 billion tons had been established, sufficient to supply Russian needs for 900 years at the 1960 rate of production.[19]

TECHNOLOGY

A method known as "tubbing" for sinking shafts through quicksand zones was introduced in North America for the first time. International Minerals & Chemical Corp. contracted for such a technique to be used on its shaft near Esterhazy, Saskatchewan, after other methods had failed to penetrate satisfactorily the 300-foot-thick Blairmore stratum.

The method called for the installation of a series of 76 cast iron rings about 15 feet in diameter by 5 feet high to form a sleeve 350 feet long and incasing the shaft from the 1,130-foot level to the 1,488-foot level. The rings were to be sealed together with lead gaskets and locked with bolts. When completed, the total weight of the lining will be approximately 3,500 tons.

Before the tubbing operations could be started, it was necessary to freeze the quicksand area around the shaft. Freezing operations

[17] World Mining, vol. 13, No. 13, December 1960, p. 55.
[18] Chemical Trade Journal and Chemical Engineer (London), vol. 147, No. 3824, Sept. 16, 1960, p. 624.
[19] Izvestiya (Moscow) [Raw Material Resources for Fertilizers]: Mar. 17, 1960.

were started in 1959. The shaft was enlarged at the 600-foot level to permit the use of drilling rigs, and pipes, which lead to a freezing plant on the surface, were inserted down through drilled holes around the shaft's outer edges.

Lithium chloride, used as a freezing mixture, was run through the pipes at a temperature of -58° F. to freeze the Blairmore stratum so that the tubbing operations could proceed. It took about a year to freeze the earth sufficiently to withstand the strong water pressure, but by the summer of 1960 a wide area around the pipes had been lowered to −50° F.[20]

A modification of an old mining device known as the "Galloway stage" is ready for operation for sinking the remainder of the shaft. A similar shaft sinking device has been used successfully in South African mines, but this will be its first use in the Western Hemisphere. This triple-decker equipment is said to permit the simultaneous mucking of blasted rock, the setting of forms, and the pouring of concrete shaft lining.[21]

The Russians claimed to have developed a new method for upgrading potash ores.[22]

An Italian process for providing substantially pure potassium sulfate from kainite was patented.[23] The process briefly consists of converting kainite into schoenite ($K_2SO_4 \cdot MgSO_4 \cdot 6H_2O$), solution of the schoenite with subsequent precipitation of lead syngenite ($K_2SO_4 \cdot PbSO_4$), dissolving the lead syngenite, removing the insoluble lead sulfate, and finally crystallizing nearly pure potassium sulfate.

A new process for making potassium nitrate was developed by Southwest Potash Corp. which will be used in its Vicksburg, Miss., plant. The process was said to make nitrate of potash available for the first time at prices competitive with other fertilizer chemicals.[24]

A method for producing pure potassium compounds from the saline byproducts of the sugar industry was developed by the Societa Bario e Derivati of Milan. Both potassium nitrate and potassium carbonate were claimed to have been made free of sodium.[25]

A technical bulletin on potassium and sodium-potassium alloys was published by MSA Research Corp., Callery, Pa.[26]

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[20] Work cited in footnote 7.
[21] Chemical Week, Digging Fast to Deep Potash: Vol. 86, No. 12, Mar. 19, 1960, pp. 68, 70.
[22] Chemical Week, Engineering Processes, Potash Quality Control: Vol. 86, No. 11, Mar. 12, 1960, p. 46.
[23] Carbotti, Sergio (assigned to Societa Sali Potassici, Palermo, Italy), Process for Recovering Potassium From Solutions Thereof: U.S. Patent 2,966,395, Dec. 27, 1960.
[24] Agricultural Chemicals, Southwest Potash Develops New Process for Potassium Nitrate: Vol. 15, No. 8, August 1960, p. 35.
[25] Chemical Trade Journal and Chemical Engineer (London), Potash Salts in Italy: Vol. 146, No. 3794, Feb. 19, 1960, p. 402.
[26] Chemistry, Bulletin Prepared on Potassium and Sodium-Potassium Alloys: Vol. 33, No. 6, February 1960, p. 30.

Pumice

By John W. Hartwell[1] and Victoria M. Roman[2]

PUMICE and pumiceous materials sold or used by United States producers in 1960 decreased 3 percent in quantity and 2 percent in average price.

DOMESTIC PRODUCTION

Pumice production was reported from 112 operations by 96 companies, individuals, railroads, or highway departments in 14 States during 1960.

Total output of pumice and related materials was 2.2 million tons, 3 percent less than in 1959. Arizona was the leading State with 6 active mines and 32 percent of the 1960 total. It was followed by California, with 19 percent from 45 mines; New Mexico, with 17 percent from 14 mines; and Hawaii, with 16 percent from 22 operations.

A deposit containing 470,000 tons of pumice was developed near Bishop, Calif. The material was estimated to weigh 14 pounds per cubic foot.

TABLE 1.—Pumice[1] sold or used by producers in the United States

(Thousand short tons and thousand dollars)

Year	Pumice and pumicite		Volcanic cinder		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1951-55 (average)	899	$2,497	(2)	(2)	(2)	(2)
1956	887	3,222	595	$1,527	1,482	$4,749
1957	1,055	3,091	772	1,537	1,827	4,628
1958	925	3,091	1,048	2,196	1,973	5,287
1959	784	3,267	1,492	2,596	2,276	5,893
1960	602	2,767	1,610	2,802	2,212	5,566

[1] Includes volcanic cinder.
[2] Includes 669,831 short tons of volcanic cinder in 1953, valued at $565,846, and 690,056 short tons, valued at $475,424 in 1954. Volcanic cincer not reported before 1953.

CONSUMPTION AND USES

Consumption and uses of natural pumiceous materials other than pumice or pumicite increased 32 percent over 1959 due to larger quantities being used where color and quality were not important.

The largest use of domestic pumice was for admixtures and aggregates, 42 percent, followed by railroad ballast, 37 percent.

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.

TABLE 2.—Pumice sold or used by producers in the United States

(Thousand short tons and thousand dollars)

State	1959		1960	
	Quantity	Value	Quantity	Value
Arizona	487	$1,153	703	$1,164
California	574	2,162	427	1,895
Colorado	40	66	32	70
Hawaii	276	548	361	676
Idaho	93	137	56	88
New Mexico	493	1,023	365	827
Utah	39	81	60	134
Washington	9	112	(1)	(1)
Wyoming	94	77	33	30
Other States [2]	171	504	175	685
Total	2,276	5,863	2,212	5,569

[1] Included with "Other States" to avoid disclosing individual company confidential data.
[2] Includes States indicated by footnote 1, and Kansas, Nebraska, Nevada, Oklahoma, and Oregon.

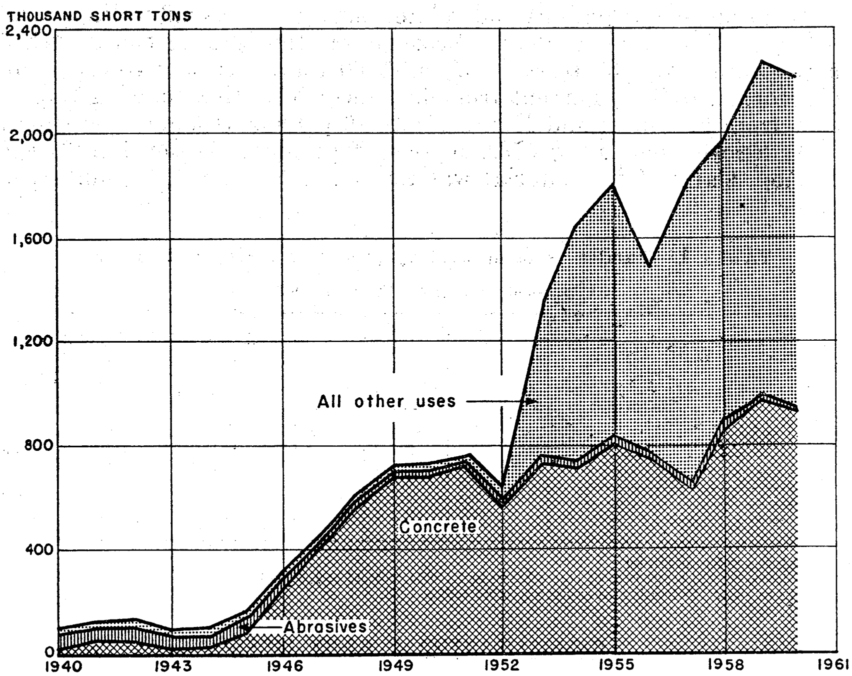

FIGURE 1.—Trends in pumice by uses, 1940–60.

PRICES

Nominal price quotations covering domestic and imported prepared pumice were carried regularly in trade publications. The Oil, Paint and Drug Reporter quoted the following average prices for 1960 per pound, bagged, in ton lots: Domestic, coarse to fine, $0.03625; imported, Italian, silk-screened, coarse, $0.0650; the same but fine, $0.040. Imported, Italian, sun-dried, coarse, was quoted at $60 per ton.

E&MJ Metal and Mineral Markets quoted nominal yearend prices for pumice in 1960, per pound, f.o.b. New York or Chicago, in barrels: Powdered, 3 to 5 cents; lump, 6 to 8 cents.

Average values per ton for pumice in various use categories compared with 1959 (in parentheses) were: Cleansing and scouring compounds and other abrasive uses, $61.62 ($58.44); concrete admixtures and aggregate, $2.91 ($2.97); acoustic plaster, $27.10 ($22.24); insulation, $10.02 ($4.37); railroad ballast, $1.04 ($1.27); other and unclassified uses, $2.83 ($2.85).

The average value for the 678,000 short tons of crude pumice sold or used in 1960 was $2.12 per ton, a 6-percent increase over 1959. The average value for 1,532,000 tons of prepared pumice was $2.69, an 8-percent decrease under 1959.

TABLE 3.—Pumice sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1959		1960	
	Quantity	Value	Quantity	Value
Abrasive: Cleaning and scouring compounds	12	$685	11	$678
Acoustic plaster	1	31	(1)	(1)
Concrete admixture and concrete aggregate	975	2,754	929	2,704
Railroad ballast	841	1,071	824	858
Other uses [2]	447	1,322	448	1,329
Total	2,276	5,863	2,212	5,569

[1] Included with "Other uses."
[2] Insecticides, insulation, brick manufacture, filtration, other abrasive uses, roads (surfacing and ice control), absorbents, soil conditioner, and miscellaneous uses.

FOREIGN TRADE [3]

Imports.—Pumice valued at less than $15 per ton comprised 60 percent of the total pumice imports, compared with 83 percent in 1959, and had an average value of $8.40. All imported pumice, with an average value of $15.38 a ton manufactured, n.s.p.f., came from Italy, compared with 39 percent in 1959. The average value of imported pumice, rated at over $15 per ton, averaged $19.65, compared with $19.45 in 1959.

Exports.—Canada received $80,000 worth of pumice from the United States in 1959, a 3-percent increase over 1958. U.S. statistics of pumice exports were grouped with other mineral commodities and were therefore not available separately.

Tariff.—Duty per pound on imported pumice was the same as in 1959: Crude valued at $15 a ton and under, 0.045 cent; crude valued over $15 a ton, 0.12 cent; wholly or partially manufactured, 0.45 cent.

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

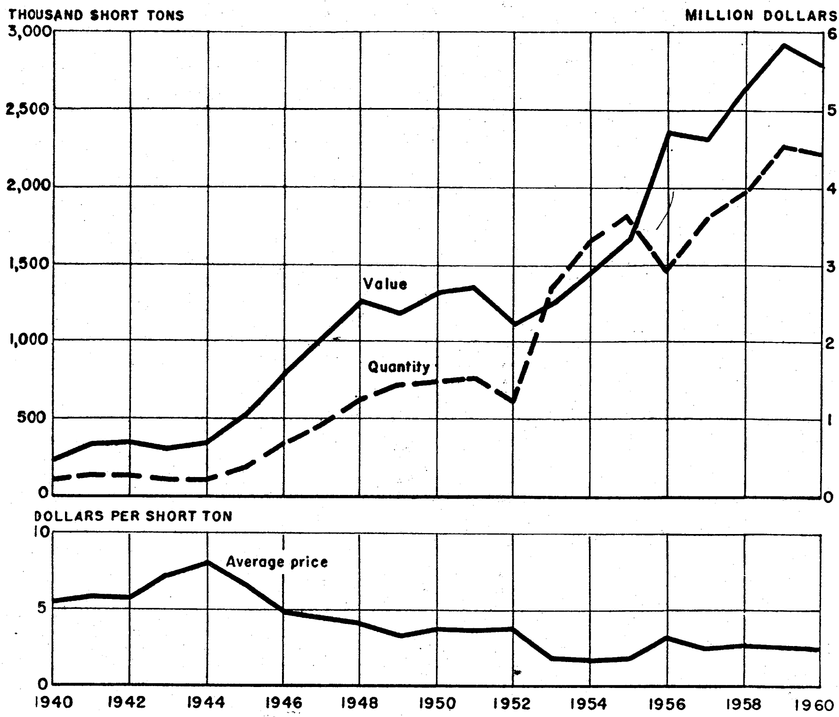

FIGURE 2.—Total value, quantity, and price per ton of pumice, 1940–60.

TABLE 4.—U.S. imports for consumption of pumice, by countries

Country	Crude or unmanufactured				Wholly or partly manufactured				Manufactured, n.s.p.f.	
	1959		1960		1959		1960		1959	1960
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Value	
Canada										$600
France										243
Germany, West									$18,482	32,027
Greece	15,668	$102,121								
Italy	6,053	50,074	6,556	$58,113	3,988	$91,706	3,916	$102,951		572
Japan									1,424	994
Norway										180
United Kingdom									575	1,353
Total	21,721	152,195	6,556	58,113	3,988	91,706	3,916	102,951	20,481	35,969

Source: Bureau of the Census.

WORLD REVIEW

Greece.—In 1958 exports of pumice stone totaled 45,800 tons, about one-third of total production.[4]

Iceland.—A West German company leased a pumice deposit in Iceland near Hafnarfjordur, and mining was started during 1960. This company expected to export up to 50,000 tons annually after 1963.

Pumice stone was produced by local companies for the manufacture of building blocks.

Peru.—A company was formed in 1960 to mine and process volcanic ash in the southern Peruvian Andes. The ash will be used in the production of pipe, tile, building block, and mortar, providing a supply of inexpensive building materials.

West Indies.—Three large deposits of pumiceous material were reported to have been found on the islands of the Lesser Antilles. Other deposits of pumice, pumicite, volcanic cinders, and pozzolanic earths were known to exist.[5]

TABLE 5.—World production of pumice by countries [1] [2]

(Short tons)

Country [1]	1951-55 (average)	1956	1957	1958	1959	1960
Argentina [3]	[4] 49,604	15,708	20,278	20,230	[5] 20,000	[5] 20,000
Austria: Trass	44,694	37,499	38,875	29,784	34,885	38,581
Cape Verde Islands: Pozzolan					10,033	4,043
France:						
Pumice	12,379	14,337	8,781	7,385	3,748	[5] 3,700
Pozzolan	242,049	423,041	468,228	418,878	407,855	[5] 419,000
Germany, West (marketable)	2,444,555	3,966,111	3,261,735	3,255,121	4,039,966	4,742,138
Greece:						
Pumice	35,594	77,162	61,242	49,604	16,535	[5] 11,000
Santorin earth	43,768	93,696	87,634	94,428	110,231	[5] 88,000
Iceland	[6] 13,338	[5] 19,000	15,102	[5] 15,000	[5] 15,000	[5] 15,000
Italy:						
Pumice	144,803	211,959	221,990	145,413	258,254	[5] 3,400,000 (Pumice, Pumicite, and Pozzolan combined)
Pumicite	39,258	18,150	37,302	137,899	146,717	
Pozzolan	1,441,400	2,750,702	2,897,620	2,992,880	3,055,978	
Kenya		1,831	2,319	821	2,515	2,711
New Zealand	8,286	8,527	16,991	25,851	31,803	[5] 31,000
Spain (Canary Islands)	809	1,681			1,836	
United Arab Republic (Egypt Region)	441	[5] 170	1,836	1,185	2,756	[5] 2,800
United States (sold or used by producers):						
Pumice and pumicite	765,119	887,553	1,054,594	925,026	783,873	601,315
Volcanic cinder	[7] 773,804	594,661	772,384	1,047,930	1,492,247	1,609,050
World total (estimate) [1] [2]	6,120,000	9,200,000	9,000,000	9,200,000	10,500,000	11,000,000

[1] Pumice is also produced in Japan, Mexico, U.S.S.R., and a few other countries, but data on production are not available; estimates by senior author of chapter included in total.
[2] This table incorporates some revisions. Data do not add to totals shown because of rounding where estimated figures are included in the detail.
[3] Includes volcanic ash and cinders, and pozzolan.
[4] Average for 1 year only, as 1955 was first year of commercial production.
[5] Estimate.
[6] Average for 1954-55.
[7] Average for 1953-55; volcanic cinder was not reported before 1953.

Compiled by Helen L. Hunt, Division of Foreign Activities.

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[4] Bureau of Mines, Mineral Trade Notes: Vol. 51, No. 6, December 1960, p. 54.
[5] Eckel, Edwin B., Pumice and Pozzolan Deposits in the Lesser Antilles: U.S. Geol. Survey, Repts., Open-File Ser., No. 592, 58, September 1960, 22 pp.; Geol. Sci. Abs., vol. 3, No. 2, February 1961, p. 47.

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TECHNOLOGY

A book published on the geology of industrial rocks and minerals contained information on pumice and pumicite. Data included descriptions and locations of occurrences, chemical and physical properties, production, uses, and 35 references. Also included was information on the properties of pumice when used as an abrasive, a concrete aggregate, and a pozzolan material.[6] Descriptions of over 180 pumice and pumicite deposits in Washington State were published.[7]

The Colorado School of Mines published data on pumice and pumicite which included terminology, definitions and classifications, locations of Colorado deposits and their composition, uses, and prices.[8]

A patent on the use of expanded pumicite as a cover for open tanks of volatile liquids was granted.[9]

A method of making a porous or cellular product from pumice or obsidian was patented. The volcanic rock is ground and mixed with sodium nitrate and hydroxide, and fired at 1,300° to 2,000° F. until the material melts and foams.[10]

A patent was issued for a method of making insulation products using fine porous powder from volcanic glass such as pumice or obsidian.[11]

Canadian patents were issued for the manufacture of a hydraulic cement using quicklime and pumicite, fly ash, or other siliceous material as the principal ingredients,[12] and a load-bearing, flexible, road-surfacing material containing a cellular pozzolan such as pumicite mixed with asphalt.[13]

British patents were granted for the use of pumice as a paint filler,[14] for a ceramic surface layer on concrete building material consisting of sodium silicate, a filler such as pumice, and a refractory material,[15] and for a method of manufacturing a gypsum board using pumice as a lightweight aggregate.[16]

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[6] Bates, R. L., Geology of Industrial Rocks and Minerals: Harper and Bros., New York, N.Y., 1960, pp. 39–50.

[7] Valentine, G. M., and Huntting, M. J., Inventory of Washington Minerals: Wash. Department of Conservation, Div. of Mines and Geol., Bull. 37, vol. 1, pt. 1, 1960, pp. 83–91 (text); vol. 2, pt. 1, 1960, p. 63 (map).

[8] Williamson, D. R., and Burgin, Lorraine, Pumice and Pumicite: Colorado School of Mines, Mineral Ind. Bull., vol. 3, No. 3, May 1960, 12 pp.

[9] Hurley, J. R. (assigned to Phillips Petroleum Co.), Popped Volcanic Ash Cover for Liquids: U.S. Patent 2,926,988, Mar. 1, 1960.

[10] Booth, A. E. (assigned to Armstrong Cork Co., Lancaster, Pa.), Method of Making Foamed and Expanded Product from Volcanic Glass: U.S. Patent 2,946,693, July 26, 1960.

[11] Booth, A. E., and Hess, R. L. (assigned to Armstrong Cork Co., Lancaster, Pa.). Method of Making Porous Products from Volcanic Glass and Alumina: U.S. Patent 2,956,891, Oct. 18, 1960.

[12] Schifferle, C. J. (assigned to Joseph J. Coney), Canadian Patent 607,514, Oct. 25, 1960.

[13] Jones, C. T., Canadian Patent 595,081, Mar. 29, 1960.

[14] British Patent 938,694, June 29, 1960.

[15] Wessel, H., British Patent 836,423, June 1, 1960.

[16] Taylor, J. B. (assigned to British Plaster Board Holdings Ltd.), British Patent 832,256, Apr. 6, 1960.

Quartz Crystal (Electronic Grade)

By James D. Cooper[1] and Gertrude E. Tucker[2]

CONSUMPTION of electronic-grade quartz crystal in 1960 increased 10 percent over 1959. The number of piezoelectric units manufactured increased 28 percent, indicating continuation of a general trend toward production of smaller units.

DOMESTIC PRODUCTION

No natural electronic-grade quartz crystal was produced domestically in 1960. Two companies produced cultured quartz crystal. Sales of cultured quartz crystal by Sawyer Research Products, Inc., Eastlake, Ohio, totaled 4,575 pounds, compared with 3,880 pounds in 1959. Most of the sales were in the United States, but small quantities went to Europe and Japan. Western Electric Co., North Andover, Mass., started production of cultured electronic- and optical-grade quartz crystal at its new plant at Merrimack Valley, Mass. Capacity was reported to be about 14,000 pounds per year, which was scheduled for use by Western Electric and affiliated companies.[3]

Total plant capacity for production of cultured quartz crystal was about 30,000 pounds per year at the end of 1960.

CONSUMPTION

Consumption of raw quartz crystal for producing piezoelectric units was 230,000 pounds in 1960 compared with 210,000 pounds in 1959. Approximately 3,100 pounds of cultured quartz crystal was domestically produced. A total of 8,712,000 piezoelectric units was produced, of which 8,396,000 were made from raw quartz crystal and 316,000 from blanks carried over from prior years and from imported blanks. The yield per pound of raw quartz crystal was 36.5 finished crystal units, compared with 28.6 units in 1959. Producers report the yield from cultured quartz crystal was from 2 to 10 times the yield from natural quartz.

Of 57 producers (54 companies) in 21 States reporting production of piezoelectric units in 1960, 17 did not consume raw quartz crystal but manufactured finished units from partially processed blanks. Almost 90 percent of the total production was reported by 32 plants in 10 States. Pennsylvania was first in production, followed by Kansas, Missouri, Massachusetts, and Illinois. Oscillator plates constituted

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[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.
[3] Missiles and Rockets, Home Grown Quartz Signals End of Dependence on Imports: Vol. 7, No. 24, Dec. 12, 1960, p. 24.

91 percent of the total piezoelectric units produced. The remaining 9 percent consisted of filter plates, telephone resonator plates, transducer crystals, radio bars, and other miscellaneous items.

In 1960, a total of 42 quartz crystal consumers, representing 40 companies in 17 States, reported to the Bureau of Mines. Forty of the consumers were also producers of piezoelectric units, two produced only semifinished blanks. About 90 percent of the raw quartz crystal consumed was reported by 25 consumers in 8 States. Pennsylvania, with 32 percent of the total consumption, was the leading State, followed by Kansas, Massachusetts, Missouri, and Illinois.

TABLE 1.—Salient electronic- and optical-grade quartz crystal statistics

	1951–55 (average)	1956	1957	1958	1959	1960
Imports of electronic- and optical-grade quartz crystal (estimated) [1] thousand pounds	866	521	432	274	[2] 367	[2] 676
Value thousands	$2,025	$1,142	$652	$341	[2] $638	[2] $504
Consumption of raw electronic-grade quartz crystal [3] [4] thousand pounds	296	162	182	158	210	230
Production, piezoelectric units,[4] number, thousands	4,981	5,390	[5] [6] 5,787	[5] [6] 5,510	[5] [6] 6,820	[6] 8,712

[1] Imports for 1953–60 are Brazilian pebble valued at 35 cents or more per pound.
[2] Excludes quartz crystal imported from Brazil and accepted under Government agricultural barter contracts.
[3] For 1954 and subsequent years, data include some reworked scrap quartz crystal.
[4] Revised figures, 1954–56.
[5] Revised figure.
[6] Includes finished crystal units produced from reprocessed blanks, from raw quartz crystal previously reported as consumption, and from imported blanks.

PRICES

Prices for natural electronic-grade quartz crystal sold domestically in 1960 were generally higher than in 1959. The approximate price range for various weight classes was as follows:

Weight class (grams):	*Price per pound*
100–200	$3.00 to $5.00
201–300	4.50 to 12.50
301–500	8.00 to 14.00
501–700	12.00 to 20.00
701–1,000	18.00 to 24.00
1,001–2,000	24.00 to 35.00

Prices for cultured quartz crystal quoted by Sawyer Research Products, Inc., were from $27.50 to $35 per pound, depending on quantity commitments, unchanged from the previous year.

Prices for lasca, used to produce clear fused quartz, were about $0.50 per pound for first quality material, with small lots selling for as much as $1 per pound. Second quality lasca was priced at about $0.25 per pound.

FOREIGN TRADE [4]

Imports of electronic- and optical-grade quartz crystal valued at more than 35 cents per pound were almost double the 1959 figure; however, the total value was down 21 percent.

[4] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

Brazil was the major supplier with 661,000 pounds, or 98 percent. The remaining 15,000 pounds came from Canada, United Kingdom, West Germany, and Japan. Part of the imports from Japan comprised material sent from the United States for partial processing.

Imports of quartz crystal valued at less than 35 cents per pound—classed as lasca—totaled 444,299 pounds, valued at $57,736, an increase of 89 percent in quantity and 217 percent in value over 1959. Of this, 92 percent came from Brazil and the balance from Japan. The increased imports indicated rising demand for fusing-grade quartz, and possibly some stockpiling of raw material for production of cultured quartz crystal.

Exports of quartz crystal were valued at $353,869 compared with $165,794 in 1959. The principal countries of destination were Canada, Japan, United Kingdom, and the Bahamas, in that order. Reexports were valued at $26,634 compared with $34,150 in 1959. Canada was the principal country of destination.

WORLD REVIEW

Brazil.—Exports of electronic- and fusing-grade quartz crystal totaled 3,590,765 pounds, valued at US$1,032,000.[5] This represented a 72-percent increase in quantity but a decrease of 6 percent in value over 1959.

Malagasy Republic.—Production of piezoelectric quartz crystal during the first 9 months of 1960 was 2,646 pounds valued at US$8,745. Exports during the same period were 5,935 pounds valued at US$23,610. Production in 1959 was 11,790 pounds valued at US-$42,105 and exports totaled 18,740 pounds valued at US$74,332.

Production and exports of ornamental quartz were 4,851 pounds valued at US$810 and 19,624 pounds valued at US$4,325, respectively, during the first 9 months of 1960. For the same period, production of fusing-grade quartz was 7,276 pounds valued at US$400, and exports were 30,650 pounds valued at US$2,030.[6]

Spain.—The Margarita mine, which was operated about 100 years ago for gem-quality quartz (Spanish topaz), reportedly was reopened for production of electronic-grade quartz crystal.[7] Production data are not available.

TECHNOLOGY

The frequency changes due to compressional stress on AT type quartz crystal plates excited in the third overtone mode were determined. The results are useful in studying the mechanism of thickness vibrations. Determination of the zero effect—which occurs when pressure is applied to crystal plates at about 60° from the X axis—is of practical use in mounting plates which may be exposed to shock or vibration.[8]

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[5] U.S. Embassy, Rio de Janeiro, Brazil, State Department Dispatch 953: Apr. 26, 1961, encl. 1, p. 5.

[6] U.S. Consulate, Johannesburg, Union of South Africa, State Department Dispatch No. 61: Aug. 31, 1960, p. 1; No. 90, Oct. 4, 1960, p. 2; No. 196, Jan. 10, 1961, p. 2.

[7] Pough, Dr. Frederick H., The "Spanish Topaz" Mines: Jewelers' Circ.-Keystone, vol. 130, No. 4, January 1960, pp. 62, 64.

[8] Ballato, A. D., and Bechman, R., Effect of Initial Stress in Vibrating Quartz Plates: Proc. IRE, vol. 48, No. 2, February 1960, pp. 261–262.

Sawyer Research Products, Inc., Eastlake, Ohio, produced cultured quartz crystal with a Q-factor equal to the best natural quartz crystal. The production method involves electrostatic sweeping. The company also successfully demonstrated that domestic feed material could be used in producing cultured quartz crystal. Previously, only imported natural quartz crystal was used.

Development of pressure-sensitive bimetal strips to replace constant-temperature ovens for control of the frequency of quartz crystal units was announced. In addition to savings in space, weight, and power requirements, use of the bimetal strips extends the useful life of the crystal units.[9]

Research on methods to improve cultured quartz crystal continued, and additional patents were issued on methods of preparing seed bodies and for growing crystals.[10]

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[9] Electronic News, Bi-Metal Strips Employed in Quartz Crystal Stabilizer: Vol. 5, No. 200, Apr. 25, 1960, p. 28.

[10] Jaffe, Hans, and Turobinski, T. J. (assigned to Clevite Corp., Cleveland, Ohio), Method of Growing Quartz Single Crystals: U.S. Patent No. 2,923,605, Feb. 2, 1960.

Hale, D. R., and Jost, J. M. (assigned to Clevite Corp., Cleveland, Ohio), Method of Growing Quartz Single Crystals and Seed Body Therefor: U.S. Patent No. 2,923,606, Feb. 2, 1960.

Stanley, J. M., and others (assigned to United States of America as represented by the Secretary of the Army), Method of Fabricating a Synthetic Quartz Crystal: U.S. Patent No. 2,944,027, July 5, 1960.

Rare-Earth Minerals and Metals

By John G. Parker [1]

DOMESTIC mine shipments of rare-earth oxides in 1960 were lower than in 1959. No monazite was imported because the thorium procurement program of the Atomic Energy Commission (AEC) expired and most processors used industrial stocks of rare-earth products.

Exploration for monazite and other rare-earth minerals was aided by the Office of Minerals Exploration (OME). Financial aid up to 50 percent of the allowable costs of exploration was contributed by the Government.

DOMESTIC PRODUCTION

Concentrate.—No euxenite or thorite concentrates were shipped during 1960. Molydenum Corporation of America produced bastnasite concentrate from its property at Mountain Pass, Calif. A very small amount of monazite sand was mined by Titanium Alloy Manufacturing Division, National Lead Co., in Duval County, Fla.

Metals and Compounds.—Processors of rare-earth concentrates and producers of separated metals and compounds were American Potash & Chemical Corp., West Chicago, Ill.; American Scandium Corp., Cincinnati, Ohio; W. R. Grace & Co., Davison Chemical Division, Pompton Plains, N.J.; Lunex Co., Pleasant Valley, Iowa; Michigan Chemical Corp., St. Louis, Mich.; Molybdenum Corporation of America, Pittsburgh, Pa.; Research Chemicals Division, Nuclear Corporation of America, Burbank, Calif.; and Vitro Chemical Co., Chattanooga, Tenn. About 50 tons of the rare-earth element and thorium-bearing material stockpiled as byproducts from Idaho euxenite concentrate by General Services Administration was sold to industry for research purposes.

The principal producers of cerium and misch metal and rare-earth-bearing alloys and ferrocerium (including lighter flints) were American Metallurgical Products Co., Castalloy, Inc., The Dow Chemical Co., G. C. Fuller Manufacturing Co., Hills-McCanna Co., Mallinckrodt Chemical Works, Ronson Metals Corp., and Union Carbide Metals Co.

Maywood Chemical Works discontinued production of rare-earth compounds at the beginning of 1960; General Cerium Corp. and St.

[1] Commodity specialist, Division of Minerals.

Eloi Corp. went out of business. American Scandium Corp. entered business as an oxide and metal producer. Electro Metallurgical Co. merged with Union Carbide Corp. as part of Union Carbide Metals Co. American Potash & Chemical Corp. announced it was doubling its ion-exchange facilities and continuing new product and process research. Michigan Chemical Corp. bought the Atomic Energy Commission rare-earth ion-exchange facility at St. Louis, Mich.—reportedly the largest in the world—at an open bidding sale. Vitro Chemical Co. announced that 1960 sales of rare-earth chemicals and metal alloys were 34 percent over those of the preceding year. Late in the year, Vitro Corporation of America acquired the minority interest in Vitro Chemical Co. held by the French firm, Pechiney, Compagnie de Produits Chimiques et Electrometallurgiques, and made an agreement giving Vitro exclusive U.S. and Canadian rights to Pechiney process and product patents on rare-earth chemicals, compounds, metals, and alloys until the end of 1974.[2]

CONSUMPTION AND USES

Apparent consumption of rare-earth elements was about 1,800 short tons of rare-earth oxides, nearly 20 percent greater than for the preceding year. Processors offered high-purity earth compounds in large quantities for research, as well as commercial grades. A series of articles appeared on the use of rare-earth elements and compounds, particularly cerium oxide, in the glass industry.[3]

Rare-earth processors continued research to reduce the cost of rare-earth products to increase the possibility of their use as polishing agents by flat glass and ophthalmic (eye glass) lens plants. However, it was realized that price reductions would be limited on large amounts of specific rare-earth items because of the concomitant excess quantities of other rare-earth products.[4]

Addition of rare-earth elements to steel was said to have permitted production of steel ingots approximately twice the size of those made by the usual practice.[5] It was stated that close to 1 million pounds of rare-earth double salts would be used in 1960 in making rimmed steel. This constituted about 95 percent of rare-earth usage in steelmaking.[6]

Misch metal was used in nodular cast iron to control deleterious elements and in cast steel to improve ductility and impact properties. Its use was said to improve fluidity and castability in precision castings.[7]

Samarium 153 was used as a radiographic source in a portable X-ray unit.[8]

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[2] Vitro Corporation of America, 1960 Annual Report.

[3] Hampel, Clifford A., The Rare Earths: Glass Ind., vol. 41, No. 1, January 1960, pp. 14–16.

Hampel, Clifford A., Cerium in The Glass Industry. pt. 2: Glass Ind., vol. 41, No. 2, February 1960, pp. 82–86, 109–113.

Hampel, Clifford A., Rare Earths in The Glass Industry: Glass Ind., vol. 41, No. 3, March 1960, pp. 148–153, 174.

Duncan, L. K., Cerium Oxide for Glass Polishing: Glass Ind., vol. 41, No. 7, July 1960, pp. 387–391, 412–414.

[4] American Metal Market, vol. 67, No. 184, Sept. 23, 1960, p. 9.

[5] American Metal Market, vol. 67, No. 57, Mar. 24, 1960, p. 7.

[6] Steel, The Metalworking Daily: Vol. 146, No. 19, May 9, 1960, pp. 179–180.

[7] American Metal Market, vol. 67, No. 178, Sept. 15, 1960, pp. 1, 5.

[8] Metal Progress, vol. 77, No. 4, April 1960, p. 52.

Advanced powder metallurgy techniques were used by Sintercast Division of Chromalloy Corp. to produce rare-earth composites dispersed in either aluminum or stainless steel. The material is supplied as tubing, strip, foil, plate, and custom shapes and is designed for better and longer lasting use in nuclear equipment.[9]

STOCKS

The rare-earth basic compounds stocks that had been built up as a byproduct from thorium production would be depleted in a short time based on the 1960 rate of rare-earth consumption. It was evident that a new rare-earth raw material procurement program would have to be initiated by industry to maintain production. Future imports would probably come from the Union of South Africa.

PRICES

Nominal quotations on imported monazite remained almost the same as for 1959: Per pound, c.i.f. U.S. ports, massive, 55 percent total rare-earth oxides including thorium, 14 cents; and sand, 55-percent-grade, 10 to 15 cents; 66-percent, 18 cents; and 68-percent, 20 cents. The only change was in the price of 55-percent-grade sand, noted at midyear.[10] No transactions were undertaken for purchase of imported or domestic monazite. The price of domestic bastnasite was not available.

Prices of misch metal ranged from $2.80 to about $3.75 per pound, depending upon the quantity and the source. Price cuts—some over 50 percent in the smallest size lots—were announced by Research Chemicals for separated rare-earth metals. Six new high-purity rare-earth metals became available at prices generally 60 to 75 percent higher than for the commercial grade.

American Metal Market periodically published price lists of rare-earth metals. New price schedules for rare-earth production chemicals and for research quantities of high-purity rare-earth and yttrium salts were issued by American Potash & Chemical Corp.

FOREIGN TRADE[11]

Imports.—Imports of cerium metal, ferrocerium, and other cerium alloys and compounds totaled 39,394 pounds valued at $108,697. Of this quantity, Austria shipped 49 percent, West Germany, 37 percent, France, 6 percent, Japan, 5 percent, and the United Kingdom, 3 percent. Imports of monazite concentrate were negligible.

Exports.—Exports of cerium ores, metals, alloys, and ferrocerium (including lighter flints) totaled 42,927 pounds valued at $132,289. The United Kingdom received 50 percent, Canada and France, 17 percent each, Australia, about 5 percent, West Germany, about 4 percent, Colombia and Venezuela, less than 2 percent each, and Japan

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[9] Materials in Design Engineering, vol. 52, No. 3, September 1960, pp. 224–228.
[10] E&MJ Metal and Mineral Markets, June 2, 1960, vol. 31, No. 22, p. 7.
[11] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

and Mexico, about 1 percent each. The remainder, in decreasing order of quantity shipped, went to Panama, Sweden, Netherlands Antilles, Italy, Saudia Arabia, and Peru.

WORLD REVIEW

Australia.—Efforts to conserve thorium reserves caused the Australian Bureau of Mineral Resources to consider conservation of monazite contained in tailings of heavy mineral beach sand concentrates from plants on the east coast and in the Capel-Bunbury area of Western Australia.[12] Meanwhile, monazite was recovered as a byproduct from zircon-rutile beach sands in New South Wales. Products were usually made by gravity processes, followed by other separatory methods and digestion of monazite by concentrated sulfuric acid. Finally, the rare-earth hydroxides were calcined at 1,100° C. to produce mixed rare-earth oxides for use as polishing powder.

Brazil.—It was reported that approximately 1,150 short tons of monazite concentrate, containing about 60 percent rare-earth elements plus thorium, was produced in 1960.[13]

Canada.—Rio Tinto Dow continued its research on extracting rare-earth metals from waste liquors of Ontario uranium mines.[14]

Ceylon.—High-grade monazite concentrate production was 370 short tons in 1960.[15]

Congo, Republic of the.—No monazite was mined, and information on the production of bastnasite was not available.[16]

India.—Production figures for monazite were not available for 1960.[17]

Research and development of light metal alloys, based on domestic alloy elements including rare-earth metals, was conducted by the National Metallurgical laboratory.[18]

Indonesia.—To aid development of mineral resources, the Government divided minerals into three categories, the second of which—"vital minerals"—included those, such as monazite, which contain cerium. These minerals may be exploited only by state companies, provincial governments, or, in some cases, by private companies with headquarters in Indonesia and with an Indonesian board of directors.[19]

Korea, Republic of.—Approximately 13 short tons of monazite concentrate valued at US$3,000 to US$4,000 (2,500,000 hwan) was produced.[20]

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[12] Mining Journal (London), Feb. 3, 1961, p. 121.
[13] U.S. Embassy, Rio de Janeiro, Brazil, State Department Dispatch 953: April 26, 1961.
[14] Nucleonics, vol. 18, No. 10, October 1960, p. 129.
[15] U.S. Embassy, Colombo, Ceylon, State Department Dispatch 910: Apr. 20, 1961, p. 1.
[16] U.S. Embassy, Leopoldville, Republic of the Congo, State Department Dispatch 389: Mar. 29, 1961, p. 2.
[17] U.S. Embassy, New Delhi, India, State Department Dispatch 1121: Apr. 28, 1961, encl. 1, p. 3.
[18] U.S. Consulate General, Calcutta, India, State Department Dispatch 426: Feb. 16, 1961, p. 1.
[19] Mining Journal (London), vol. 255, No. 6538, Dec. 9, 1960, p. 655.
[20] U.S. Embassy, Seoul, Republic of Korea, State Department Dispatch 455: Apr. 4, 1961, encl. 1, p. 2.

Malagasy, Republic of.—A very small quantity of bastnasite was exported during the first quarter of 1960.[21] Monazite production reached about 460 short tons, but no other rare-earth bearing minerals such as bastnasite or euxenite were reported to have been produced.[22]

Malaya.—Monazite and zircon were recovered as byproducts from two large ilmenite properties in Trengganu, owned by a Japanese firm, Ishihara Industrial Co. of Osaka.

Rhodesia and Nyasaland, Federation of.—Preliminary results of a drilling program carried out by the Geological Survey in late 1959 and early 1960 on a monazite deposit in northwestern Zomba district did not appear promising.[23]

United Arab Republic (Egypt Region).—Details of the mining projects included under the Second Five Year Industrialization Plan were published early in 1960. Plans were made to recover monazite from black sands at Port Said during the next few years. The black sands, which Egyptian Black Sands Co. can process at the rate of 30,000 tons annually, contain 0.5 percent monazite. General Ilmenite Co. installed new equipment and expected to begin producing in 1961.[24]

TECHNOLOGY

The AEC reported on the various aspects of research concerning rare-earth metals. The toxicity of the cerium group of elements was shown in the formation of fatty liver. At the Ames Laboratory, single crystals of a number of rare-earth metals were grown and measurements were made of the magnetic and electrical properties of some of the metals. Rare-earth elements were recovered from reactor-fuel processing wastes at Oak Ridge by a continuous solvent extraction system, using di-2-ethylhexyl phosphoric acid as the extractant and nitric acid as the stripper. The Lawrence Radiation Laboratory used the atomic beam resonance technique to make electron structure measurements on the rare-earth element group. At Los Alamos Scientific Laboratory, it was found that all rare-earth elements have different electrolytic behaviors when a lithium amalgam cathode is used.[25]

Rare-earth element research in solution chemistry, ceramic systems, metals, alloys, and intermetallics was discussed in a seminar at the Arrowhead Conference Center of the University of California.[26]

At Pennsylvania State University, cooperative use and product research were continued on the rare-earth ore, bastnasite.[27]

Five reports summarized part of the research on rare-earth elements being continued by the Federal Bureau of Mines. Data on reduction and refining were presented; electronegativity values were revised; solvent extraction, ion exchange, and other methods used to extract

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[21] U.S. Consulate General, Johannesburg, Union of South Africa, State Department Dispatch 61: Aug. 31, 1960, p. 2.

[22] U.S. Embassy, Tananarive, Malagasy, State Department Dispatch 190: Apr. 17, 1961, pp. 1, 2.

[23] U.S. Consulate General, Johannesburg, Union of South Africa, State Department Dispatch 57: Aug. 29, 1960, p. 22.

[24] U.S. Embassy, Cairo, Egypt, State Department Dispatch 525: Jan. 11, 1961, encl. 1, pp. 1, 5.

[25] Atomic Energy Commission, Atomic Energy Research in the Life and Physical Sciences 1960: Spec. Rept., January 1961, pp. 31–32, 106, 115–116.

[26] Journal of Metals, vol. 12, No. 9, September 1960, p. 671.

[27] American Metal Market, vol. 67, No. 193, Oct. 6, 1960, p. 5.

rare-earth elements and compounds from rare-earth solutions and bastnasite were described; and the investigation of a binary rare-earth system by thermal analysis, resistivity, X-ray, and metallographic methods was outlined.[28]

Other extractive metallurgical methods devised by workers in industry and government were announced.[29]

A general survey on the spectrographic analysis of rare-earth elements was published.[30]

Extraction of most rare-earth elements with solution of 2-thenoyltrifluoroacetone in 4-methyl-2-pentanone enhanced emission spectra up to 100 times that attainable with aqueous solutions, thereby extending the limits of detection.[31]

New methods of overcoming spectroscopic problems of rare-earth metals and actinides included means of obtaining greater accuracy of frequency determination, new measurement techniques involving photomultipliers, and recording of spectral lines in the lower frequency end of the spectrum.[32]

Cerium of valence three and four was extracted differentially by di-2-ethylhexyl phosphoric acid.[33]

The overall picture of polymorphism in trivalent rare-earth oxides has changed only slightly since the original research done 35 years ago. Each oxide has only one true stable polymorth to which the low-temperature forms invert irreversibly at temperatures which are inversely proportional to the cation radii.[34]

X-ray diffraction studies of subsolids reactions occurring in 21 binary and 9 ternary systems of rare-earth oxides were conducted.[35]

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[28] Morrice, E., Darrah, J., Brown, E., Wyche, C., Headrick, W., Williams, R., and Knickerbocker, R. G., Metallurgical Laboratory Data on Reduction and Refining of Cerium Oxide and Cerous Fluoride to Cerium Ingot: Bureau of Mines Rept. of Investigations 5549, 1960, 36 pp.

Montgomery, R. L., Electronegativities of the Rare-Earth Elements: Bureau of Mines Rept. of Investigations 5567, 1960, 11 pp.

Bauer, D. J., Rice, A. C., and Berber, J. S., Liquid-Liquid Extraction of Rare-Earth Elements: Bureau of Mines Rept. of Investigations 5570, 1960, 10 pp.

Berber, J. S., Shaw, V. E., Rice, A. C., Lindstrom, R. E., and Bauer, D. J., Technology of Bastnasite: Bureau of Mines Rept. of Investigations 5599, 1960, 20 pp.

Croeni, J., Armantrout, C. E., and Kato, H., Zirconium-Dysprosium Equilibrium Diagram: Bureau of Mines Rept. of Investigations 5688, 1960, 12 pp.

[29] Peppard, Donald F., and Mason, George W. (assigned to the United States of America as represented by the Chairman of the Atomic Energy Commission), Separation of Rare Earths by Solvent Extraction: U.S. Patent 2,955,913, Mar. 27, 1953.

Ruhoff, John R., and Gerfen, Charles O. (assigned to Mallinckrodt Chemical Works, St. Louis, Mo.), Methods of Decomposing Complex Uranium-Rare Earth Tantalo-Columbates: U.S. Patent 2,956,857, Nov. 25, 1957.

Slatin, Harvey L. (assigned to Timax Corp., Wilmington, Del.), Electrolysis of Rare-Earth Elements and Yttrium: U.S. Patent 2,961,387, Sept. 18, 1957.

Spedding, Frank H., and Powell, Jack E. (assigned to the United States of America as represented by the Chairman of the Atomic Energy Commission), Method of Separating Rare Earths by Ion Exchange: U.S. Patent 2,956,858, Mar. 13, 1958.

[30] Fassel, Velmer A., Analytical Spectroscopy of the Rare-Earths: Anal. Chem., vol. 32, No. 11, October 1960, pp. 19A–44A.

[31] Rains, T. C., House, H. P., and Menis, Oscar, Flame Spectra of Sc, Y, and Rare-Earth Elements: Anal. Chim. Acta, vol. 22, No. 4, April 1960, pp. 315–327.

[32] Bovey, L., Some Techniques for the Examination of Complex Spectra: Research Applied in Industry (London), vol. 13, No. 9, September 1960, pp. 363–372.

[33] McCown, J. J., and Larsen, R. P., Radiochemical Determination of Cerium by Liquid-Liquid Extraction: Anal. Chem., vol. 32, No. 6, May 1960, pp. 597–599.

[34] Roth, R. S., and Schneider, S. J., Phase Equilibria in Systems Involving the Rare-Earth Oxides, Pt. I, Polymorphism of the Oxides of the Trivalent Rare-Earth Ions: Nat. Bureau of Standards Jour. Res., vol. 64A, No. 4, July–August 1960, pp. 309–316.

[35] Schneider, S. J., and Roth, R. S., Phase Equilibria in Systems Involving the Rare-Earth Oxides, Pt. II, Solid State Reactions in Trivalent Rare-Earth Oxide Systems: Nat. Bureau of Standards Jour. Res., vol. 64A, No. 4, July–August 1960, pp. 317–332.

The fused-disk technique was used with X-ray emission spectroscopy to determine major quantities of some lighter rare-earth elements for industrial control purposes.[36]

Solid-state reaction at elevated temperatures was used to prepare a series of rare-earth stannates isostructural with pyrochlore.[37]

Industry-supported research explored development of rare-earth compounds with high melting points and good thermal stabilities for semiconductor applications. The work dealt largely with specimen preparation and study of electrical properties of certain rare-earth selenides and tellurides.[38]

Investigations continued on the use of rare-earth oxides such as dysprosia and on dysprosia-based ceramics as nuclear control materials.[39] Cerium-oxygen compounds with very low thorium content were used as activators in lithium- or boron-containing scintillation glasses which had high neutron sensitivity. Samarium II ions in a calcium flouride crystal were excited by a xenon discharge lamp to generate the coherent and continuous light waves, known as lasers, in the visible and infrared spectrum. Lasers are highly directional beams for potential navigation of planes or space ships.[40]

Thulium foil was fabricated by procedures including hot rolling at 1,450° F. after forging of copper-jacketed wafers of thulium, hot rolling in air of unjacketed wafers 0.1 inch in thickness to 0.010 inch foil with subsequent removal of oxide film by sand blasting and pickling, and vacuum annealing and cold rolling of unjacketed wafers. The last procedure yields about 40 percent from a 1-inch diameter ingot.[41]

A new and improved method to prepare rare-earth metal master alloys directly from the rare-earth halide salt was discussed.[42]

Brass alloys with carefully controlled addition of cerium showed elongation greater than the unalloyed metal. Misch metal may be added instead of pure cerium.[43]

Russian technical journals published a large number of papers concerning the rare-earth elements. Small additions of lanthanum considerably increased the hardness of vanadium.[44]

The possibility of using organic acids as complexing agents for separation of heavy rare-earth elements was investigated. It was discovered that strong complexes were formed with the rare-earth elements by nitriloacetic, tartaric, citric, and lactic acids, and that the

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36 Maneval, David R., and Lovell, Harold L., Determination of Lanthanum, Cerium, Praseodymium, and Neodymium as Major Components by X-Ray Emission Spectroscopy: Anal. Chem., vol. 32, No. 10, September 1960, pp. 1289–1292.

37 Whinfrey, Charles G., Eckart, Donald W., and Tauber, Arthur, Preparation and X-Ray Diffraction Data for Some Rare Earth Stannates: Jour. Am. Chem. Soc., vol. 82, No. 11, June 5, 1960, pp. 2695–2697.

38 Electronic News, vol. 5, No. 189, Feb. 29, 1960, p. 24.

39 Battelle Memorial Institute, Reactor Core Materials, A Quarterly Technical Progress Review, prepared for the United States Atomic Energy Commission: Vol. 3, No. 4, November 1960, pp. 28–29.

40 Chemical and Engineering News, vol. 38, No. 52, Dec. 26, 1960, p. 39.

41 Klepfer, H. H., and Snyder, M. E., Fabrication of Thulium Foil: Trans. Met. Soc. of AIME, vol. 218, No. 4, August 1960, p. 765.

42 Morana, S. J., Preparation of Rare-Earth Master Alloys: 118th meet. Electrochem. Soc., Houston, Tex., 1960; abs., Jour. Electrochem. Soc., vol. 107, No. 8, August 1960, p. 193C.

43 American Metal Market, vol. 67, No. 210, Nov. 1, 1960, p. 5.

44 Savitskii, Ye. M., Baron, V. V., and Others [Phase Diagram of the V–La System]: Trudy Instituta Metallurgii Imeni A. A. Baikova, 1960, No. 5, pp. 166–173.

latter two were most effective in separating yttrium from the heavier rare-earth elements.[45]

Cerium 144 was shown to have a potential use as a radioisotopic fuel to produce heat or generate electricity in an atomic battery for satellite instruments.[46]

Other papers concerned ion exchange and other separatory techniques applied to rare-earth elements.[47]

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[45] Ryabchikov, D. I., and Vagina, N. S. [Evaluation of Various Complexing Agents in the Preparation of Enriched Concentrates of Rare Earths of the Yttrium Group]: Zhurnal Neorganicheskoi Khimii, vol. 5, February 1960, pp. 356–358; Nuclear Sci. Abs., vol. 14, No. 19, Oct. 15, 1960, p. 2418.

[46] Battelle Memorial Institute, Defense Metals Information Center Report 142: Columbus, Ohio, Dec. 28, 1960, OTS PB151101.

[47] Preobrazhenskii, B. K., Kalyamin, A. V., and Lilova, O. M. [The Problem of the Effect Exerted by the Size of the Molecules of Complex-Formers and the Temperature on the Ion-Exchange Separation of Radioactive Rare Earth Elements]: Radiokhimiia, vol. 2, No. 2, April 1960, pp. 239–242; Central Intelligence Agency Sci. Inf. Rept., Aug. 26, 1960, p. 21.

Valtsev, V. K., and Solovyev, L. K. [Distribution of Rare-Earth Elements in the Process of the Dissolution in Water of the Products of the Interaction of Their Oxides With Ammonium Iodide]: Isvestiia Sibirskogo Otdelenie Akademii Nauk SSSR, No. 4, April 1960, pp. 81–86; Central Intelligence Agency Sci. Inf. Rept., Aug. 26, 1960, p. 21.

Salt

By Robert T. MacMillan [1] and Victoria M. Roman [2]

SALT PRODUCTION in the United States in 1960 reached a new high. Although brine output was slightly below the 1959 level, gains in rock salt more than compensated for the loss.

DOMESTIC PRODUCTION

Louisiana and Texas were the leading salt-producing States in 1960, each with almost 19 percent of the output; Michigan and New York each produced about 16 percent; Ohio, 12 percent, and California and Kansas each 5 percent. The other salt-producing States accounted for the remaining 8 percent.

Salt was produced at 89 plants by 54 companies. Four companies operating 14 plants produced 47 percent of the total production, and 6 other companies with 24 plants produced 36 percent. The remaining plants supplied 17 percent of the output.

Over 1 million tons of salt was produced at each of 7 plants; 11 plants reported production ranging from 500,000 to 1 million tons, and 31 plants produced 100,000 to 500,000 tons each. Of the remaining plants, 17 reported production of less than 10,000 tons each.

A new salt-producing area came into production with the opening of a new evaporating plant near Williston, N. Dak. The plant was operated by Dakota Salt and Chemical Co., a subsidiary owned by General Carbon and Chemical Co. Highly pure salt was produced by brining methods from a 230-foot-thick bed 8,000 feet underground. The company planned to lease the cavities resulting from salt extraction to producers and distributors of LP gas for storage purposes.

International Salt Co. was reported to be closing its Ludlowville refinery near Ithaca, N.Y. The vacuum pans were to be moved to the Watkins Glen refinery in a move to improve operating efficiency.

CONSUMPTION AND USES

Over 9 million tons of salt, mostly as brine, was consumed in making chlorine and caustic soda; more salt was used for this purpose than for any other. Soda ash production, the next highest use, required 6.5 million tons, 500,000 tons less than in 1959. All chemicals, includ-

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.

ing chlorine and soda ash, consumed 67 percent of the salt output in 1960.

The third largest use of salt was for snow and ice removal on highways and for road stabilization. This use increased 17 percent in 1960. Articles were published dealing with the use of salt in highway ice control and road stabilization.[3]

TABLE 1.—Salient salt statistics

(Thousand short tons and thousand dollars)

	1951–55 (average)	1956	1957	1958	1959	1960
United States:						
Sold or used by producers	20,772	24,206	23,844	[1] 21,910	25,160	25,479
Value [2]	$89,483	[1]$136,138	[1]$148,886	$141,486	$155,839	$161,140
Imports for consumption	99	368	651	611	1,025	1,057
Value	$521	$2,354	$3,523	$3,368	$5,438	$4,484
Exports	366	336	391	363	424	422
Value	$3,079	$2,464	$2,591	$2,273	$2,660	$2,548
Consumption, apparent	20,505	24,238	24,104	[1] 22,158	25,761	26,114
World: Production	66,000	[1] 75,200	[1] 79,400	[1] 82,600	[1] 88,200	94,200

[1] Revised figure.
[2] Values are f.o.b. mine or refinery and do not include cost of cooperage or containers.

TABLE 2.—Salt sold or used by producers in the United States [1]

(Thousand short tons and thousand dollars)

State	1959 [1]		1960	
	Quantity	Value	Quantity	Value
California	1,388	(2)	1,443	(2)
Kansas	1,123	$13,670	1,213	$14,109
Louisiana	4,807	20,918	4,792	21,959
Michigan	4,485	35,725	4,088	33,759
New Mexico	36	322	39	331
New York	4,011	30,958	4,008	30,763
Ohio	2,858	20,486	3,108	24,149
Oklahoma	(2)	(2)	3	16
Texas	4,519	17,498	4,756	18,222
Utah	209	2,453	231	3,092
West Virginia	811	3,305	920	3,673
Other States [3]	916	10,542	878	11,067
Total	25,163	155,877	25,479	161,140

[1] Includes Puerto Rico as follows: 1959: 3,000 tons, $38,000.
[2] Included with "Other States" to avoid disclosing individual company confidential data.
[3] Includes States indicated by footnote 2, and Alabama, Colorado, Nevada, North Dakota (1960 only), and Virginia.

TABLE 3.—Salt sold or used by producers in the United States,[1] by methods of recovery

(Thousand short tons and thousand dollars)

Method of recovery	1959		1960	
	Quantity	Value	Quantity	Value
Evaporated:				
Bulk:				
Open pans or grainers	326	$9,476	317	$8,578
Vacuum pans	2,088	44,612	2,109	45,510
Solar	1,278	7,112	1,346	8,055
Pressed blocks	288	6,763	330	7,575
Total	3,980	67,963	4,102	69,718

[3] Roads and Streets, Ohio Salt Stabilizes 130 Miles: Vol. 103, No. 4, April 1960, pp. 101, 105.
Roads and Streets, Chemical Mixtures Aid Safe Winter Driving: Vol. 103, No. 10, October 1960, p. 46.

TABLE 3.—Salt sold or used by producers in the United States[1] by methods of recovery—Continued

Method of Recovery	1959		1960	
	Quantity	Value	Quantity	Value
Rock:				
Bulk	6,105	$39,713	6,406	$43,457
Pressed blocks	55	1,406	60	1,526
Total	6,160	41,119	6,466	44,983
Salt in brine (sold or used as such)	15,023	46,795	14,911	46,439
Grand total	25,163	155,877	25,479	161,140

[1] Includes Puerto Rico as follows: 1959: 3,000 tons, $38,000.

TABLE 4.—Evaporated salt sold or used by producers in the United States[1]

(Thousand short tons and thousand dollars)

State	1959		1960	
	Quantity	Value	Quantity	Value
Kansas	389	$9,035	401	$9,358
Louisiana	168	4,279	191	4,737
Michigan	872	18,598	830	17,085
Oklahoma	(2)	(2)	1	14
Texas	105	2,945	103	2,987
Other States[3]	2,446	33,106	2,576	35,537
Total[1]	3,980	67,963	4,102	69,718

[1] Includes Puerto Rico as follows: 1959: 3,000 tons, $38,000.
[2] Included with "Other States" to avoid disclosing individual company confidential data.
[3] Includes States indicated by footnote 2, and California, Nevada, New Mexico, New York, North Dakota (1960 only), Ohio, Utah (1960 only), and West Virginia.

TABLE 5.—Rock salt sold by producers in the United States

(Thousand short tons and thousand dollars)

Year	Quantity	Value	Year	Quantity	Value
1951–55 (average)	4,765	$26,358	1958	5,407	$37,125
1956	5,623	[1] 36,039	1959	6,160	41,119
1957	5,341	36,389	1960	6,466	44,983

[1] Revised figure.

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
1951–55 (average)	285	$4,480	64	$906	349	$5,386
1956	269	4,968	52	994	321	5,962
1957	289	6,064	55	1,327	344	7,391
1958	280	6,413	53	1,372	333	7,785
1959	288	6,763	55	1,406	343	8,169
1960	330	7,575	60	1,526	390	9,101

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TABLE 7.—Salt sold or used by producers in the United States, by classes and consumers or uses

(Thousand short tons)

Consumer or use	1959				1960			
	Evaporated	Rock	Brine	Total	Evaporated	Rock	Brine	Total
Chlorine	469	1,266	7,259	8,994	(1)	(1)	7,546	9,146
Soda Ash	-------	19	7,046	7,065	-------	(1)	(1)	6,534
Textile and dyeing	78	141	-------	219	70	125	-------	195
Soap (including detergents)	31	6	-------	37	30	6	-------	36
All other chemicals	173	563	578	1,314	191	481	636	1,308
Meatpackers, tanners, and casing manufacturers	352	448	-------	800	351	421	-------	772
Fishing	25	8	-------	33	22	7	-------	29
Dairy	56	4	-------	60	57	3	-------	60
Canning	169	40	-------	209	175	44	-------	219
Baking	118	6	-------	124	116	7	-------	123
Flour processors (including cereal)	54	5	-------	59	56	7	-------	63
Other food processing	75	10	-------	85	75	8	-------	83
Ice manufacturers and cold-storage companies	27	33	-------	60	25	31	-------	56
Feed dealers	567	335	-------	902	579	367	-------	946
Feed mixers	203	86	-------	289	203	91	-------	294
Metals	42	111	-------	153	41	73	-------	114
Ceramics (including glass)	3	11	-------	14	3	9	-------	12
Rubber	(1)	(1)	(1)	116	(1)	(1)	(1)	130
Oil	34	66	13	113	37	66	43	146
Paper and pulp	(1)	101	(1)	142	9	91	37	137
Water-softener manufacturers and service companies	156	193	3	352	172	209	15	396
Grocery stores	567	181	-------	748	588	207	-------	795
Railroads	12	50	-------	62	12	41	-------	53
Bus and transit companies	1	36	-------	37	(1)	(1)	-------	34
States, counties, and other political subdivisions (except Federal)	(1)	(1)	-------	2,022	144	2,220	-------	2,364
U.S. Government	17	19	-------	36	16	21	-------	37
Miscellaneous	643	455	20	1,118	843	538	16	1,397
Undistributed [2]	108	1,967	104	-------	287	1,393	6,618	-------
Total	3,980	6,160	15,023	25,163	4,102	6,466	14,911	25,479

[1] Included with "Undistributed" to avoid disclosing individual company confidential data.
[2] Includes some exports and consumption in Territories, oversea areas administered by the United States and Puerto Rico.

PRICES

Prices quoted for salt by Oil, Paint and Drug Reporter remained at the 1959 level. Quoted prices and value data were as follows:

Rock salt, paper bags, carlots, f.o.b. New York	per 100 pounds	$1.09
Salt, vacuum, common fine, carlots, f.o.b. New York	do	1.34
Dry salt, average value	per ton	10.85
Salt in brine, average value	per ton contained salt	3.11

FOREIGN TRADE [4]

Imports.—Dry salt imports for consumption were 3 percent above the million-ton level established in 1959. Canada continued to supply the greatest tonnage (43 percent in 1960), but provided substantially less than in 1959. Imports from Mexico were 2½ times the 1959 figure and represented 31 percent of the total. The Bahamas supplied 18 percent of the imports, and the remaining 8 percent came from other Caribbean Islands, Italy, and West Germany.

[4] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 8.—Distribution (shipments) of evaporated and rock salt produced in the United States,[1] by destination

(Thousand short tons)

Destination	1959		1960	
	Evaporated	Rock	Evaporated	Rock
Alabama	23	236	30	229
Alaska	1	----------	3	----------
Arizona	13	13	16	2
Arkansas	11	44	12	57
California	630	76	675	67
Colorado	55	25	77	27
Connecticut	13	51	13	57
Delaware	7	6	7	6
District of Columbia	6	3	6	5
Florida	19	69	20	64
Georgia	39	72	44	73
Hawaii	17	----------	4	----------
Idaho	17	3	26	3
Illinois	244	383	209	475
Indiana	130	153	130	191
Iowa	129	142	126	147
Kansas	56	184	61	190
Kentucky	39	150	36	176
Louisiana	26	176	31	143
Maine	10	146	10	141
Maryland	41	89	44	114
Massachusetts	46	128	43	189
Michigan	145	365	176	309
Minnesota	130	87	121	96
Mississippi	16	63	21	68
Missouri	71	121	73	183
Montana	21	2	25	2
Nebraska	63	71	67	79
Nevada	6	149	10	163
New Hampshire	5	164	5	140
New Jersey	124	211	122	258
New Mexico	15	37	14	61
New York	199	1,106	213	1,131
North Carolina	80	114	80	115
North Dakota	16	5	21	4
Ohio	239	419	236	506
Oklahoma	26	41	27	42
Oregon	89	(2)	25	----------
Pennsylvania	151	190	155	253
Rhode Island	10	15	10	18
South Carolina	19	27	22	20
South Dakota	27	15	27	16
Tennessee	70	85	84	91
Texas	80	208	83	215
Utah	46	(2)	59	(2)
Vermont	6	61	6	57
Virginia	69	58	68	82
Washington	295	----------	129	----------
West Virginia	22	58	25	37
Wisconsin	137	134	133	139
Wyoming	14	1	15	1
Other [3]	217	204	427	24
Total	3,980	6,160	4,102	6,466

1 Production from Puerto Rico included (1959 only).
2 Included with "Other" to avoid disclosing individual company confidential data.
3 Includes shipments to Territories, oversea areas administered by the United States, exports, and some shipments to unspecified destinations.

Imports of salt in brine were reported from Canada, but separate tonnage and value figures were not available, as salt in brine was listed as an unenumerated article by the Tariff Act of 1930.

Exports.—Exports of salt in 1960 were slightly less than in 1959. Shipments to Canada were one-fifth as large as in 1959; however, those to Japan more than doubled.

Total imports were approximately 4 percent of U.S. production, and exports were less than 2 percent.

Tariff.—The duty on bulk salt imported into the United States, unchanged since June 30, 1958, was $0.017 per hundred pounds. Duty on packaged salt was unchanged at $0.035 per hundred pounds. Duty on salt in brine, an unenumerated article in paragraph 1558 of the Tariff Act of 1930, was 10 percent ad valorem.

TABLE 9.—Salt shipped to the Commonwealth of Puerto Rico and oversea areas administered by the United States

Territory	1959		1960	
	Short tons	Value	Short tons	Value
American Samoa	142	$4,675	144	$4,915
Guam	123	10,805	55	6,398
Puerto Rico	13,289	1,005,011	14,029	1,020,453
Virgin Islands	98	10,387	83	10,270

Source: Bureau of the Census.

TABLE 10.—U.S. imports for consumption of salt, by countries

Country	1959		1960	
	Short tons	Value	Short tons	Value
North America:				
Bahamas	178,800	$659,503	194,520	$759,526
Canada	624,452	4,221,170	451,315	2,998,321
Dominican Republic	55,560	212,237	63,743	259,731
Jamaica	2,627	7,710	16,194	44,027
Leeward and Windward Islands	20,633	67,505	5,152	13,800
Mexico	128,382	160,934	326,097	404,732
Trinidad and Tobago	4,363	16,141		
Total	1,014,817	5,345,200	1,057,021	4,480,137
Europe:				
Germany, West			2	1,866
Italy	9,812	91,991	5	1,443
United Kingdom			(1)	268
Total	9,812	91,991	7	3,577
Asia: Japan	(1)	450		
Grand total	1,024,629	5,437,641	1,057,028	4,483,714

[1] Less than 1 ton.

Source: Bureau of the Census.

TABLE 11.—U.S. imports for consumption of salt, by classes

Year	In bags, sacks, barrels, or other packages (dutiable)		Bulk (dutiable)	
	Short tons	Value	Short tons	Value
1951–55 (average)	3,417	[1] $44,658	95,606	[1] $476,144
1956	25,255	[1] 360,864	342,957	1,992,864
1957	34,501	[1] 426,596	616,344	3,096,098
1958	43,864	558,902	567,179	2,809,557
1959	37,726	531,151	986,903	4,906,490
1960	17,693	267,634	1,039,335	4,216,080

[1] Data known to be not comparable with other years.

Source: Bureau of the Census.

TABLE 12.—U.S. imports for consumption of salt, by customs districts

Customs district	1959		1960	
	Short tons	Value	Short tons	Value
Buffalo	20,497	$209,233	35,520	$235,801
Chicago	140,641	894,351	47,733	300,955
Duluth and Superior	43,673	300,362	42,025	268,505
Florida	250	1,344		
Georgia	125,586	464,690	129,414	501,430
Hawaii	(1)	450		
Maine and New Hampshire	744	18,848	1,200	29,030
Massachusetts	40,004	144,270	29,821	97,499
Michigan	319,434	2,138,123	284,611	1,843,322
New York	52,740	249,970	63,793	260,971
Ohio	62,139	414,968	8,037	50,690
Oregon	46,415	58,117	77,442	96,806
Philadelphia			2	1,866
Puerto Rico			8,711	43,556
Rochester			418	2,872
St. Lawrence	201	2,000		
San Diego			25	299
San Francisco	80	896		
Vermont	3,187	25,958	606	4,323
Virginia	53,214	194,813	47,925	176,311
Washington	81,967	102,817	248,653	308,286
Wisconsin	33,857	216,431	31,092	261,192
Total	1,024,629	5,437,641	1,057,028	4,483,714

[1] Less than 1 ton.

Source: Bureau of the Census.

WORLD REVIEW

Australia.—Queensland Salt Industries, Ltd., opened a new salt works and refinery in central Queensland. The plant, including salt pans used to evaporate underground brines, occupied 460 acres.[5]

Canada.—Canadian rock salt production increased 11 percent in 1960, whereas brine salt output decreaesd 2 percent.[6] Production statistics for the various types of salt were:

Type of salt		*1959*	*1960*
Fine vacuum salt	thousand short tons	453	432
Mine rock salt	do	1,190	1,321
Salt recovered in chemical operations	do	16	15
Salt content of brines	do	1,575	1,543
Total	do	3,234	3,311

China.—China ranked second in world salt output in 1960. Most of the salt was used for food; however, a growing chemical industry required sizable quantities for soda ash and caustic soda production. The salt was produced chiefly in the coastal provinces by the evaporation of sea water, but inland sources of salt were also available, including salt lakes and wells in the Tzu-liu-ching area of Szechwan.[7]

India.—Formerly an importer of salt, India had increased production so that over 300,000 tons was exported in 1959, chiefly to Japan.

[5] Chemical Trade Journal and Chemical Engineer (London), Salt Production in Australia: Vol 147, No. 3826, Sept. 30, 1960, p. 742.

[6] Dominion Bureau of Statistics, Ottawa, Canada, vol. 16, No. 1, January 1961, 1 p. Collings, R. K., Salt: Dept. of Mines and Tech. Surveys, Ottawa, Canada, 1961, 7 pp.

[7] Mining Engineering, Major Sectors of China's Mineral Industry: Vol. 12, No. 8, August 1960, p. 911.

TABLE 13.—U.S. exports of salt, by countries

Destination	1959		1960	
	Short tons	Value	Short tons	Value
North America:				
Bermuda			20	$2,392
Canada	232,286	$1,366,511	51,480	567,122
Central America:				
British Honduras	127	4,005	10	320
Canal Zone			108	1,844
Costa Rica	295	12,696	266	8,493
El Salvador			46	3,215
Guatemala	56	2,518	208	11,412
Honduras	202	6,221	249	10,612
Nicaragua	350	8,990	489	12,824
Panama	150	2,100	54	3,336
Mexico	4,156	152,460	4,678	173,130
West Indies:				
Bahamas	20	3,040	114	13,144
Cuba	7,455	209,515	1,979	53,652
Dominican Republic	102	5,676	64	4,616
Haiti	15	1,400	52	3,814
Netherlands Antilles	309	23,207	373	26,570
Other West Indies	14	1,201	64	5,731
Total	245,537	1,799,540	60,254	902,227
South America:				
Ecuador	155	4,235	251	6,134
Venezuela	1	120	369	12,240
Other South America	24	3,265	69	7,674
Total	180	7,620	689	26,048
Europe:				
United Kingdom	65	514	213	12,623
Other Europe	25	8,756	30	19,698
Total	90	9,270	243	32,321
Asia:				
Japan	177,641	755,274	359,919	1,525,814
Korea, Republic of	17	1,566	7	284
Lebanon	60	9,062	27	3,482
Philippines	330	19,023	112	10,080
Saudi Arabia	227	32,924	165	16,447
Other Asia	60	5,327	48	5,771
Total	178,335	823,176	360,278	1,561,878
Africa	13	620	130	8,883
Oceania	193	19,990	170	16,443
Grand total	424,348	2,660,216	421,764	2,547,800

Source: Bureau of Census.

The salt industry of Aden, which formerly supplied large quantities of salt to Japan, was said to be declining.[8]

United Kingdom.—Large, new discoveries of salt were reported in the Cheshire Basin near Whitchurch by the Geological Survey of Great Britain. Borings to a depth of 5,500 feet revealed two saliferous beds of rock salt and subordinate marl. The upper bed, 1,327 feet thick, was entered at 1,141 feet and the lower, 625 feet thick, was encountered at 3,541 feet. Brines pumped from these beds supplied the salt industry of Cheshire. Salt resources of approximately 400 billion tons was estimated for the area.[9]

[8] Bureau of Mines, Mineral Trade Notes: Vol. 51, No. 5, November 1960, pp. 51–52.
[9] Chemical Trade Journal and Chemical Engineer (London), New Discoveries of Rock Salt: Vol. 147, No. 3817, July 29, 1960, p. 225.

TABLE 14.—World production of salt by countries [1] [2]

(Thousand short tons)

Country [1]	1951–55 (average)	1956	1957	1958	1959	1960
North America:						
Canada	1,023	1,599	1,772	2,361	3,317	3,311
Costa Rica	4	[3] 6	49	[3] 33	14	[3] 14
Guatemala	14	15	18	18	22	237
Honduras	[3] 9	15	13	[3] 11	[3] 11	[3] 11
Mexico	216	243	333	400	573	[3] 573
Nicaragua	14	11	10	11	12	12
Panama	8	9	9	7	9	8
Salvador	37	55	55	[3] 55	[3] 55	[3] 55
United States (including Puerto Rico):						
Rock salt	4,761	5,623	5,342	5,407	6,160	6,466
Other salt	16,022	18,593	18,512	16,504	19,003	19,013
West Indies:						
British:						
Bahamas	104	154	192	112	233	231
Leeward Islands (exports)	6	1	1	[3] 1	----------	----------
Turks and Caicos Islands	14	15	18	22	23	28
Cuba	62	71	75	75	[3] 66	[3] 66
Dominican Republic:						
Rock salt	15	36	47	49	71	[3] 71
Other salt	15	1	18	18	22	[3] 22
Haiti	32	50	[3] 11	[3] 11	11	[3] 11
Netherlands Antilles	[3] 3	1	1	[3] 1	[3] 1	----------
Total	22,359	26,498	26,476	25,096	29,603	30,129
South America:						
Argentina:						
Rock salt	2	3	2	(4)	(4)	(4)
Other salt	480	413	359	622	639	[3] 639
Brazil	891	880	880	1,053	941	[3] 937
Chile	52	[3] 55	37	[3] 44	[3] 44	[3] 44
Colombia:						
Rock salt	170	214	228	243	235	259
Other salt	44	41	106	78	63	75
Ecuador	37	29	26	21	24	31
Peru	88	112	126	116	116	117
Venezuela	83	42	95	97	86	[3] 55
Total [1] [3]	1,865	1,810	1,880	2,290	2,165	2,175
Europe:						
Austria:						
Rock salt	1	1	1	1	1	2
Other salt	394	481	568	567	443	530
Bulgaria	80	64	82	123	98	98
Czechoslovakia	174	17	177	179	177	[3] 177
France:						
Rock salt and salt from springs	2,696	3,139	3,265	3,059	3,061	[3] 3,086
Other salt	643	625	639	908	842	[3] 970
Germany:						
East	[3] 1,653	1,863	1,935	1,960	[3] 1,984	[3] 1,984
West (marketable):						
Rock salt	2,982	3,591	3,598	3,556	3,659	4,001
Brine salt	334	356	357	370	363	374
Greece	90	103	99	106	108	[3] 105
Italy:						
Rock salt and brine salt	1,057	1,112	1,190	1,135	1,373	1,721
Other salt	922	946	817	840	1,014	[3] 1,102
Malta	3	2	1	2	2	1
Netherlands	541	690	791	876	1,087	1,208
Poland:						
Rock salt	1,017 (rock and other salt combined)	435	417	432	560	574
Other salt		963	1,017	1,344	1,455	1,571
Portugal	[5] 211	149	345	343	236	[3] 236
Rumania	540	929	934	807	926	[3] 926
Spain:						
Rock salt	431	535	565	617	616	593
Other salt	930	714	926	983	873	[3] 772
Switzerland	129	131	144	138	151	164
U.S.S.R. [3]	6,800	7,200	7,200	7,200	7,200	8,300
United Kingdom:						
Great Britain:						
Rock salt	57	111	99	130	160	168
Other salt	4,859	5,472	5,484	5,397	5,956	6,286
Northern Ireland	13	10	8	7	----------	----------
Yugoslavia	141	160	163	190	150	[3] 186
Total [1] [3]	27,100	30,200	31,200	31,600	32,900	35,500

See footnotes on p. 945.

TABLE 14.—World production of salt by countries [1] [2]—Continued

(Thousand short tons)

Country [1]	1951–55 (average)	1956	1957	1958	1959	1960
Asia:						
Aden	314	278	222	164	196	[3] 127
Afghanistan	28	25	[6] 63	[3] 66	[6] 43	[3] [6] 44
Burma	86	96	128	123	123	163
Cambodia	53	26	33	33	[3] 33	[3] 33
Ceylon	52	119	89	20	34	60
China [3]	5,765	7,280	8,820	11,500	12,600	15,400
Cyprus	4	6	7	6	6	[3] 6
India:						
Rock salt	6	4	4	6	4	4
Other salt	3,204	3,551	4,041	4,659	3,499	3,782
Indonesia	276	120	383	303	347	218
Iran [7]	255	309	331	82	88	[3] 88
Iraq [7]	24	21	22	[3] 20	29	[3] 26
Israel	41	29	35	37	37	41
Japan	510	693	917	1,166	1,285	977
Jordan	8	12	11	12	18	13
Korea, Republic of	224	217	407	481	430	430
Lebanon [3]	12	17	13	13	14	14
Pakistan:						
Rock salt	157	181	174	198	176	203
Other salt	239	254	333	197	141	272
Philippines	54	71	122	154	193	105
Portuguese India	20	7	11	6	3	9
Ryukyu Islands	3	6	3	4	4	1
Taiwan	358	363	427	489	474	486
Thailand	[3] 298	273	290	471	386	369
Turkey:						
Rock salt	30	33	10	40	39	34
Other salt	388	386	494	498	503	456
United Arab Republic (Syria Region)	14	36	37	[3] 44	[3] 22	6
Viet-Nam, South	114	66	88	68	[3] 66	[3] 96
Yemen	[3] 121	28	[3] 121	----------	121	121
Total [3]	12,660	14,500	17,640	21,340	21,400	24,100
Africa:						
Algeria	97	117	132	150	147	[3] 147
Angola	62	89	57	76	76	64
Canary Islands	19	20	17	17	14	[3] 13
Cape Verde Islands	21	24	22	17	22	26
Chad, Republic of	6	[3] 6	[3] 6	[3] 6	2	[3] 2
Congo, Republic of the (formerly Belgian Congo)	1	1	(4)	(4)	1	1
Eritrea	197	146	181	166	138	[3] 138
Ethiopia: Rock salt	15	[3] 13	[3] 13	[3] 17	[3] 17	21
French Somaliland	56	8	2	----------	----------	----------
Ghana [3]	24	24	24	24	24	24
Kenya	22	24	25	21	22	24
Libya	15	19	19	14	17	[3] 22
Mauritius	3	4	4	4	4	4
Morocco	51	56	72	67	37	33
Mozambique	13	13	20	24	21	[3] 22
Senegal, Republic of (including Mauritania)	64	[3] 72	[3] 72	78	78	55
Somali Republic [3]	4	6	4	3	3	8
South-West Africa:						
Rock salt	7	6	7	7	6	4
Other salt	45	83	66	89	50	76
Sudan	57	60	60	60	[3] 55	60
Tanganyika	22	31	29	40	41	39
Tunisia	159	149	165	187	94	[3] 94
Uganda	8	10	11	11	10	6
Union of South Africa	158	190	161	241	261	279
United Arab Republic (Egypt Region)	532	584	569	444	422	575
Total [1] [3]	1,659	1,756	1,739	1,764	1,563	1,738
Oceania:						
Australia	366	457	478	481	509	[3] 507
New Zealand	1	13	9	23	[3] 23	[3] 23
Total	367	470	487	504	532	[3] 530
World total (estimate) [1] [2]	66,000	75,200	79,400	82,600	88,200	94,200

See footnotes on p. 945.

Improvements at the Winsford Rock Salt mine, including a primary crushing plant underground, new skips, and diesel trucks for underground haulage, resulted in tripling the output of an estimated 300,000 tons per year in 1960. Increased demand for salt for clearing roads of ice and snow was chiefly responsible for the production rise.[10]

TECHNOLOGY

Brittleness of sodium chloride crystals was found to be related to microcracks on the surfaces of the crystals. Immersion of carefully cleaved crystals in water followed by drying in alcohol and ether produced crystals relatively free of surface cracks. It was possible to bend these crystals through angles greater than 120° without breaking them. Disposition of various crystalline substances, including sodium chloride, on crystal surfaces of rock salt adversely affected ductility of polished crystals of rock salt. Crystals stored under dry atmospheres retained their ductility. Elimination of surface flaws in other ionic solids did not necessarily improve ductility but always changed the fracture origin.[11]

A new process for producing highly pure evaporated salt at the International Salt Co., Avery Island, La., plant was described.[12] Employing a double-effect evaporator, salt assaying 99.99 percent NaCl was produced at a rate of 15 tons per hour. The process was designed to utilize low-grade rock salt, such as tailings, from screening steps; it was not applicable where brine is the only raw material. Thus, chemical treatment of brine, the use of tubular heaters, and the maintenance and scaling problems associated with them were eliminated. By taking advantage of the inverse temperature solubility curve of gypsum ($CaSO_4$) this troublesome impurity was controlled, not by chemical precipitation as in the older plants, but by selecting a temperature (220° F.) for dissolving the salt at which gypsum remained undissolved and was removed with other insolubles by settling and filtration. The salt was crystallized by flash-cooling the clarified solution to 180° F. Steam consumption was said to be comparable to quadruple-effect, forced-circulation, or calandria-type evaporators.

Articles were published describing the development of a thermoadhesive method for dry separation of minerals and the application of the process to beneficiating rock salt at the International Salt Co.,

[10] Chemical Age (London), Winsford Extensions Treble Capacity for Rock Salt: Vol. 84, No. 2159, Nov. 26, 1960, p. 92.
[11] Stokes, R. J., Johnston, T. L., and Li, C. H., Environmental Effects on the Mechanical Properties of Ionic Solids with Particular Reference to the Joffe Effect; Trans. Met. Soc. AIME, vol. 218, August 1960, pp. 655–662.
[12] Chemical Engineering, New Process Automates Salt Refining: Vol. 67, No. 22, Oct. 31, 1960, pp. 49–50.

[1] Salt is produced in Albania, Bolivia, Hungary, Malagasy, Nigeria, and North Korea, but figures of production are not available. Estimates for these countries are included in total.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Less than 500 tons.
[5] Average for 1952–55.
[6] Year ended March 20 of year following that stated.
[7] Year ended March 31 of year following that stated.
[8] Exports.
[9] Average for 1953–55.

Compiled by Helen L. Hunt, Division of Foreign Activities.

Detroit, Mich., mine.[13] The process has two main steps: Selective heating of the crude minerals by radiation and separation of the heated minerals on a heat-sensitive surface. For optimum separation of minerals, the radiant-heat source is selected to emit radiation corresponding to the wavelengths most effectively absorbed by the impurities but not by the minerals being upgraded. In beneficiating rock salt, tungsten filament lamps emitting radiation wavelengths shorter than 3 microns were found to be most satisfactory. Although pure halite crystals are transparent to radiation wavelengths between .3 and 13 microns, water films which absorb radiation in the 3 to 6 micron range were often present in the crude salt, making it necessary to use wavelengths below 3 microns in order not to heat the salt.

A wide range of thermoadhesive plastics was available for separating differentially heated minerals. The Detroit rock-salt beneficiating plant used a neoprene endless belt on which a heated styrene resin was continuously sprayed. The crude salt, after passing beneath a battery of heating lamps, was spread uniformly on the freshly prepared surface of the belt. As the belt passed over the pulley, the hotter particles (impurities) in the salt were flung off with less momentum and were collected as tailings. The temperature difference between rejection of a particle and nonrejection was about 20° F. Results of tests on No. 1 rock salt (particle size range .279 to .375 inch) indicated that it was possible to upgrade crude salt to 98 percent NaCl with 96 percent recovery of the salt or to 99 percent NaCl with 86 percent recovery.

Several patents were issued relating to compounds and procedures for reducing the caking tendency of salt to make it free flowing. Water-dispersible alkali-metal ferrocyanide was the reagent in two instances,[14] and a water-insoluble calcium polyphosphate was used in another.[15]

Corrosion of several types of stainless steel by salt and dry air between 200° and 1,600° F. was reported. Between 1,100° and 1,600° F., the attack was intergranular for austenitic steels. Reaction of sodium chloride with chromium carbide was postulated as the chief mechanism through which the rapid intergranular corrosion occurred.[16]

Mathematical problems in designing a continuous compacting machine for agglomerating fine granular solids, such as rock salt fines, were discussed in a journal article.[17] The fine salt was fed between rotating rolls and emerged as a continuous ribbon of salt which was broken into granules of the desired size. Void content of the product, flow properties, moisture content, temperature, and feed rate were related to the roll diameter, width between rolls, loading, and roll speed.

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[13] Brison, R. J., and Tangel, O. F., Development of a Thermoadhesive Method for Dry Separation of Minerals: Min. Eng., vol. 12, No. 8, August 1960, pp. 913–917.
Bleimeister, W.C., and Brison, R. J., Beneficiation of Rock Salt at the Detroit Mine: Min. Eng., vol. 12, No. 8, Aug. 1960, pp. 918–921.

[14] Miller, H. C. (assigned to Morton Salt Co.), Noncaking Rock Salt Composition: U.S. Patent 2,947,603, Aug. 2, 1960.
Diamond, H. W. (assigned to Morton Salt Co.), Noncaking Rock Salt Composition: U.S. Patent 2,965,444, Dec. 20, 1960.

[15] Bell, R. N., and Netherton, L. E. (assigned to Victor Chemical Works), Conditioned Sodium Chloride: U.S. Patent 2,922,697, Jan. 26, 1960.

[16] Metal Progress, Salt Corrodes 18–8 Stainless Steels: Vol. 78, No. 4, October 1960, pp. 200–204.

[17] Kurtz, B. E., and Bardiuhn, A. J., Compacting Granular Solids: Chem. Eng. Prog., vol. 56, No. 1, January 1960, pp. 67–72.

Bench mining of rock salt in a massive Louisiana salt dome successfully overcame problems of the conventional face drilling system. Cost reductions of 50 percent for labor and 40 percent for dynamite and blasting caps also were claimed for the benching method. A 50-foot-wide bench was prepared by drilling a row of seven vertical holes 8½ feet back from the face of the bench. The holes were drilled to a 34-foot depth, allowing 4 feet to collect cuttings not cleaned from the hole. After undercutting through the holes with a shortwall cutter having a 9-foot bar, the holes were charged with a 60-percent-strength semigelatin explosive. A typical blast, requiring 186 pounds of explosive, broke about 900 tons of salt ready for loading.[18]

The addition of 10 to 20 percent salt to permissible explosives had a pronounced effect in reducing the probability of igniting fire damp in gallery tests in coal mines. Fine granulation of the salt was more effective than coarse.[19]

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[18] West, W., Bench Mining Salt on the Gulf Coast: Min. Cong. Jour., vol. 46, No. 3, March 1960, pp. 69–70.

[19] Hana, N. E., Damon, G. H., and Van Dolah, R. W., Reducing the incendivity of Permissible Explosives by Sodium Chloride: Bureau of Mines Rept. of Investigations 5683, 1960, 19 pp.

Sand and Gravel

By Perry G. Cotter[1] and Jewel B. Mallory[2]

PRODUCTION of sand and gravel for construction in the United States declined 3 percent in 1960, reflecting the decline of $1 billion in total expenditures for private building. Concrete pavement awards increased 19 percent; the effect of this step-up in proposed construction should be evident in production of sand and gravel in 1961.

Output of industrial sands decreased 5 percent in 1960, although the total value increased slightly.

Starts for new housing units declined nearly 20 percent from 1959, mainly because of a slowdown in the Capehart (military) housing program.

Shortages of easily available supplies of sand and gravel in several States, particularly around areas of rapid urbanization, created the necessity for reevaluating zoning restrictions and the need for investigating new sources of supply, reexamining specifications, and improving mining methods.

LEGISLATION AND GOVERNMENT PROGRAMS

Under a new natural resources zoning classification authorized by the San Diego (Calif.) County Board of Supervisors, mining sand and gravel may take precedence over real estate development in certain designated areas. Purchasers of property in these areas will be informed that sand and gravel operations may be their neighbors. This action was taken as one method to relieve pressure for new sources of construction materials.[3]

The possibility of sand and gravel operators being involved in legislation as a result of "nonconforming use" under zoning regulations was discussed in an article. Case histories of three such controversies were listed.[4] A decision by the Illinois Supreme Court allowed the Elmhurst-Chicago Stone Co. to operate a quarry within 200 feet of residential property lines. The ruling was based upon evidence that the property had been owned and operated by the company before the effective date of a local zoning ordinance and that continuing operation of the quarry was a legal nonconforming use.[5]

Bond approvals for public construction, based upon November 1960 elections, were expected to reach a new peak of $5.5 billion, almost double the $2.8 billion voted in 1959. This should be a factor in producing sand and gravel in 1961.[6]

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[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.
[3] Rock Products, "Natural Resources," Zoning Plan Set Up in San Diego: Vol. 63, No. 2, February 1960, p. 75.
[4] Gray, Albert W., Watch Your Nonconforming Use: Rock Products, vol. 63, No. 7, July 1960, pp. 100, 102, 106.
[5] Rock Products, Industry News: Vol. 63, No. 5, May 1960, p. 63.
[6] Construction Review, Construction Comments: Vol. 6, No. 12, December 1960, p. 4.

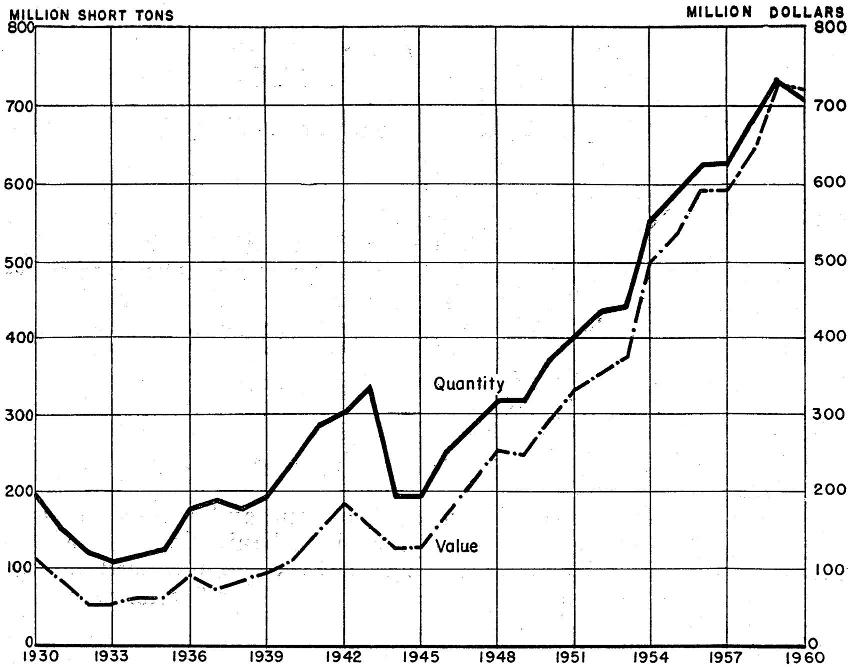

FIGURE 1.—Production and value of sand and gravel in the United States, 1930–60.

DOMESTIC PRODUCTION

Production of sand and gravel declined for the first time in 10 years. Output was 707 million short tons valued at $719 million, decreases of 3 and 1 percent, respectively, from 1959. Although production in most States declined, that in 10 States, having the greatest population density, increased 2 percent. Production in 10 Southern States with few large cities declined 8 percent.

Commercial Production.—Commercial operations supplied 74 percent of the total production of sand and gravel. The average price reported for commercially produced material was $1.13 a ton.

Portable plants, because of their mobility, were replacing the smaller stationary plants to some extent, particularly for supplying the needs for highway projects.

TABLE 1.—Sand and gravel sold or used by producers in the United States, by classes of operations and uses

(Thousand short tons and thousand dollars)

Class of operation and use	1959		1960	
	Quantity	Value	Quantity	Value
Construction:				
Building:				
Sand	123,237	$128,122	122,788	$127,868
Gravel	114,190	142,371	107,799	135,842
Paving:				
Sand	[1] 104,700	[1] 88,424	99,241	91,599
Gravel	[1] 313,475	[1] 271,485	289,148	258,455
Fill:				
Sand	15,551	8,727	20,355	10,929
Gravel	16,814	9,460	27,908	15,140
Railroad ballast:				
Sand	990	534	622	468
Gravel	4,812	3,695	4,650	3,810
Other:				
Sand	5,508	5,034	4,086	3,384
Gravel	6,956	7,697	6,423	7,366
Total construction	[1] 706,233	[1] 665,549	683,020	654,861
Industrial sand:				
Unground:				
Glass	6,251	20,122	6,433	21,521
Molding	6,246	15,144	6,063	16,001
Grinding and polishing	1,179	2,517	1,023	2,030
Blast sand	695	3,137	679	3,303
Fire or furnace	534	1,188	559	1,214
Engine	873	1,535	890	1,683
Ferrosilicon	65	175	63	173
Filtration	395	934	269	624
Oil (hydrafrac)	85	360	153	939
Other	1,946	4,571	1,201	3,469
Total unground	18,269	49,683	17,333	50,957
Ground [2]	930	8,007	981	8,004
Total industrial	19,199	57,690	18,314	58,961
Miscellaneous gravel	4,773	5,473	5,920	4,971
Grand total	[1] 730,205	[1] 728,712	707,254	718,793
Commercial:				
Sand	231,554	266,457	234,059	271,044
Gravel	303,369	332,188	288,539	317,886
Government-and-contractor: [3]				
Sand	[1] 37,631	[1] 22,074	31,347	22,165
Gravel	[1] 157,651	[1] 107,993	153,309	107,698

[1] Revised figure.
[2] See table 11 for use breakdown.
[3] Approximate figures for operations by States, counties, municipalities, and other Government agencies under lease.

TABLE 2.—Sand and gravel sold or used by producers in the United States [1]

(Thousand short tons and thousand dollars)

Year	Sand		Gravel		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1951–55 (average)	176,491	$175,227	308,578	$245,253	485,069	$420,480
1956	235,190	246,276	391,305	349,919	626,495	596,195
1957	236,020	244,640	396,235	355,110	632,255	599,750
1958	241,658	251,071	442,840	401,718	684,498	652,789
1959 [2]	269,185	288,531	461,020	440,181	730,205	728,712
1960	265,406	293,209	441,848	425,584	707,254	718,793

[1] Includes possessions and other areas administered by the United States (1951–56).
[2] Revised figures.

TABLE 3.—Sand and gravel sold or used by producers in the United States, by States, and classes of operations

(Thousand short tons and thousand dollars)

State	1959						1960					
	Commercial		Government-and-contractor		Total		Commercial		Government-and-contractor		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	4,271	$4,526	81	$68	4,352	$4,594	4,305	$4,692	54	$67	4,359	$4,759
Alaska	631	1,162	5,228	4,103	5,859	5,265	987	1,695	5,026	3,788	6,013	5,483
Arizona	5,117	5,308	8,341	6,658	13,458	11,966	6,371	6,975	8,119	7,260	14,490	14,235
Arkansas	6,973	7,535	4,723	4,322	11,696	11,857	5,935	6,732	2,257	3,530	8,192	10,262
California	76,011	97,440	11,934	11,469	87,945	108,909	73,033	93,310	14,646	14,193	87,679	107,503
Colorado	10,302	10,857	10,595	7,960	20,897	18,817	10,293	10,888	8,760	5,994	19,053	16,882
Connecticut	4,578	4,845	171	68	4,749	4,913	5,115	5,244	1,460	716	6,575	5,960
Delaware	1,107	970	134	101	1,241	1,071	1,084	907	----------	----------	1,084	907
Florida	6,674	5,177	----------	----------	6,674	5,177	6,757	5,559	----------	----------	6,757	5,559
Georgia	2,909	2,982	----------	----------	2,909	2,982	3,338	3,047	----------	----------	3,338	3,047
Hawaii	454	1,235	9	18	463	1,253	473	1,299	17	25	490	1,324
Idaho	2,102	2,218	7,082	5,862	9,184	8,080	2,486	2,617	4,602	3,977	7,088	6,594
Illinois	27,538	32,289	2,703	1,428	30,241	33,717	31,202	35,150	1,936	1,105	33,138	36,255
Indiana	19,994	17,762	363	162	20,357	17,924	20,202	18,102	550	275	20,752	18,377
Iowa	11,376	10,559	2,108	1,099	13,484	11,658	12,164	12,005	2,528	1,511	14,692	13,516
Kansas	9,257	6,661	2,077	1,276	11,334	7,937	8,178	6,148	1,532	660	9,710	6,808
Kentucky	4,798	5,361	283	207	5,081	5,568	4,912	5,528	201	235	5,113	5,763
Louisiana	15,505	19,898	547	213	16,052	20,111	13,935	18,990	384	116	14,319	19,106
Maine	1,532	1,058	7,920	2,586	9,452	3,644	1,968	1,181	7,865	2,711	9,833	3,892
Maryland	9,383	12,755	651	228	10,034	12,983	9,638	13,110	438	111	10,076	13,221
Massachusetts	11,468	11,076	1,742	710	13,210	11,786	10,900	11,328	3,889	1,685	14,789	13,013
Michigan	35,474	34,672	12,578	6,521	48,052	41,193	34,026	32,171	12,884	7,133	46,910	39,304
Minnesota	16,366	15,012	12,120	5,714	28,486	20,726	18,786	18,002	11,516	6,609	30,302	24,611
Mississippi	6,921	7,199	599	544	7,520	7,743	6,068	5,522	113	46	6,181	5,568
Missouri	9,574	10,959	705	447	10,279	11,406	9,631	11,194	576	407	10,207	11,601
Montana	2,064	2,335	8,866	10,252	10,930	12,587	1,806	2,209	10,783	9,448	12,589	11,657
Nebraska	10,405	7,695	797	606	11,202	8,301	10,114	8,174	762	572	10,876	8,746
Nevada	2,180	2,804	4,256	4,719	6,436	7,523	2,035	2,881	2,050	2,343	4,085	5,224
New Hampshire	1,740	1,686	3,384	1,201	5,124	2,887	2,017	1,816	4,604	1,871	6,621	3,687
New Jersey	10,962	18,589	71	31	11,033	18,620	11,538	19,493	56	18	11,594	19,511
New Mexico	10,116	10,718	2,344	2,614	12,460	13,332	5,356	5,348	2,063	2,111	7,419	7,459
New York	23,992	29,527	3,951	1,888	27,943	31,415	24,816	30,276	5,871	4,876	30,687	35,152
North Carolina	5,727	5,935	2,853	1,491	8,580	7,426	5,999	5,932	2,802	1,521	8,801	7,453
North Dakota	4,659	3,726	5,224	2,790	9,883	6,516	3,292	2,518	5,356	4,386	8,648	6,904
Ohio	36,216	44,150	2,388	989	38,604	45,139	35,090	43,209	612	611	35,702	43,820

Oklahoma	4,376	4,988	1,626	939	6,002	5,927	4,823	6,544	1,601	924	6,424	7,468
Oregon	7,213	7,887	10,874	7,619	18,087	15,506	7,402	8,083	10,271	8,087	17,673	16,170
Pennsylvania	14,225	23,220	32	13	14,257	23,233	12,927	21,102	84	102	13,011	21,204
Rhode Island	1,616	1,499	124	89	1,740	1,588	1,516	1,343	19	12	1,535	1,355
South Carolina	3,059	3,056	45	21	3,104	3,077	2,991	3,031	38	17	3,029	3,048
South Dakota	5,381	3,949	12,394	7,109	17,775	11,058	3,299	2,527	10,249	6,832	13,548	9,359
Tennessee	5,695	7,187	526	383	6,221	7,570	5,479	7,020	814	635	6,293	7,655
Texas	29,520	32,098	5,775	2,628	35,295	34,726	26,918	29,857	2,926	897	29,844	30,754
Utah	6,018	4,769	2,825	1,667	8,843	6,436	4,895	4,136	1,953	2,046	6,848	6,182
Vermont	1,064	998	[1] 1,256	[1] 592	[1] 2,320	[1] 1,590	901	946	908	272	1,809	1,218
Virginia	8,148	12,058	304	311	8,452	12,369	7,450	11,320	216	112	7,666	11,432
Washington	11,325	11,170	10,035	7,406	21,360	18,576	10,748	9,821	14,549	9,158	25,297	18,979
West Virginia	4,854	10,513			4,854	10,513	4,413	9,711	93	91	4,506	9,802
Wisconsin	21,997	16,899	20,002	10,636	41,999	27,535	22,874	18,582	12,807	7,066	35,681	25,648
Wyoming	2,056	1,673	2,636	2,309	4,692	3,982	2,112	1,655	3,816	3,701	5,928	5,356
Total	534,923	598,645	[1] 195,282	[1] 130,067	[1] 730,205	[1] 728,712	522,598	588,930	184,656	129,863	707,254	718,793
Guam			28	20	28	20			1	1	1	1
Panama Canal Zone	14	21			14	21	65	68			65	68
Johnston Island									1	4	1	4
Puerto Rico	259	269	271	619	530	888	8,996	8,669			8,996	8,669
Canton Island			(2)	(2)	(2)	(2)						

[1] Revised figure. [2] Less than 1,000.

TABLE 4.—Sand and gravel sold or used by producers in the United States in 1960, by States, uses, and classes of operations

(Commercial unless otherwise indicated)

State	Sand, construction							
	Building				Paving			
	Commercial		Government-and-contractor		Commercial		Government-and-contractor	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alabama	1,369,685	$1,189,845			541,388	$432,132		
Alaska	121,072	410,537	43,404	$130,006	98,500	130,020	196,960	$365,819
Arizona	1,447,700	1,821,400	113,100	112,900	519,500	487,800	1,058,200	976,000
Arkansas	1,348,195	1,324,427			1,000,353	902,494	699,096	1,070,426
California	19,458,108	23,621,518	21,407	29,421	8,225,115	9,455,071	4,497,180	5,158,886
Colorado	1,724,900	2,026,100	2,300	6,900	859,700	742,100	810,700	637,200
Connecticut	1,272,192	1,232,534			950,249	875,915	62,400	21,600
Delaware	103,689	111,812			185,633	171,904		
Florida	5,054,133	3,924,689			399,823	377,631		
Georgia	2,405,893	1,627,290			395,768	281,629		
Hawaii	410,083	1,159,321	1,456	5,100	57,974	130,512		
Idaho	288,028	508,454	31,755	30,268	48,969	68,247	91,832	95,018
Illinois	4,768,981	4,291,686			6,805,894	6,407,309	388,647	192,803
Indiana	4,080,608	3,241,513			3,296,157	2,666,132	700	355
Iowa	2,887,826	2,546,599			1,642,607	1,527,594	37,204	15,338
Kansas	3,135,841	2,389,579			2,800,672	1,985,488	819,621	425,770
Kentucky	2,203,863	2,508,751			721,841	737,904		
Louisiana	2,063,591	2,270,960			2,019,275	2,247,950		
Maine	186,217	127,989			238,021	204,262	522,308	201,634
Maryland	2,578,277	3,233,216			1,867,180	2,540,506	(1)	(1)
Massachusetts	2,907,009	2,834,164			1,440,099	1,356,408	162,382	91,068
Michigan	4,094,531	3,178,882	898	360	4,700,904	4,090,790	929,192	410,211
Minnesota	3,684,734	3,104,043			2,510,484	1,789,737	2,574,329	1,352,066
Mississippi	814,334	610,002			1,267,512	938,424	(1)	(1)
Missouri	3,262,220	2,742,620			1,462,801	1,322,028	(1)	(1)
Montana	313,976	523,735	16,740	31,059	15,425	22,424	171,203	248,338
Nebraska	1,821,300	1,478,400	22,000	11,000	780,100	598,000	40,900	16,500
Nevada	312,356	501,353	6,076	8,525	102,537	112,448	256,247	339,482
New Hampshire	219,270	221,946			312,662	198,181	287,333	130,230
New Jersey	3,762,747	3,693,505			2,116,262	1,811,670	1,518	531
New Mexico	928,700	1,042,600	22,100	31,000	103,100	101,800	14,900	13,700
New York	8,397,922	10,591,560	11,015	16,297	4,002,598	4,703,720	434,180	291,005
North Carolina	2,247,311	1,599,621			439,654	320,478	2,379,332	1,198,998
North Dakota	341,400	394,900	6,600	8,500	34,200	47,400	419,500	243,300

Ohio	6,410,369	7,252,468	334	487	6,653,871	6,989,341	195,698	228,722
Oklahoma	1,585,666	1,377,294			1,150,527	1,448,273	(1)	(1)
Oregon	768,528	923,882	32,037	72,013	521,716	570,956	303,887	276,445
Pennsylvania	3,802,203	5,461,055			2,063,029	3,106,240		
Rhode Island	397,478	369,998			216,785	159,024	6,921	2,564
South Carolina	1,221,014	572,300			341,437	110,292	38,373	16,864
South Dakota	572,400	689,000	1,600	1,200	211,900	194,400	520,200	343,000
Tennessee	1,877,627	2,574,511			385,940	435,982		
Texas	6,606,296	6,165,878			3,869,624	4,335,459	458,331	62,348
Utah	794,300	791,100	83,300	166,600	318,100	252,000	52,600	43,000
Vermont	107,553	100,778			241,710	147,384	223,766	98,581
Virginia	1,379,428	1,734,400			1,834,581	2,478,685	67,647	25,015
Washington	1,835,102	2,031,266	470,254	591,600	528,240	478,468	162,976	153,052
West Virginia	1,254,507	1,475,835			380,538	574,109		
Wisconsin	3,070,861	2,711,225	450	203	2,615,300	2,099,400	5,937,846	3,006,546
Wyoming	150,300	211,300	50,600	86,800	48,200	68,700	45,300	113,600
Undistributed [1]							1,027,434	498,910
Total	121,850,324	126,527,841	937,426	1,340,239	73,344,455	73,234,821	25,896,843	18,364,925
Canton Island								
Guam								
Johnston Island								
Panama Canal Zone	33,000	34,650			32,000	33,499		
Puerto Rico	1,708,450	1,244,587			1,507,747	1,017,264		

[1] Figures withheld to avoid disclosing individual company confidential data; included with "Undistributed."

TABLE 4.—Sand and gravel sold or used by producers in the United States in 1960, by States, uses, and classes of operations—Continued

(Commercial unless otherwise indicated)

State	Sand, construction—Continued									
	Railroad ballast		Fill				Other [2]			
			Commercial		Government-and-contractor		Commercial		Government-and-contractor	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alabama	12,746	$6,919	3,998	$1,880						
Alaska	47,100	15,700	1,450	1,000	192,550	$418,213			36,500	$118,625
Arizona			131,500	76,700	73,800	19,200	(1)	(1)		
Arkansas			246,169	130,050			(1)	(1)		
California	54,250	51,223	2,280,211	1,624,522	700,462	632,162	292,949	$280,776		
Colorado	(1)	(1)	49,700	36,800			68,300	166,600		
Connecticut			278,201	130,642			135,749	120,548	607	304
Delaware			(1)	(1)			(1)	(1)		
Florida			565,825	306,107			(1)	(1)		
Georgia	8,787	6,814	(1)	(1)						
Hawaii										
Idaho			6,870	2,711	15,600	6,240	11,329	12,142	1,753	1,647
Illinois	(1)	(1)	673,627	391,968			132,313	140,427		
Indiana			1,029,829	394,575	199	70	(1)	(1)		
Iowa	18,664	13,668	671,225	320,756	16,691	5,915				
Kansas	19,765	14,557	559,166	258,608			34,887	29,080		
Kentucky			370,303	263,979						
Louisiana	(1)	(1)	119,704	64,352			(1)	(1)		
Maine			117,577	34,929			33,070	11,269	3,038	1,113
Maryland			43,689	16,279			(1)	(1)		
Massachusetts			286,475	128,111			415,758	273,386		
Michigan	(1)	(1)	1,958,840	764,244	1,192,904	370,122	9,853	5,530		
Minnesota	(1)	(1)	462,659	242,051	13,792	3,528	(1)	(1)	1,355	406
Mississippi			3,750	2,529			24,998	14,281		
Missouri	16,206	10,947	285,813	241,294			(1)	(1)		
Montana			7,976	8,449			5,312	2,303	195	150
Nebraska	17,700	9,800	170,500	94,500			60,700	23,700		
Nevada			23,457	21,170	65	65	(1)	(1)		
New Hampshire			(1)	(1)	40,500	14,175	(1)	(1)		
New Jersey			134,420	67,531	672	235	2,012	3,012		
New Mexico			(1)	(1)			(1)	(1)		
New York	(1)	(1)	700,899	231,121	310,117	192,880	643,744	656,398	278,494	72,778
North Carolina	(1)	(1)	19,943	12,375						
North Dakota			9,000	8,200			500	200		

Ohio	1,386	1,000	793,111	628,906			121,823	132,405		
Oklahoma	(1)	(1)	334,686	159,709			(1)	(1)		
Oregon			156,564	87,279	5,400	2,430	(1)	(1)	376,203	131,671
Pennsylvania			101,233	117,341			(1)	(1)		
Rhode Island			(1)	(1)			66,473	60,145		
South Carolina			(1)	(1)						
South Dakota	(1)	(1)	8,900	11,600			(1)	(1)		
Tennessee			(1)	(1)			(1)	(1)		
Texas	(1)	(1)	1,608,024	676,441			129,004	140,916		
Utah			13,700	6,800			23,600	21,100		
Vermont			(1)	(1)	34,401	2,370	35,856	13,154	1,519	281
Virginia	(1)	(1)	138,294	80,345			(1)	(1)	25,468	10,187
Washington	(1)	(1)	1,116,601	573,529	780,124	304,243	6,244	10,394	3,355	1,513
West Virginia			(1)	(1)						
Wisconsin	(1)	(1)	751,021	412,618	407,833	150,827	(1)	(1)		
Wyoming	13,500	13,500	500	300			400	300		
Undistributed [1]	411,584	323,784	334,020	174,202			1,102,719	926,847		
Total	621,688	467,912	16,569,430	8,806,503	3,785,110	2,122,675	3,357,593	3,044,913	728,487	338,675
Canton Island										
Guam					965	965				
Johnston Island									1,300	3,800
Panama Canal Zone										
Puerto Rico			2,795,356	2,040,000			(3)	(3)		

[1] Figures withheld to avoid disclosing individual company confidential data; included with Undistributed."
[2] Includes unspecified.
[3] Figures withheld to avoid disclosing individual company confidential data.

TABLE 4.—Sand and gravel sold or used by producers in the United States in 1960, by States, uses, and classes of operations—Continued

(Commercial unless otherwise indicated)

State	Sand, industrial							
	Glass		Molding		Grinding and polishing [4]		Fire or furnace	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alabama			94,950	$217,821				
Alaska								
Arizona								
Arkansas	(1)	(1)	(1)	(1)				
California	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Colorado					1,300	$8,400		
Connecticut			2,000	1,000				
Delaware								
Florida	(1)	(1)	(1)	(1)	(1)	(1)		
Georgia	(1)	(1)	(1)	(1)	(1)	(1)		
Hawaii								
Idaho	(1)	(1)	(1)	(1)				
Illinois	1,343,578	$3,305,897	527,826	1,657,689	(1)	(1)	(1)	(1)
Indiana	(1)	(1)	419,549	578,494			136,334	$152,861
Iowa			(1)	(1)	(1)	(1)		
Kansas			(1)	(1)	1,627	974		
Kentucky	11,322	44,385	2,700	6,700				
Louisiana					(1)	(1)		
Maine								
Maryland	(1)	(1)			(1)	(1)	(1)	(1)
Massachusetts			(1)	(1)	2,500	12,500		
Michigan	(1)	(1)	1,699,124	2,718,827	(1)	(1)		
Minnesota	(1)	(1)	(1)	(1)	(1)	(1)		
Mississippi			(1)	(1)				
Missouri	422,485	1,093,002	69,926	159,963	(1)	(1)		
Montana								
Nebraska								
Nevada	(1)	(1)	(1)	(1)			(1)	(1)
New Hampshire								
New Jersey	(1)	(1)	1,545,765	4,731,150	130,764	545,970	13,726	35,204
New Mexico								
New York			190,124	715,063				
North Carolina								
North Dakota								
Ohio	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Oklahoma	(1)	(1)	(1)	(1)	9,821	24,913		
Oregon			718	3,590				
Pennsylvania	(1)	(1)	(1)	(1)	(1)	(1)	141,183	395,826

Rhode Island			(1)	(1)				
South Carolina	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
South Dakota			4,500	15,800				
Tennessee	(1)	(1)	215,836	636,314	(1)	(1)		
Texas	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Utah			23,300	39,100				
Vermont					(1)	(1)		
Virginia	(1)	(1)	(1)	(1)	300	375		
Washington					(1)	(1)		
West Virginia	(1)	(1)	(1)	(1)	(1)	(1)	29,196	33,575
Wisconsin			82,567	178,323	20,453	54,410		
Wyoming								
Undistributed [1]	4,655,483	17,077,915	1,184,217	4,341,739	1,535,323	4,685,429	238,682	596,370
Total	6,432,868	21,521,199	6,063,102	16,001,573	1,702,088	5,332,971	559,121	1,213,836
Canton Island								
Guam								
Johnston Island								
Panama Canal Zone								
Puerto Rico								

[1] Figures withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[4] Includes 679,257 tons of blast sand valued at $3,303,212.

TABLE 4.—Sand and gravel sold or used by producers in the United States in 1960, by States, uses, and classes of operations—Continued

(Commercial unless otherwise indicated)

State	Sand, industrial—Continued											
	Engine		Ferrosilicon		Filtration		Oil (hydrafrac)		Other		Ground sand	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alabama												
Alaska									16,893	$37,432		
Arizona	(1)	(1)					(1)	(1)				
Arkansas											(1)	(1)
California	62,504	$210,427			8,457	$61,711	(1)	(1)	16,784	92,914	(1)	(1)
Colorado	(1)	(1)			2,500	21,000			1,100	5,200	7,500	$11,200
Connecticut					(1)	(1)						
Delaware	31,730	23,797										
Florida					(1)	(1)			(1)	(1)		
Georgia	(1)	(1)			(1)	(1)			(1)	(1)	(1)	(1)
Hawaii	(1)	(1)							(1)	(1)		
Idaho					(1)	(1)						
Illinois	57,039	104,603			(1)	(1)	(1)	(1)	(1)	(1)	181,235	1,850,532
Indiana	91,507	106,966			(1)	(1)			(1)	(1)		
Iowa	(1)	(1)			(1)	(1)			(1)	(1)		
Kansas	29,730	55,257			(1)	(1)						
Kentucky	(1)	(1)							(1)	(1)		
Louisiana	1,000	500			(1)	(1)			(1)	(1)	34,400	215,100
Maine	2,989	3,736							162	72		
Maryland	(1)	(1)							(1)	(1)		
Massachusetts											(1)	(1)
Michigan	54,404	68,198							(1)	(1)	(1)	(1)
Minnesota	(1)	(1)							(1)	(1)	(1)	(1)
Mississippi	799	524										
Missouri	39,797	31,925	(1)	(1)					32,533	90,701	(1)	(1)
Montana												
Nebraska	500	300										
Nevada									35,869	85,142		
New Hampshire	(1)	(1)			(1)	(1)						
New Jersey	20,677	67,192			33,536	114,490			183,318	596,677	(1)	(1)
New Mexico												
New York	(1)	(1)			18,768	32,048			42,888	32,930	2,000	2,900
North Carolina									5,800	5,800		
North Dakota												
Ohio	(1)	(1)	(1)	(1)	(1)	(1)			(1)	(1)	151,327	653,368
Oklahoma	8,530	6,500	(1)	(1)	684	4,263			(1)	(1)	(1)	(1)
Oregon	(1)	(1)										

Pennsylvania	(1)	(1)	(1)	(1)					(1)	(1)	(1)	(1)
Rhode Island												
South Carolina	(1)	(1)			(1)	(1)			35,714	47,754		
South Dakota							2,500	$21,300				
Tennessee	864	1,080										
Texas	37,017	26,798			6,000	43,000	87,090	624,479	(1)	(1)	(1)	(1)
Utah	1,300	2,900										
Vermont	(1)	(1)										
Virginia	33,862	49,827			(1)	(1)			(1)	(1)	(1)	(1)
Washington											(1)	(1)
West Virginia	117,827	328,228	(1)	(1)					(1)	(1)	(1)	(1)
Wisconsin	(1)	(1)			(1)	(1)	(1)	(1)	(1)	(1)		
Wyoming												
Undistributed [1]	297,931	594,525	63,129	$172,687	199,461	348,057	63,104	292,998	830,254	2,474,233	605,037	5,271,273
Total	890,007	1,683,283	63,129	172,687	269,406	624,569	152,694	938,777	1,201,315	3,468,855	981,499	8,004,373
Canton Island												
Guam												
Johnston Island												
Panama Canal Zone												
Puerto Rico											(3)	(3)

[1] Figures withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[3] Figures withheld to avoid disclosing individual company confidential data.

TABLE 4.—Sand and gravel sold or used by producers in the United States in 1960, by States, uses, and classes of operations—Continued

(Commercial unless otherwise indicated)

State	Gravel, construction							
	Building				Paving			
	Commercial		Government-and-contractor		Commercial		Government-and-contractor	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alabama	1,007,166	$1,342,796			1,017,218	$1,215,115	53,909	$66,847
Alaska	123,017	391,449	329,870	$110,338	337,079	489,291	957,907	693,424
Arizona	1,547,600	1,950,800	29,000	37,900	2,085,800	2,049,100	6,832,800	6,108,000
Arkansas	1,502,628	1,889,240			1,376,172	1,651,975	1,558,297	2,459,219
California	20,667,027	26,843,929	22,444	30,996	18,303,592	23,544,719	9,283,755	8,214,621
Colorado	2,179,800	2,623,300	196,400	148,900	5,041,300	4,686,000	7,715,100	5,165,600
Connecticut	1,013,016	1,461,801			922,468	1,076,217	1,396,739	694,370
Delaware	(1)	(1)			(1)	(1)		
Florida	288,286	333,503			183,189	329,194		
Georgia	161,373	246,650			30,055	43,592		
Hawaii							1,363	1,600
Idaho	487,020	616,556	44,255	42,428	1,453,773	1,198,086	4,152,106	3,695,763
Illinois	3,321,613	3,348,619	27,041	10,746	11,685,506	10,885,538	1,517,347	900,761
Indiana	3,640,234	4,001,781	55,000	36,000	5,578,511	5,697,128	422,907	209,691
Iowa	1,567,173	2,403,440			4,784,048	4,346,278	2,437,132	1,469,920
Kansas	234,026	227,736	12,315	3,695	1,276,135	1,086,734	585,088	189,086
Kentucky	969,944	1,250,842			592,721	689,022	200,966	234,750
Louisiana	3,288,849	4,107,410	264,524	79,357	4,939,672	8,312,216	120,000	36,000
Maine	231,711	287,796			793,014	366,559	7,334,362	2,505,383
Maryland	2,135,799	3,483,714			1,978,890	2,798,031	(1)	(1)
Massachusetts	2,705,770	3,738,376			2,030,664	1,969,937	3,497,881	1,550,148
Michigan	4,520,452	5,319,400	26,894	13,447	15,642,358	13,952,335	10,337,760	6,228,349
Minnesota	3,046,168	4,589,934			7,995,614	6,788,710	8,588,085	5,135,200
Mississippi	1,274,191	1,437,395			2,350,904	2,184,964	(1)	(1)
Missouri	2,043,686	2,526,282			1,480,411	1,516,100	561,034	391,161
Montana	486,472	676,743	38,862	70,778	538,669	623,135	10,548,171	9,093,390
Nebraska	1,905,200	1,620,500	62,100	31,000	5,005,400	4,113,100	552,200	488,900
Nevada	502,057	762,109	8,881	12,143	791,970	767,590	1,763,185	1,974,464
New Hampshire	184,641	244,368			823,495	964,116	4,264,062	1,722,031
New Jersey	1,775,369	3,016,035			865,903	1,092,882	54,328	17,790
New Mexico	985,800	1,378,000	39,500	77,600	3,083,700	2,645,100	1,986,900	1,988,900
New York	4,432,931	6,956,881	93,000	81,300	3,727,230	4,496,981	3,515,536	3,191,379
North Carolina	1,301,160	1,799,605			1,671,741	1,757,857	422,485	322,030
North Dakota	389,800	706,300	46,600	64,300	2,170,700	1,224,300	4,883,600	4,069,800

Ohio	5,369,353	6,781,858	62,238	80,679	11,691,359	13,774,325	311,424	258,059
Oklahoma	156,998	168,351			926,649	1,571,104	(1)	(1)
Oregon	1,544,252	1,782,190	3,702,384	2,510,760	3,330,663	3,941,559	4,278,575	4,480,501
Pennsylvania	3,369,786	4,557,919			1,992,568	2,877,280		
Rhode Island	290,910	334,133			218,331	222,520	12,446	9,574
South Carolina	(1)	(1)			(1)	(1)		
South Dakota	95,800	120,400	132,500	138,400	1,581,400	946,400	9,595,000	6,349,600
Tennessee	1,803,774	2,098,427			859,232	683,054	712,872	585,521
Texas	6,980,849	9,452,523			6,906,461	7,189,472	2,467,134	834,745
Utah	958,700	981,600	342,900	684,100	2,624,700	1,918,900	1,474,600	1,152,100
Vermont	71,798	121,283			383,794	539,108	636,512	169,770
Virginia	1,665,493	2,504,531	43,814	3,245	2,051,559	3,668,291	79,229	73,835
Washington	2,930,389	2,822,880	1,310,562	1,659,121	3,056,224	2,881,148	3,863,204	3,131,166
West Virginia	1,116,174	1,287,348			313,690	519,188	91,400	90,280
Wisconsin	3,408,524	3,198,424			10,305,643	7,960,168	6,307,244	3,856,882
Wyoming	152,700	216,100	113,700	229,800	1,557,700	1,029,400	3,548,900	3,231,100
Undistributed [1]	958,955	1,674,283			727,756	532,547	1,139,629	596,938
Total	100,794,434	129,685,540	7,004,784	6,157,033	159,085,631	164,816,366	130,063,174	93,638,648
Canton Island								
Guam								
Johnston Island								
Panama Canal Zone								
Puerto Rico	1,482,027	2,227,067			1,471,019	2,096,703		

[1] Figures withheld to avoid disclosing individual company confidential data; included with "Undistributed."

TABLE 4.—Sand and gravel sold or used by producers in the United States in 1960, by States, uses, and classes of operations—Continued

(Commercial unless otherwise indicated)

State	Gravel, construction—Continued										Gravel, miscellaneous	
	Railroad ballast		Fill				Other					
			Commercial		Government-and-contractor		Commercial		Government-and-contractor			
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alabama	(1)	(1)	-----	-----	-----	-----	1,698	$9,084	-----	-----	(1)	(1)
Alaska	120,300	$113,300	105,471	$80,256	3,268,577	$1,952,095	800	1,235	-----	-----	15,212	$24,449
Arizona	-----	-----	391,900	212,300	12,500	6,200	196,400	196,400	-----	-----	4,200	8,400
Arkansas	-----	-----	152,285	60,816	-----	-----	(1)	(1)	-----	-----	(1)	(1)
California	386,886	327,171	1,442,798	1,188,581	39,212	45,325	739,517	968,643	81,667	$81,667	187,581	256,711
Colorado	-----	-----	104,100	74,700	35,700	35,700	95,700	249,500	-----	-----	140,200	190,700
Connecticut	(1)	(1)	314,914	198,003	-----	-----	86,061	58,398	-----	-----	40,924	21,799
Delaware	-----	-----	4,907	1,962	-----	-----	-----	-----	-----	-----	3,000	9,000
Florida	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Georgia	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Hawaii	-----	-----	1,701	2,552	14,411	18,680	-----	-----	-----	-----	-----	-----
Idaho	(1)	(1)	103,547	73,688	264,255	105,601	38,169	52,708	-----	-----	(1)	(1)
Illinois	163,938	119,525	805,136	446,788	2,640	792	75,224	93,935	-----	-----	237,440	160,251
Indiana	384,740	310,420	1,400,855	812,223	71,158	28,807	(1)	(1)	-----	-----	(1)	(1)
Iowa	(1)	(1)	342,100	152,873	8,100	2,025	(1)	(1)	28,875	17,325	18,710	28,065
Kansas	-----	-----	29,207	23,788	39,158	17,681	24,121	49,364	76,000	24,000	(1)	(1)
Kentucky	-----	-----	(1)	(1)	-----	-----	-----	-----	-----	-----	-----	-----
Louisiana	309,766	451,927	274,022	325,211	-----	-----	417,309	478,068	-----	-----	-----	-----
Maine	27,993	8,267	228,104	80,226	5,260	2,705	31,146	14,274	-----	-----	78,486	41,389
Maryland	2,719	1,196	31,071	14,391	-----	-----	(1)	(1)	-----	-----	417,595	247,351
Massachusetts	5,800	3,200	510,291	279,665	229,162	44,070	300,130	234,873	-----	-----	185,928	105,339
Michigan	169,853	184,975	507,400	288,667	396,762	110,548	(1)	(1)	-----	-----	(1)	(1)
Minnesota	506,880	480,439	234,037	134,369	338,546	117,254	31,806	26,989	-----	-----	67,887	43,631
Mississippi	57,399	21,441	45,537	55,560	-----	-----	86,462	68,248	-----	-----	(1)	(1)
Missouri	118,343	64,884	61,132	33,608	-----	-----	1,500	1,500	-----	-----	26,381	23,407
Montana	328,510	268,271	83,365	57,163	6,075	2,430	5,273	4,154	1,606	1,606	20,992	22,950
Nebraska	-----	-----	5,800	5,200	85,000	25,200	5,700	6,300	-----	-----	341,200	223,800
Nevada	5,186	5,705	(1)	(1)	15,869	7,747	-----	-----	-----	-----	(1)	(1)
New Hampshire	4,300	1,788	128,479	65,286	11,880	4,752	(1)	(1)	-----	-----	177,454	50,513
New Jersey	(1)	(1)	132,988	79,253	-----	-----	36,798	83,255	-----	-----	11,542	37,187
New Mexico	-----	-----	55,100	47,500	-----	-----	200	100	-----	-----	109,800	75,300
New York	18,901	26,900	1,211,089	606,203	1,190,808	1,009,463	654,712	496,757	37,462	20,755	735,668	672,770
North Carolina	(1)	(1)	4,606	4,309	-----	-----	-----	-----	-----	-----	232,064	373,583

North Dakota	180,500	58,300	106,300	42,400	-----	-----	28,000	13,000	-----	-----	31,100	23,600
Ohio	162,117	125,257	627,680	416,938	42,216	43,249	1,789,945	2,735,677	-----	-----	343,094	301,110
Oklahoma	-----	-----	807	465	-----	-----	-----	-----	-----	-----	(1)	(1)
Oregon	(1)	(1)	718,490	493,610	1,570,185	612,372	19,194	14,118	2,178	726	275,437	199,631
Pennsylvania	(1)	(1)	102,029	89,725	83,855	102,086	(1)	(1)	-----	-----	84,710	70,039
Rhode Island	-----	-----	178,880	76,868	-----	-----	30,067	22,993	-----	-----	81,852	42,757
South Carolina	(1)	(1)	-----	-----	-----	-----	(1)	(1)	-----	-----	-----	-----
South Dakota	176,000	126,100	34,500	11,800	-----	-----	122,600	94,000	-----	-----	417,500	217,300
Tennessee	(1)	(1)	-----	-----	101,250	50,000	-----	-----	-----	-----	(1)	(1)
Texas	-----	-----	102,748	104,604	-----	-----	67,361	55,554	-----	-----	224,899	122,249
Utah	23,500	5,700	56,300	25,200	-----	-----	41,900	78,900	-----	-----	15,300	13,100
Vermont	-----	-----	9,241	3,383	12,000	1,650	5,390	2,114	-----	-----	(1)	(1)
Virginia	-----	-----	(1)	(1)	-----	-----	-----	-----	-----	-----	(1)	(1)
Washington	341,454	204,864	699,709	534,759	7,613,957	2,982,671	149,546	194,434	344,280	334,881	55,043	62,324
West Virginia	(1)	(1)	7,104	12,397	1,350	500	(1)	(1)	-----	-----	(1)	(1)
Wisconsin	502,653	364,766	773,325	384,565	153,476	51,185	(1)	(1)	-----	-----	839,543	795,022
Wyoming	161,000	80,500	10,000	13,800	-----	-----	-----	-----	57,600	40,200	18,100	20,900
Undistributed [1]	491,431	454,923	156,264	143,151	-----	-----	710,907	540,963	-----	-----	481,475	486,530
Total	4,650,169	3,809,819	12,295,319	7,758,806	15,613,362	7,380,788	5,793,636	6,845,538	629,668	521,160	5,920,317	4,971,157
Canton Island	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Guam	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Johnston Island	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Panama Canal Zone	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Puerto Rico	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

[1] Figures withheld to avoid disclosing individual company confidential data; included with "Undistributed."

Government-and-Contractor Production.—The volume of sand and gravel production classified as Government-and-contractor was 26 percent of the total output, a decrease of 1 percent from 1959. Its value was $130 million, an average of 70 cents per ton. This output went into government-financed construction projects, including Federal, State, and local programs for new highway construction, educational facilities, and hospital construction. States reported 58 percent of Government-and-contractor production in 1960; counties, 26 percent; Federal agencies, 14 percent; and municipalities, 2 percent. Most production was by contract; the remainder was by regular maintenance crews.

The entire production of a private producer must be on a contract to a Government agency to be classed under the Government-and-contractor category. If any part of the production is sold commercially, the entire output is designated as commercial.

Degree of Preparation.—Unprocessed sand and gravel, because of its availability and low unit value, was used to some extent for fill, base course, and subgrade in highway construction. The reported value for such material was as low as 20 cents a ton in some instances.

More rigid specifications for federally financed highway construction increased the demand for washed, screened, and graded material. Output of such processed material amounted to 90 percent of commercial production and averaged $1.18 per ton, compared with $0.61 for unprepared material. Sixty-eight percent of Government-and-contractor production was prepared, compared with 45 percent in 1959; its average value was $0.81 per ton.

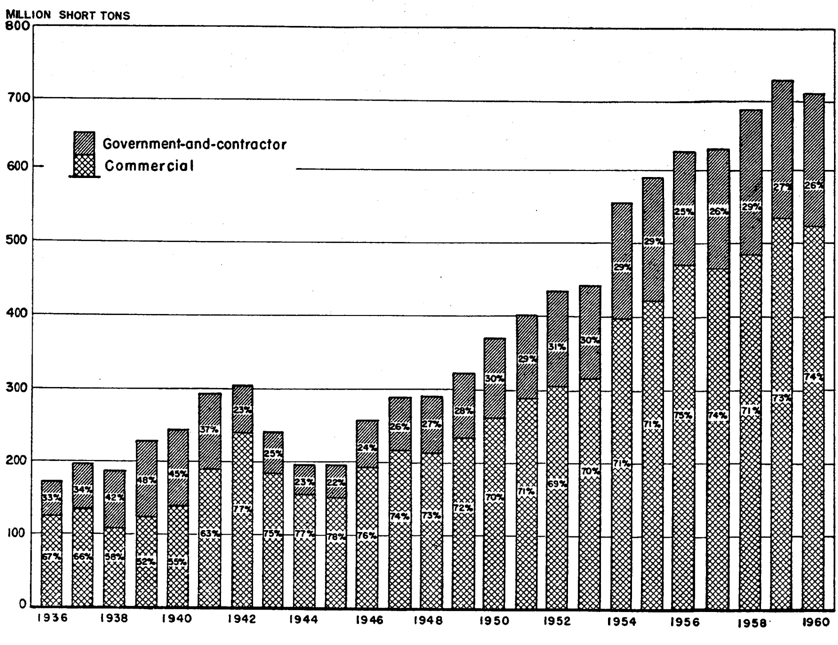

FIGURE 2.—Sand and gravel sold or used in the United States, 1936–60.

TABLE 5.—Sand and gravel sold or used by Government-and-contractor producers in the United States,[1] by uses

(Thousand short tons and thousand dollars)

Year	Sand: Building Quantity	Sand: Building Value	Sand: Paving Quantity	Sand: Paving Value	Sand: Fill Quantity	Sand: Fill Value	Sand: Other Quantity	Sand: Other Value
1951-55 (average)	1,418	$1,522	16,234	$7,371	(2)	(2)	(2)	(2)
1956	2,321	2,058	19,568	9,586	(2)	(2)	(2)	(2)
1957	2,324	1,903	24,159	12,280	(2)	(2)	(2)	(2)
1958	1,584	1,807	28,496	15,151	(2)	(2)	(2)	(2)
1959	1,353	1,419	[3] 34,097	[3] 19,654	1,927	$899	254	$102
1960	937	1,340	25,897	18,365	3,785	2,122	728	338

Year	Gravel: Building Quantity	Gravel: Building Value	Gravel: Paving Quantity	Gravel: Paving Value	Gravel: Fill Quantity	Gravel: Fill Value	Gravel: Other Quantity	Gravel: Other Value	Total Government-and-contractor sand and gravel Quantity	Total Government-and-contractor sand and gravel Value
1951-55 (average)	9,256	$6,023	115,448	$57,258	(2)	(2)	(2)	(2)	142,356	$72,174
1956	5,434	3,689	127,717	77,740	(2)	(2)	(2)	(2)	155,040	93,073
1957	7,857	5,860	130,908	83,734	(2)	(2)	(2)	(2)	165,248	103,777
1958	3,814	4,116	161,310	106,432	(2)	(2)	(2)	(2)	195,204	127,506
1959	10,387	6,882	[3] 144,525	[3] 100,308	2,719	$789	20	$14	[3] 195,282	[3] 130,067
1960	7,004	6,157	130,063	93,639	15,613	7,381	629	521	184,656	129,863

[1] Includes possessions and other areas administered by the United States (1951-56).
[2] Not available.
[3] Revised figure.

Size of Plants.—Increased use by contractors of mobile crushing, washing, and screening plants resulted in the use of small easily accessible deposits of sand and gravel for highway construction, although the total tonnage produced by these plants was relatively small. A total of 2,050 plants, producing between 50,000 and 500,000 tons per year, supplied 61 percent of production, and the large operators (500,000 to over 1 million tons), 185 in number, furnished 30 percent of production.

Production Trends.—Reserves of sand and gravel were considered adequate in most areas although with the trend toward suburban development around most large cities they may become unavailable if local authorities fail to plan for development of these resources when zoning restrictions are considered.

The problems generated by encroaching housing developments brought home forcibly, to some operators, the necessity for developing and maintaining good public relations.

A few producers voluntarily limited operations to daylight hours, suppressed dust nuisances, shielded operations from highways by planting shrubbery, and established personal relationships with their new neighbors. Others restored worked-out pits with waste fill and topsoil and used these areas for further housing developments.

In some areas worked-out gravel pits were made into recreation areas with artificial lakes offering fishing, boating, and swimming facilities.

TABLE 6.—Sand and gravel sold or used by Government-and-contractor producers in the United States,[1] by types of producer

(Thousand short tons and thousand dollars)

Type of producer	1951-55 (average)		1956		1957	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction and maintenance crews	46,100	$17,120	47,592	$22,582	49,646	$24,076
Contractors	96,256	55,054	107,448	70,491	115,602	79,701
Total	142,356	72,174	155,040	93,073	165,248	103,777
States	79,555	40,703	94,767	56,746	97,813	60,120
Counties	39,626	15,825	40,608	21,066	44,303	23,234
Municipalities	2,726	1,264	4,149	2,401	3,092	2,547
Federal agencies	20,449	14,382	15,516	12,860	20,040	17,876
Total	142,356	72,174	155,040	93,073	165,248	103,777
	1958		**1959**		**1960**	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction and maintenance crews	[2] 49,770	$26,314	49,800	$28,643	52,017	$31,199
Contractors	145,434	101,192	[2] 145,482	[2] 101,424	132,639	98,664
Total	[2] 195,204	127,506	[2] 195,282	[2] 130,067	184,656	129,863
States	123,555	78,676	[2] 111,696	[2] 74,947	107,944	77,100
Counties	49,329	29,639	56,293	34,975	48,535	31,622
Municipalities	[2] 2,970	1,959	3,282	1,972	2,897	1,755
Federal agencies	19,350	17,232	24,011	18,173	25,280	19,386
Total	[2] 195,204	127,506	[2] 195,282	[2] 130,067	184,656	129,863

[1] Includes possessions and other areas administered by the United States (1951-56).
[2] Revised figure.

TABLE 7.—Sand and gravel sold or used by producers in the United States, by classes of operation and degrees of preparation

(Thousand short tons and thousand dollars)

	1959		1960	
	Quantity	Value	Quantity	Value
Commercial operations:				
Prepared	464,896	$556,620	472,580	$558,280
Unprepared	70,027	42,025	50,018	30,650
Total	534,923	598,645	522,598	588,930
Government-and-contractor operations: [1]				
Prepared	[2] 88,361	[2] 79,299	125,324	101,784
Unprepared	[2] 106,921	[2] 50,768	59,332	28,079
Total	[2] 195,282	[2] 130,067	184,656	129,863
Grand total	[2] 730,205	[2] 728,712	707,254	718,793

[1] Includes operations by or for States, counties, municipalities, and Federal Government agencies as follows—1959: 1,764 operations; 1960: 1,606.
[2] Revised figure.

TABLE 8.—Number and production of domestic commercial sand and gravel plants by size of operation

Annual production (short tons)	1959				1960			
	Plants [1]		Production		Plants [1]		Production	
	Number	Percent of total	Thousand short tons	Percent of total	Number	Percent of total	Thousand short tons	Percent of total
Less than 25,000	2,091	41.0	20,421	3.8	1,671	35.6	16,961	3.2
25,000 to 50,000	744	14.6	26,477	4.9	793	16.9	28,816	5.5
50,000 to 100,000	841	16.5	59,331	11.1	832	17.7	59,831	11.5
100,000 to 200,000	655	12.9	92,398	17.3	672	14.3	93,642	17.9
200,000 to 300,000	345	6.8	84,389	15.8	309	6.6	74,870	14.3
300,000 to 400,000	143	2.8	49,336	9.2	145	3.1	50,085	9.6
400,000 to 500,000	88	1.7	39,028	7.3	92	1.9	41,005	7.9
500,000 to 600,000	60	1.2	32,854	6.1	64	1.4	34,895	6.7
600,000 to 700,000	28	.5	18,013	3.4	29	.6	18,652	3.6
700,000 to 800,000	24	.5	17,886	3.3	22	.5	16,420	3.1
800,000 to 900,000	12	.2	10,053	1.9	15	.3	12,702	2.4
900,000 to 1,000,000	15	.3	14,229	2.7	12	.2	11,392	2.2
1,000,000 and over	50	1.0	70,508	13.2	43	.9	63,327	12.1
Total	5,096	100.0	534,923	100.0	4,699	100.0	522,598	100.0

[1] Includes a few companies operating more than 1 plant but not submitting separate returns for individual plants.

Methods of Transportation.—Transportation remained the highest single cost factor in marketing sand and gravel. Truck shipments transported 88 percent of sand and gravel in 1960, continuing the trend toward this method of transportation established in previous years. Larger capacity trucks were used, and the weight of trucks was reduced by designing truck bodies of aluminum and light-metal alloys as a means of reducing transportation expense. Rail shipments remained the same as in 1959, transporting 9 percent of the material. Waterway transportation predominated in areas where barge operation was feasible, specifically where the material was later processed on shore installations, although this tonnage was only 3 percent of the total production. The use of portable plants to work local deposits in close proximity to the job was an important element in reducing costs of transportation on road construction.

TABLE 9.—Sand and gravel sold or used in the United States, by classes of operation and methods of transportation

	1959		1960	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Commercial:				
Truck	442,154	61	435,794	62
Rail	66,983	9	61,962	9
Waterway	25,073	3	23,457	3
Unspecified	713	(1)	1,385	(1)
Total commercial	534,923	73	522,598	74
Government-and-contractor: Truck [2]	[3] 195,282	27	184,656	26
Grand total	[3] 730,205	100	707,254	100

[1] Less than 0.5 percent.
[2] Entire output of Government-and-contractor operations assumed to be moved by truck.
[3] Revised figure.

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Conveyors.—Conveyor systems were improved by designing belts capable of operating at higher speeds and using standardized sections of varying widths and lengths, all having interchangeable accessories. The entire facility of one specialized sand plant, including scalping tank, dewatering wheel, settling tank, and stacking conveyor was mounted on a self-propelled pivoting framework. The plant could be rotated through nearly a full circle. The stacking conveyor for handling wet sand was fitted with a 30-inch wide V-ribbed belt.[7] A 900-foot suspension conveyor was devised to span the Snake River in Washington and to deliver 600 tons per hour of aggregate to the batch plant of the Ice Harbor Dam project.[8]

Employment and Productivity.—Increases in the use of automatic-control devices, larger and more mobile transportation units, and more extended use of portable plants, continued to increase output in tons per man-shift.

Data reported for commercial sand and gravel plants showed a 9-percent increase in productivity per man hour.

CONSUMPTION AND USES

Construction Uses, Including Ballast.—Decreased consumption of sand and gravel was caused mainly by reduced expenditures for private construction. The construction industry, as in past years, consumed most of the sand and gravel produced for building, airport runways, and concrete and bituminous paving. Small quantities were produced for fill material and railroad ballast.

Industrial Sands.—Consumption of industrial sands, including ground sand, totaled 18 million tons, a decrease of 1 million tons from 1959. A slight increase in glass sand output was due chiefly to increased production of sheet and plate glass for buildings, automobiles, and aircraft.

Ground sand production increased 5 percent with specific gains in filler, foundry, and glass sands.

PRICES

Average value of total sand and gravel output at producer plants, both commercial and Government-and-contractor operations, was $1.02 per short ton, compared with $1 per ton in 1959. Average value per ton for commercial operations was $1.13 per ton; that for Government-and-contractor operations was $0.70. The price for construction sand in December 1960 (average of prices in 20 cities) was reported as $2.36 per ton.[9] The relatively higher price was due to more rigid specifications and local demand.

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[7] Herod, Buren C., Specialized Sand Plant Revolves for Stockpiling: Pit and Quarry, vol. 52, No. 9, March 1960, pp. 109–111.
[8] Engineering News-Record, Dambuilders Bridge River With Aggregate Conveyor: Vol. 164, No. 24, June 16, 1960, p. 26.
[9] Engineering News Record, vol. 166, No. 23, June 8, 1961, p. 60.

TABLE 10.—Employment in the commercial sand and gravel industry and average output per man in the United States in 1960, by States[1]

State	Employment					Production (short tons)	Average output per man		Percent of commercial industry represented
	Average number of men	Time employed							
		Average number of days	Total man shifts	Man-hours					
				Average man per day	Total		Per shift	Per hour	
Alabama	457	254	116,206	8.5	987,755	4,041,727	34.8	4.1	94
Alaska	71	103	7,330	8.7	63,775	913,694	124.7	14.3	93
Arizona	635	238	151,054	8.1	1,223,534	6,370,700	42.2	5.2	100
Arkansas	731	247	180,572	8.6	1,552,923	5,934,501	32.9	3.8	100
California	4,171	224	936,148	8.1	7,582,797	73,032,815	78.0	9.6	100
Colorado	735	172	126,210	8.5	1,072,781	10,292,500	81,6	9.6	100
Connecticut	326	228	74,208	8.2	608,502	4,309,465	58.1	7.1	84
Delaware	80	207	16,596	8.4	139,403	1,084,329	65.3	7.8	100
Florida	305	281	85,734	8.8	754,456	5,453,546	63.6	7.2	81
Georgia	276	259	71,380	8.4	599,592	3,224,049	45.2	5.4	97
Hawaii	63	138	8,684	8.0	69,468	473,040	54.5	6.8	100
Idaho	247	174	43,071	8.2	353,179	2,486,128	57.7	7.0	100
Illinois	1,814	231	418,561	8.7	3,641,480	31,202,655	74.5	8.6	100
Indiana	1,146	245	281,250	8.5	2,390,628	20,081,353	71.4	8.4	99
Iowa	984	223	218,973	9.0	1,970,755	12,164,441	55.6	6.2	100
Kansas	508	212	107,547	9.0	967,925	5,866,147	54.5	6.1	72
Kentucky	251	280	70,156	9.8	687,531	4,089,766	58.3	5.9	83
Louisiana	1,177	264	311,289	8.5	2,645,958	13,934,820	44.8	5.3	100
Maine	199	167	33,191	8.3	275,489	1,720,798	51.8	6.2	87
Maryland	363	241	87,626	8.5	744,818	5,694,495	65.0	7.6	59
Massachusetts	699	185	129,352	8.2	1,060,684	8,141,796	62,9	7.7	75
Michigan	1,894	216	409,774	8.7	3,565,035	34,025,785	83.0	9.5	100
Minnesota	1,621	157	255,192	9.1	2,322,248	18,785,711	73.6	8.1	100
Mississippi	509	252	128,201	8.8	1,128,171	6,068,410	47.3	5.4	100
Missouri	708	228	161,387	8.3	1,339,515	9,630,844	59.7	7.2	100
Montana	222	135	29,986	8.1	242,886	1,805,970	60.2	7.4	100
Nebraska	670	201	134,773	9.3	1,253,393	7,785,700	57.8	6.2	77
Nevada	180	186	33,517	8.0	268,138	2,034,661	60.7	7.6	100
New Hampshire	102	198	20,213	8.7	175,849	1,810,996	89.6	10.3	90
New Jersey	718	237	170,315	8.3	1,413,612	8,276,548	48.6	5.9	72
New Mexico	372	184	68,594	8.0	548,751	5,325,800	77.6	9.7	99
New York	1,098	192	211,099	8.2	1,731,014	13,702,752	64.9	7.9	55
North Carolina	408	206	83,917	8.8	738,472	4,248,932	50.6	5.8	71
North Dakota	282	148	41,637	9.4	391,386	3,291,500	79.1	8.4	100
Ohio	2,022	234	472,426	8.3	3,921,138	28,522,097	60.4	7.3	81
Oklahoma	378	264	99,789	8.2	818,270	4,822,980	48.3	5.9	100
Oregon	760	188	143,212	8.1	1,160,020	7,402,203	51.7	6.4	100
Pennsylvania	941	222	208,959	8.6	1,797,046	8,443,351	40.4	4.7	65
Rhode Island	140	209	29,241	8.0	233,925	1,443,382	49.4	6.2	95
South Carolina	216	238	51,379	8.3	426,449	2,990,833	58.2	7.0	100
South Dakota	354	145	51,492	9.1	468,575	3,298,600	64.1	7.0	100
Tennessee	237	239	56,536	8.8	497,521	2,872,771	50.8	5.8	52
Texas	1,418	249	353,450	8.7	3,075,016	16,914,899	47.9	5.5	63
Utah	309	204	62,906	8.1	509,540	4,894,700	77.8	9.6	100
Vermont	102	180	18,406	8.4	154,611	575,673	31.3	3.7	64
Virginia	421	242	101,962	8.5	866,678	5,315,858	52.1	6.1	71
Washington	727	196	142,849	8.0	1,142,794	10,748,105	75.2	9.4	100
West Virginia	247	190	46,961	8.9	417,953	1,605,866	34.2	3.8	36
Wisconsin	1,478	196	289,122	8.7	2,515,361	22,873,836	79.1	9.1	100
Wyoming	170	187	31,706	8.1	256,817	2,112,400	66.6	8.2	100
Total	33,942	218	7,384,139	8.5	62,773,617	462,143,928	62.6	7.4	88

[1] Excludes operations by or for States, counties, municipalities, and Federal Government agencies.

Compiled by the Branch of Accident Analysis, Division of Accident Prevention and Health.

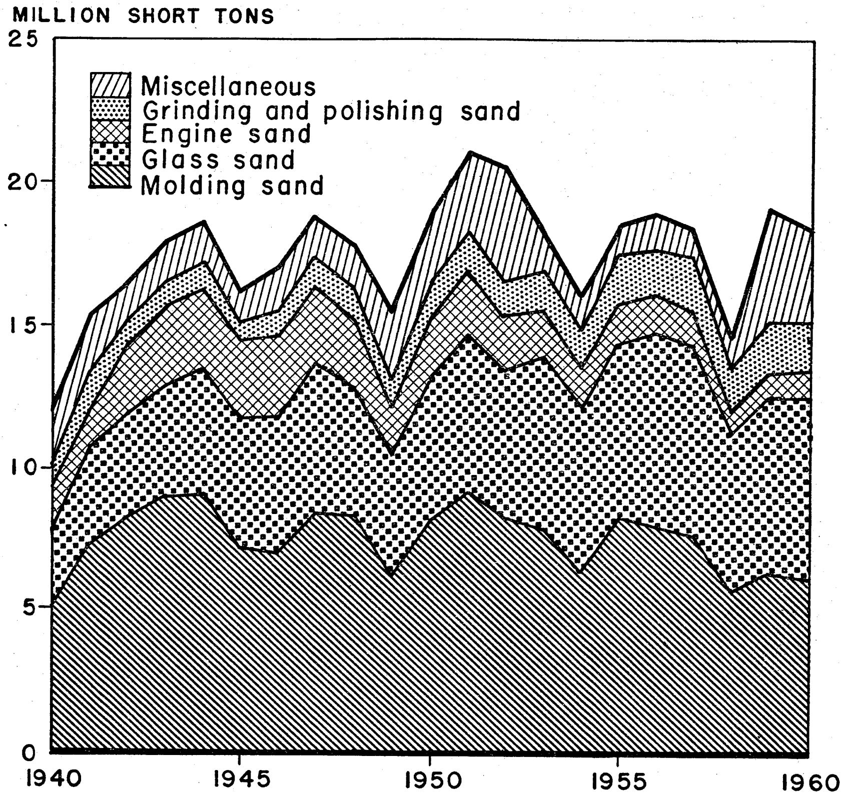

FIGURE 3.—Production of industrial sands in the United States, 1940–60.

TABLE 11.—Ground sand sold or used by producers in the United States,[1] by uses

Use	1959		1960	
	Short tons	Value	Short tons	Value
Abrasives	169,941	$1,605,147	162,391	$1,540,180
Chemicals	15,452	147,386	13,178	139,324
Enamel	9,622	107,265	9,653	107,986
Filler	118,207	787,032	123,275	752,074
Foundry uses	167,166	1,211,069	239,239	1,368,006
Glass	40,642	365,339	47,422	409,240
Pottery, porcelain, and tile	186,109	1,794,288	184,673	1,773,220
Unspecified	222,878	1,989,389	201,668	1,914,343
Total	930,017	8,006,915	981,499	8,004,373

[1] Arkansas, California, Colorado (1960 only), Georgia, Illinois, Louisiana, Massachusetts, Michigan, Minnesota, Missouri, New Jersey, New York (1960 only), Ohio, Oklahoma, Oregon (1959 only), Pennsylvania, Texas, Virginia, Washington, West Virginia, and Wisconsin (1959 only).

FOREIGN TRADE[10]

TABLE 12.—U.S. imports for consumption of sand and gravel, by classes

Year	Sand				Gravel		Total	
	Glass sand [1]		Sand, n.s.p.f., crude or manufactured					
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1951-55 (average)	5,293	[2] $98,967	304,451	[3] $334,911	69,039	[3] $11,289	378,783	[3] $445,167
1956	478	[2] 393,476	332,031	[3] 454,477	179	[3] 405	332,688	[3] 848,358
1957	683	[2] 621,065	290,280	[3] 437,114	14,877	[3] 21,951	305,840	[3] 1,080,130
1958	6,516	[2] 223,817	317,860	485,553	7,619	7,125	331,995	716,495
1959	101	[2] 91,414	348,331	463,589	102,878	92,967	451,310	647,970
1960	10,765	37,111	379,673	515,837	3,752	5,423	394,190	558,371

[1] Classification reads: "Sand containing 95 percent or more silica and not more than 0.6 percent oxide of iron and suitable for manfacturing glass."
[2] Consists mainly of synthetically prepared silica from West Germany for specialized uses and is not comparable in value to ordinary glass sand.
[3] Data known to be not comparable with other years.

Source: Bureau of the Census.

The tonnage of sand and gravel entering foreign trade is small in comparison with the total annual production. Shipments of ordinary sand and gravel were confined to small areas along the Canadian and Mexican borders where the material was used for local construction. Small quantities of specialty sands, mostly ground, were imported.

WORLD REVIEW

Australia.—Borings conducted by the Bureau of Mines, Department of South Australia, outlined a deposit of good quality sand under 8 feet of overburden, which deposit was estimated to contain 5 million tons.[11]

Canada.—Primarily because of road construction, production of sand and gravel increased to 190 million short tons valued at $110 million in 1960.[12] The 1959 output was 185 million tons valued at $105 million.[13]

A discovery of silica sand at Brothwell, Prince Edward Island, Canada, led to the establishment of two new plants, one to process sand for the electronics industry and the other to manufacture silica brick.[14]

The Sylvania sandstone formation quarried for many years in the vicinity of Rockwood, Wayne County, Mich., as a source of high-purity silica was found to project into Malden township, Essex County, Ontario. Transportation facilities to the Quebec market

[10] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.
[11] Chemical and Engineering Mining Review (Melbourne), vol. 52, No. 5, Feb. 15, 1960, p. 69.
[12] Pit and Quarry, vol. 53, No. 12, June 1961, p. 40.
[13] Canadian Mining and Metallurgical Bulletin, vol. 54, No. 585, January 1961, p. 2.
[14] Rock Products, Prince Edward Island Gets Silica Sand Plant: Vol. 63, No. 9, September 1960, p. 67.

were favorable, but high carbonate and ferric oxide content of the material and the depth of the overburden were considered unfavorable for development of the deposit.[15]

TECHNOLOGY

General.—The Michigan State Highway Department used a portable, miniature engineering seismograph to locate and define subsurface soil and rock layers. Seismic analysis proved particularly effective in establishing depth of glacial overburden and quantity of deposit of a particular type. The method was also effective in determining the location of the water table—an important factor in providing adequate drainage when designing roadway.[16]

Plant Equipment.—Greatly increased use of highly mobile tractor shovels for truck loading was noted. In some operations these shovels had entirely replaced the older clamshell cranes.

Sales rights for the German LMG bucket wheel digger were secured by a U.S. firm. Capacities of this equipment ranged from 200 to 13,000 cubic yards per hour. The maximum cutting height was 164 feet and outreach was 302 feet.[17]

A combination of a bulldozer and a 2½-yard clamshell loaded 325,000 tons of lake foundry sand during the April–November shipping season at a Lake Erie port. The bulldozer was used once to clear the dock for the next boatload and again to bring the sand within reach of the clamshell for loading into hopper cars.[18]

An Ohio producer solved the problem of recovering fines from pit-run sand by installing a sand-scalping tank and a 24-inch liquid cyclone. Formerly, the firm used sand drags; the overflow went to settling tanks. The new installation recovers more fines and eliminates much of the expense of dredging settling ponds.[19]

A western sand and gravel plant installed control consoles with which an operator electrically controls all equipment used in screening, crushing, and heavy-medium separation. Other consoles control the reclaiming belt conveyor, feeders, air-operated gates, and the flow of aggregates.[20]

An Ohio firm combined the customary lake sand production method with an operation to produce crushed gravel to meet highway specifications. In earlier operations the plus ¼-inch gravel, which amounted to 50 percent of the material pumped, was returned to the lake. Production of the combined plant was rated at 150 tons per hour.[21]

Careful planning was responsible for the successful operation of a 150-ton-per-hour sand and gravel plant in Connecticut. Two years

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[15] Reavely, G. H., and Winder, C. G., The Sylvania Sandstone in Southwestern Ontario: Canadian Min. and Met. Bull. (Montreal), vol. 54, No. 586, February 1961, pp. 139–142.

[16] Engineering News-Record, Sound Waves Map Michigan Soils: Vol. 164, No. 20, May 19, 1960, pp. 69–71.

[17] Pit and Quarry, Biggest Bucket Wheel Digger to Be Handled by U.S. Firm: Vol. 53, No. 2, August 1960, p. 28.

[18] Foundry, Handling Sand: Vol. 88, No. 3, March 1960, pp. 156, 158.

[19] Godfrey, Kneeland A., Jr., Scalper, Cyclone Solve Fines Recovery Problem: Rock Products, vol. 63, No. 1, January 1960, pp. 127–128.

[20] Rock Products, Sectional Controls for Sand and Gravel Plant: Vol. 63, No. 10, October 1960, p. 84.

[21] Traufer, Walter E., Lorain Elyria Sand Company Combines Lake and Inland Production Methods: Pit and Quarry, vol. 53, No. 3, September 1960, pp. 128–131.

were spent in locating a good deposit. The deposit (a glacial moraine) was then checked by digging test holes and a well. Construction of a crushing and screening plant as a simple straight-line operation allowed production of a material that met all State and other tests. All operations were controlled from the primary crushing station.[22]

Processing Equipment.—An aggregate producer in Arkansas processed both standard and lightweight aggregates with materials obtained from the same property. The deposit from which the two operations were supplied consisted of a 12-foot bed of sand and gravel overlying a bed of clay, which was found to have good bloating characteristics.[23]

Open-pit mining, screening and washing, and material-blending methods used in working a sedimentary deposit of quartz and quartzite were described in a paper presented before the 44th Annual Convention of the National Sand and Gravel Association at Chicago, Ill., on February 18, 1960.[24]

Production of a new semi-silica brick was begun. This brick was stated to be suitable for continuous service at temperatures up to 2,600° F. and to have unusual volume stability, load-bearing ability, and excellent resistance to structural spalling. The brick, made by a dry-press method, contained approximately 75 percent silica.[25]

An Illinois sand and gravel plant installed a twin scalping-classifying tank to reclaim a premium-specification sand. Other new features were washing, classifying, and blending facilities, which allowed the plant to produce four grades of gravel and three grades of sand. Only three men were required to operate the plant, which had a rated capacity of 200 tons per hour.[26]

A jig installation was effective at a Scottish sand and gravel plant in removing unwanted constituents such as coal, shale, and feldspar. The maximum capacity of the plant was 80 tons per hour of gravel plus 40 tons per hour of sand.[27]

Heavy-Medium Plants.—A dual heavy-medium separation unit was used to process aggregate for the Flaming Gorge Dam in northeastern Utah.[28] High-grade aggregates were produced by heavy-medium separation from a rather low-grade deposit at the new plant of Southern Pacific Milling Co. in El Rio, Calif. The deposit contains both acidic and basic particles, shale, silt-stone and sedimentary sandstone. The medium consisted of a water suspension of about equal parts of magnetite and ferrosilicon and allowed material with specific gravity of less than 2.55 to float.[29]

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[22] Pit and Quarry, Careful Planning Precedes Construction of Connecticut Sand and Gravel Plant: Vol. 53, No. 5, November 1960, pp. 112–117.
[23] Herod, Buren C., Standard and Lightweight Aggregates From Materials in Single Pit: Pit and Quarry, vol. 53, No. 5, November 1960, pp. 118–120, 123–125.
[24] Walker, John S., The Functioning of a Sand and Gravel Plant Designed for Uniform Grading Control: Cement, Lime and Gravel (London), vol. 35, No. 7, July 1960, pp. 189–192.
[25] Ceramic Industry, vol. 76, No. 1, January 1961, p. 26.
[26] Rock Products, Problem: Tough Market, Solution: Build a New Plant: Vol. 63, No. 7, July 1960, pp. 90–95.
[27] Mine and Quarry Engineering (London), A Scottish Sand and Gravel Plant: Vol. 26, No. 11, November 1960, pp. 458–467.
[28] Utley, Harry F., HMS Plays Lead Role in Aggregate Processing: Pit and Quarry, vol. 53, No. 4, October 1960, pp. 84–90.
[29] Utley, Harry F., Heavy-Media Separation: Pit and Quarry, vol. 52, No. 8, February 1960, pp. 96–100.

Portable Plants.—A Texas sand and gravel plant comprised of standardized units or sections was placed in operation. The unitized layout provided ease in erecting or dismantling and allowed integration with one or more of the companies' plants as needed. Standard components included such items as structural sections, control rooms, and switch gear.[30]

Details of a portable sand and gravel plant, having a productive capacity of 700 tons per hour, were reported. The plant, which moves on five trailers and a van, replaced four permanent plants. Portability and ease of erection gave the needed versatility to produce satisfactory products from a variety of deposits.[31]

Vertical Sand Drains.—The sand-drain method was used to build a section of the Trans-Canada Highway between Vancouver and New Westminister, British Columbia, Canada. This section of the highway crosses deposits of muskeg and soft clay up to 80 feet deep, which are too soft to support construction equipment. A thick layer of sawdust was first spread over the muskeg, followed by approximately 8 feet of sand. A mandrel was then driven to the required depth, filled with sand, and withdrawn. The porous sand drains allowed water to escape from the underlying soil layers as they consolidated under load.[32]

Patents.—The use of furfural residue as a carbonaceous material in building up a foundry molding sand, comprising silica particles and dispersed clay was described.[33]

Impurities were removed from silica sand by mixing the impure sand with ammonium chloride or similar material and heating the mixture to volatilize contaminants.[34]

A patent was granted for removing iron from silica by forming an aqueous slurry of hydrochloric acid, fluosilicic acid, and sand; separating the sand from the liquid; and washing the sand with water until it was free from acid. By this method the sand was substantially freed from iron without dissolving an appreciable quantity of silica.[35]

A patent was granted for an isomerization catalyst consisting essentially of a silica-alumina catalyst combined with metallic palladium and a small quantity of a group VIII metal of the iron series. The catalyst shows hydrocarbon cracking activity.[36]

A method for preparing silica for pigments was patented by which silica is precipitated in flocs, having a surface area of 75 to 200 square meters per gram and an average particle size of 0.015 to 0.04 micron.[37]

A synthetic silica-alumina-magnesia catalyst consisting essentially, by weight, of 55 to 85 percent SiO_2, 5 to 40 percent Al_2O_3, and 4 to 30

[30] Pit and Quarry, Sand and Gravel Plant Built to Dual-Purpose Design: Vol. 52, No. 12, June 1960, pp. 126–131.
[31] Bergstrom, John H., Teichert Teams Capacity and Mobility: Rock Products, vol. 63, No. 10, October 1960, pp. 98–102.
[32] Engineering News-Record, Sawdust Supports Highway Over Swamp: Vol. 165, No. 4, July 28, 1960, p. 42.
[33] King, Edward H., Heine, Richard W., and Schumacher, Joseph S. (assigned to Hill and Griffith Co., Cincinnati, Ohio), Carbonaceous Component for Foundry Molding Sand: U.S. Patent 2,920,970, Jan. 12, 1960.
[34] Potter, C. (assigned to Englehard Industries, Inc.), Treatment of Sand: U.S. Patent 2,911,286, Nov. 8, 1959.
[35] Gross, John H. (assigned to International Minerals and Chemical Corp.), Purification of Sand: U.S. Patent 2,952,516, Sept. 13, 1960.
[36] Miller, Elmer L., Folkins, Cary, and Folkins, Hillis O. (assigned to the Pure Oil Co., Chicago, Ill.): U.S. Patent 2,967,207, Jan. 10, 1961.
[37] Thornhill, Fred S. (assigned to Columbia-Southern Chemical Corp.), Method of Preparing Silica Pigments: U.S. Patent 2,940,830, June 14, 1960.

percent MgO was used in a patented process for converting hydrocarbons. The catalyst was said to have a pore volume of 0.5 to 1 cubic centimeters per gram and a surface area of 400 to 550 square meters per gram when converting hydrocarbons.[38]

Glass.—A technique for winding glass fiber filaments was developed, which can be applied to the building of open or closed spherical, conical, and cylindrical vessels, irregular shapes, and flat surfaces. Heat, strength, and weight factors can be controlled. The process will be of value in constructing airborne thrust chambers, rocket chambers, cones, and pressure vessels.[39]

A new factory for producing glass fiber, which will have a capacity of 12,000 tons per year, was to be built near Bergamo, Italy. A process developed by Cie. de Saint-Gobain of Paris will be used.[40]

Foundry Sands.—The preparation of sands to be used in the shell-molding process for producing accurate castings was described in a series of articles. Types of sands, suitable resins, and the proportioning of the sand-resin mix were described.[41]

An operation that used an automatic batching system for preparing cold-setting sand mixes was reported. Pushbutton controls adjusted additions to the sand for various mixes, weighed the dry ingredients, metered the oil binders, cycled the mixing, and discharged the sand automatically.[42]

The problem of sand segregation, a serious foundry problem, was the subject of a report made by a committee of the American Foundrymen's Society. The mechanism of foundry sand segregation, the effects upon surface area, casting finish, and methods for decreasing segregation were described.[43]

Large-scale tests in foundries indicated that peat is an acceptable substitute for wood flour in making greensand molds.[44]

Special Silicas.—An investigation was conducted to develop a method by which the toughness of sands used for grinding glass could be evaluated. Sands from five widely separated geographical locations and having different geological origins were tested and found to have significant variations in toughness. In grinding plate glass, spherical grains were found to be more resistant to crushing than angular grains. The ball-milling technique used for evaluating glass-grinding sands was judged to be reliable.[45]

The use of colloidal silica to keep painted surfaces clean was described. A very thin coating of the silica, applied by brush, spray, or mopping, was used. The coating filled imperfections and pores and kept out dirt. The film did not affect weathering of paint nor interfere with repainting.[46]

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38 Braithwaite, David G. (assigned to Nalco Chemical Co.), Conversion of Hydrocarbons with a Synthetic Silica-Alumina-Magnesia Catalyst Composite: U.S. Patent 2,958,648, Nov. 1, 1960.

39 Zimmerman, G. A., and Krupp, C. P., Filament Winding Stretches Production: Missiles and Rockets, vol. 7, No. 28, Nov. 28, 1960, pp. 28–30.

40 Chemistry and Industry (London), No. 34, Aug. 20, 1960, p. 1073.

41 Willetts, E. R. B., Shell Moulding Sands: Metal Ind. (London), vol. 96, No. 11, Mar. 11, 1960, pp. 207–210; vol. 96, No. 12, Mar. 18, 1960, pp. 235–236.

42 Foundry, Cold Setting Sand Mixes: Vol. 88, No. 3, March 1960, pp. 103–107.

43 Seaton, T. W., Sand Segregation: Metal Ind. (London), vol. 96, No. 4, Jan. 22, 1960.

44 Foundry, Peat Use in Sand: Vol. 88, No. 10, October 1960, p. 152.

45 Hoffman, Richard C., Toughness of Grinding Sands: The Glass Ind., vol. 41, No. 9, September 1960, pp. 483–486, 524, 526.

46 Rock Products, Colloidal Silica Applied to Surfaces Will Keep Them Clean: Vol. 63, No. 10, October 1960, p. 14.

The conclusions of two research workers[47] were in agreement as to the need for ultrafine grinding of quartz materials used in manufacturing cement. Silicon, in the form of silicates, is much more reactive in the kiln than quartz. Consequently, it is important to determine the presence of quartz in the raw materials used and control the fineness of grinding to compensate for its presence. It was concluded that fine grinding of quartz produces a disturbed layer of highly reactive material upon siliceous particles and that it is possible by this method to use quartz and basic or devitrified volcanic rocks as a source of active pozzolans.

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[47] Fernandez, A. V., Determining the Content of Free Silica and the Specific Surface of New Materials for Cement Manufacture: Building Science Abs. (London), vol. 33, No. 7, July 1960, p. 197.
Alexander, K. M., Reactivity of Ultrafine Powders Produced From Siliceous Rocks: Jour. Am. Concrete Inst., vol. 32, No. 5, November 1960, pp. 557-569.

Silicon (High-Purity)

By H. Austin Tucker [1]

FOR THE first time, the Federal Bureau of Mines collected production data from prime producers and published it in a separate chapter as interest in high-purity silicon for electronic purposes intensified. High-purity silicon data formerly appeared in the Minor Metals Chapter.

The output of high-purity silicon increased markedly in 1960 because of increased demand and technological improvements. Prime producers shifted steadily toward making more single-crystal silicon to broaden their marketing base as inventories continued to increase and sharp price declines in polycrystal silicon occurred.

Data on lower grades of silicon, such as those used for alloying aluminum and copper alloys and in producing silicones, are included in the Ferroalloys Chapter.

DOMESTIC PRODUCTION

In 1960, producers of high-purity silicon made and marketed 76,000 pounds of polycrystal silicon and 19,000 pounds of single crystal. The latter was converted by producers from bulk polycrystal with losses ranging from 20 to 50 percent. To maintain comparability with reports of production of bulk silicon for previous years, 105,000 pounds of polycrystal high-purity silicon was calculated to have been produced in 1960, and 73,000 pounds in 1959. The conversion of greater quantities of polycrystal to single-crystal silicon helped increase the value of the total quantity sold to $22.9 million in 1960, compared with $16.9 million in 1959.

The product mix of high-purity silicon producers began changing from primarily bulk silicon to more single-crystal material in 1960. Before 1960, most firms made polycrystal silicon as their major product, which they sold in bulk either directly to manufacturers of electronic devices or to firms that converted it to single-crystal material for such manufacturers. But in 1960, as inventories increased, more prime producers installed crystal-making equipment as a means of upgrading their product and thereby increasing its marketability. As a result, single-crystal shipments increased more than threefold over 1959.

[1] Commodity specialist, Division of Minerals.

TABLE 1.—Production, shipments, value, and stocks of high-purity silicon in the United States [1]

Specifications		Polycrystal								
Grade	Boron level, maximum (parts per billion)	Stocks as of Dec. 31, 1958 (pounds)	1959 Production (pounds)	1959 Shipments Pounds	1959 Shipments Value	Stocks as of Dec. 31, 1959 (pounds)	1960 Production (pounds)	1960 Shipments Pounds	1960 Shipments Value	Stocks as of Dec 31, 1960 (pounds)
1	3	2,841	28,693	26,217	$8,297,971	5,073	24,246	22,471	$4,513,826	6,521
2	6	1,833	16,289	14,375	3,064,008	2,852	28,709	25,016	3,850,995	6,545
3	11	1,867	13,124	11,060	1,464,743	3,197	10,336	9,404	1,216,169	4,129
Solar		744	6,572	5,695	500,794	1,338	12,234	11,894	1,317,485	1,678
Total		7,285	64,678	57,347	13,327,516	12,460	75,525	68,785	10,898,475	18,873
		Single-crystal								
1	3	162	4,521	3,589	$3,086,562	904	14,064	10,916	$8,728,123	2,918
2	6		635	535	406,870	118	3,479	2,764	2,342,553	668
3	11		327	165	118,218	183	1,645	979	734,332	742
Solar			(2)	(2)	(2)	(2)	(2)	413	221,638	596
Total		162	5,483	4,289	3,611,650	1,205	19,188	15,072	12,026,646	4,924

[1] Includes Puerto Rico.
[2] Figure withheld to avoid disclosing individual company confidential data.

In 1960, polycrystal silicon production and shipments increased significiantly in two categories and decreased in another. Solar-grade silicon with no specific purity designation doubled in both quantity made and quantity shipped, revealing the growing use of silicon as a solar-energy converter. Grade 2 silicon production and shipments increased 75 percent, indicating that manufacturers of electronic devices were becoming more selective in their purchasing and more efficient in their fabricating. On the other hand, grade 1 silicon decreased about 15 percent in quantity made and shipped. For all categories of polycrystal silicon, production increased 17 percent over that for 1959, and shipments increased 20 percent.

Considerable activity occurred among producers in 1960. New producers were Monsanto Chemical Co., with a plant at St. Charles, Mo., and Dow Corning Corp., with a semicommercial plant at Hemlock, Mich. The latter firm expected to complete its commercial plant at Hemlock by early 1961. Both of these producers made silicon using a method licensed by the West German firm, Siemens & Halske, through Westinghouse Electric Corp., exclusive holder of the rights to the process in the United States. In May, E. I. du Pont de Nemours & Co., Inc., announced that it had been licensed by International Telephone & Telegraph Co. to use a new process for making silicon of the highest purity based on the thermal decomposition of silane, SiH_4. A new manufacturing facility was established at Du Pont's plant in Newport, Del. Du Pont continued to operate its larger plant at Brevard, N.C. The Eagle Picher Co. discontinued production of high-purity silicon early in 1960. Foote Mineral Co. ceased operating its semicommercial facility in Exton, Pa., in April, although it never made silicon commercially. Mallinckrodt Chemical

Works, St. Louis, Mo., and Kemet Co., Cleveland, Ohio, began making high-purity silicon in 1958, but were not mentioned in the Mineral Yearbook for 1959 through an oversight. The remaining six producers of high-purity silicon and their plant locations were: International Metalloids, Inc., Toa Alta, Puerto Rico; Sylvania Electric Products, Inc., Towanda, Pa.; Allegheny Electronic Chemicals Co., Bradford, Pa.; Trancoa Chemical Corp., Reading, Mass.; Merck & Co., Inc., Danville, Pa.; and Texas Instruments, Inc., Dallas, Tex, which began full production in its newer and larger plant early in 1960.

CONSUMPTION AND USES

Although some solar-grade material was made into electronic devices rather than solar cells, the electronic industry primarily fabricated electronic devices from 56,900 pounds of polycrystal and 14,700 pounds of single-crystal silicon. In all, 80 million diodes and rectifiers valued at $126 million and 8.8 million transistors valued at $100 million were made. This was a considerable increase over the 53.5 million diodes and rectifiers valued at $101 million and approximately 5 million transistors valued at about $72 million manufactured in 1959.[2] Thousands of solar cells were made from the 12,300 pounds of polycrystal and monocrystal solar-grade silicon shipped by producers in 1960. Silicon remained the best material for converting solar energy to electrical energy. It was essentially the only material used for solar cells despite efforts to develop solar cells made with gallium arsenide, cadmium sulfide, and other materials.

STOCKS

Yearend stocks increased for the third successive year. The stock of polycrystal material on hand December 31, 1959, was 19 percent of the production figure for 1959; that on hand December 31, 1960, was 25 percent of the quantity produced in 1960, a significant increase. Likewise, for single-crystal silicon, the comparable increase in stocks was from 2.8 percent of production in 1959 to 25.7 percent in 1960.

PRICES

The two large price cuts of polycrystal silicon made in February and July (table 2) indicated that the market was becoming saturated early in 1960. The excess supply of silicon resulting from increased output by the new plants and from expanded production facilities of older plants, and the indicated technological improvements in making silicon contributed to price reductions.

Corresponding to the price changes for grade 1, grade 2 silicon dropped from $220 to $125 a pound; grade 3, from $130 to $100; and solar grade, from $90 to $80.

The average values reported for polycrystal silicon, as revealed by table 1, were $316 a pound for grade 1 in 1959 and $200 in 1960, and

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[2] Electronic Industries Association, Marketing Data Department monthly publications, Factory Sales of Germanium and Silicon Semiconductor Diodes and Rectifiers: December 1959, pp. 5, 7, and December 1960, pp. 5, 7; Factory Sales of Transistors: December 1959, pp. 7, 8, and December 1960, pp. 7, 8.

TABLE 2.—Price of grade 1 polycrystal silicon in 1960

(Per pound)

Marketing quantity (pounds)	January	February	July	September
Less than 25	$330	$270	$210	$175
26 to 99	330	270	210	150
100 and over	300	260	200	150

TABLE 3.—Price of single-crystal silicon

(Per gram)

Resistivity range, grade (ohm-centimeters)		October 1959	August 1960
Type N	Type P		
Below 0.09	Below 0.09		$1.59
0.1 to 50	0.1 to 100	$1.55	1.39
51 to 100	101 to 200	1.71	1.59
101 to 500	201 to 1,000	1.875	1.79

$213 for grade 2 in 1959 and $154 in 1960. Single-crystal silicon decreased in price significantly, as shown in table 3. The average value reported for single-crystal silicon did not reflect the price changes from 1959 to 1960, perhaps because of a variety of opinions among producers on grade levels and because of a shifting of items by producers from one grade to another to fulfill order requests.

WORLD REVIEW

Belgium.—The Belgian metallurgical and chemical firm, Société Générale Métallurgique de Hoboken, announced in August that it would begin large-scale production of high-purity silicon early in 1961 in a new plant being constructed at Olen. This plant, to cost $6 million, was to have a capacity of 2,200 pounds per month of silicon with a resistivity quality extending to 5,000 ohm-centimeters.

Japan.—In the summer of 1959, two Japanese firms acquired rights to produce silicon. The Mitsubishi enterprises dealt with the French firm, Pechiney, Compagnie de Produits Chimiques et Electro-Metallurgiques (Pechiney); the Shinetsu Chemical Co., Ltd., licensed the process developed by the West German firm, Siemens & Halske.[3] In 1960, Japan imported 2,400 pounds of single-crystal silicon, mostly from the United States, compared with 2,600 pounds in 1959. At yearend, this downward trend promised to continue as the result of greater production of silicon by Japanese firms, including the following six fabricators: Nitchitsu Electronics Chemical Co., Ltd., operating a 2,200-pound-per-year plant for single crystals; Komatsui Electronic Metal Co., Ltd., and Nippon Electronic Metal Co., Ltd., each planning to produce a half-ton per year; Shinetsu Chemical Co., Ltd., Toyo Electrode Co., Ltd., and Osaka Titanium Co., Ltd., planning to produce a total of ¾ to 1 ton in 1961.[4] Two additional firms

[3] Chemical Week, Pure Silicon to Japan: Vol. 85, No. 6, Aug. 8, 1959, p. 64.
[4] Electronic News, Japan Bureau, Japan Raises Output, Cuts Silicon Import: Vol. 6, Whole No. 242, Jan. 23, 1961, p. 28.

entered the field of silicon refining in 1960, Showa Denko, K. K., a chemical producer, and Shin Nippon Chisso Hiryo, K. K., a fertilizer processor.

United Kingdom.—In October, Imperial Chemical Industries, Ltd., announced that at its plant at Mercyside, England, it had increased production to a rate of 10,000 pounds of high-purity silicon per year and had dropped prices 45 percent.

TECHNOLOGY

The technology of making and fabricating high-purity silicon changed rapidly. Producers continued either to build new plants with more efficient handling and processing methods or to redesign equipment and add more units to existing plants. Consumers of silicon continued to improve fabricating techniques as well as design of electronic devices. These activities of producers and consumers tended to make more silicon available than could be fabricated, despite a greater production of semiconductor devices.

Silicon was commonly produced within the impurity range of 0.2 to 1.8 parts per billion, with less than 0.1 part per billion for certain single-crystal products. Boron had been reduced in importance as an impurity because improved refining processes took most of it out of the raw materials. Thus, the total impurity content of silicon, rather than that of boron alone, became the important factor influencing resistivity. Certain impurity elements are beneficial.

In 1960, device manufacturers experimented with crystal growth by vapor-phase techniques called thin-film or epitaxial growth, reported in Minerals Yearbook 1959, volume 1 (*see* Minor Metals Chapter). The term "epitaxial growth" means to deposit axially upon a single-crystal substrate a layer of the same material that extends the substrate's single-crystal structure. By yearend, all prime producers and device manufacturers were making, or preparing to make by this method, built-up wafers for the initial step toward fabricating transistors.

The common feature in the several methods of depositing silicon epitaxially from the gaseous phase is a hot single-crystal wafer or substrate, exposed to an atmosphere charged with a silicon compound such as silane, SiH_4. The substrate is heated to a temperature between 700° and 1,300° C. depending upon the silicon compound being used. The growth rates of the single-crystal thin-film on the substrate range from 0.25 to 5.0 microns per minute.[5] In addition to being a convenient means of obtaining thin, single-crystal layers of silicon of various thicknesses and geometric shapes, the method gives great electronic advantages. The switching times of silicon transistors have been reduced from 200 to 20 billionths of a second (nanoseconds). This time gain is important in computer applications. However, of paramount importance to the high-purity-silicon industry must be the division of work between it and the electronic industry since both can vaporize thin films. Also, the silicon industry may be finding that its chief function is to supply low-cost silicon for substrates.

[5] La Fond, D. C., Exploiting the Advantages of Vapor: Missiles and Rockets, vol. 7, No. 25, pp. 24–25, 28.

The principal application of epitaxially grown, single-crystal films was in the mesa-type transistor. This is a relatively new electronic device whose name, mesa, is derived from the western geological formation that it resembles in miniature. The built-up layers of variously doped, single-crystal silicon can be more precisely controlled through vapor deposition than by previous methods, which were limited to masking and etching. The combining of the two technologies, resulting in epitaxially grown mesa transistors, became commercially practical after an experimental device was first shown in June by the Bell Telephone Laboratories, Murray Hill, N.J.[6] In comparison with conventionally fabricated mesa transistors, they have higher breakdown voltage (90 v.), higher saturation voltage, and lower collector capacitance. Collector-base breakdown voltages are 120 volts at 10 milliamperes, and storage times are as low as 12 nanoseconds. Collector saturation voltage is reduced from 0.4 to 0.14 volt (typical). The silicon films are as thin as 0.0005 inch over a low-resistivity wafer. From this overlaid wafer, a mesa transistor is then fabricated using the same diffusion, masking, and etching techniques as for conventionally made mesas. Since the active part of the transistor is all within the high-resistivity vaporized thin-film, the technique is an easy means of providing a half-mil-thick wafer. The principal advantages of the mesa transistors made from the epitaxially grown single crystals are in high-voltage, high-current types. Ideally, the collector region of a transistor should be 0.1 mil thick. It is extremely difficult, if not impossible, to grind and lap a wafer this thin; therefore, the doped, vaporized film that continues in the same crystalline structure as the substrate but whose thickness can be measured in microns approaches the ideal. Thus, an easily applicable technique was developed for making semiconductor devices with silicon that should greatly increase the use of silicon as a fast switching transistor for computer use and render the conventional mesa transistor obsolescent.

Solar cell technology improved energy-conversion efficiency, increased resistance to radiation, and developed protective glass covers for cells. The efficiency of solar cells was commonly 8 percent. However, through the development of a nickel-plated, solder-dipped, positive-contact strip, which reduces the series resistance of the P-type layer of cells, the efficiency was raised to as high as 14 percent.[7] Accurate determination of solar cell performance remained a problem since a good sunlight simulator was lacking. Army scientists made a silicon solar cell by diffusing phosphorus into a positive-type crystal instead of by the usual method of diffusing boron into a negative-type crystal. This operation, which could be accomplished at 950° C. instead of 1,150° C., as heretofore, apparently caused less damage to the crystal structure. The beneficial effect of this change was that the cells were 10 to 40 times more resistant to high-energy radiation experienced in space flight.[8] This was important since the

[6] Electronic News, Epitaxial Si Mesa Output Underway at Motorola: Vol. 5, Whole No. 226, Oct. 10, 1960, p. 55.

[7] Missiles and Rockets, Hoffman Hits High in Solar Cell Efficiency: Vol. 6, No. 18, May 2, 1960, p. 31.

[8] Henkel, R., High Radiation-Resistant Solar Cell Evolved: Electronic News, vol. 5, Whole No. 225, Oct. 3, 1960, pp. 1, 4.

failure of the power supply of the satellite Explorer VI in 1959 apparently was caused by radiation damage. Corning Glass works developed types of glass to protect solar cells in space vehicles.[9] These glasses protected silicon solar cells from high temperature, thermal shock, and micrometeorites. One glass darkened under radiation; the other, made of fused silica, remained clear to 10^9 roentgens of gamma radiation. Several satellites were said to carry these protective glasses.

The tunnel diode, the spectacular development of 1959, had not proved as successful as expected by the end of 1960. Those made of gallium arsenide tended to break down easily, and consumption lagged for want of circuitry designs to use them. The prospects at yearend were that lower cost electronic devices made by epitaxial growth methods would dominate in switching applications and that tunnel diodes would be used only in ultra-high-speed positions, thus improving the outlook for silicon.

Texas Instruments, Inc., and International Telephone and Telegraph Corp. agreed to exchange nonexclusive patent licenses and technical information concerning semiconductor components. A patent was issued relating to the purification of silicon halides.[10] The basis of the process is the compounding of the silicon halide containing trace quantities of contaminates with a dinitrile compound of the formula NC–R–CN, where R is selected from the group consisting of aliphatic and aromatic divalent groups. It separates substantially pure silicon halide from the dinitrile compound, which retains the contaminating compounds.

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[9] Electronic News, vol. 6, Whole No. 247, Feb. 27, 1961, p. 41.
[10] Conn, John B. (assigned to Merek & Co.), Purification of Silicon Halides: U.S. Patent 2,970,040, March 7, 1958.

Silver

By J. P. Ryan [1] and Kathleen M. McBreen [2]

MINE PRODUCTION of silver in the United States declined for the fourth successive year in 1960 to the lowest in 14 years. Mine output was 30.8 million ounces, compared with 31.2 million ounces in 1959. Strikes were again the chief factor affecting production. Net industrial consumption of silver, however, increased slightly to about 102 million ounces.

Silver imports, including lend-lease returns, dropped sharply for the third successive year, but exports nearly doubled. The New York market price remained unchanged at 91⅜ cents an ounce and prices on the London market were steady, fluctuating in a narrow range slightly higher than the New York price.

Sales of silver to domestic consumers and withdrawals for subsidiary coinage, partly offset by lend-lease returns and domestic purchases, reduced free-silver stocks in the Treasury by 51.6 million ounces, nearly 30 percent. Total Treasury stocks dropped 3 percent to 1,992 million ounces at yearend.

TABLE 1.—Salient silver statistics

	1951–55 (average)	1956	1957	1958	1959	1960
United States:						
Mine production---thousand ounces--	38,185	38,721	38,165	34,111	31,194	30,766
Value---thousands--	$34,560	$35,045	$34,541	$30,872	$28,232	$27,845
Ore (dry and siliceous) produced (thousand short tons):						
Gold ore	2,325	2,255	2,359	2,411	2,289	2,267
Gold-silver ore	171	245	116	107	137	347
Silver ore	560	687	712	639	597	641
Percentage derived from—						
Dry and siliceous ores	32	29	32	41	45	37
Base-metal ores	68	71	68	59	55	63
Imports, general [1]--thousand ounces--	82,691	162,832	206,119	165,966	69,088	60,657
Exports [1]---do----	3,203	5,501	10,299	2,733	9,180	26,593
Stocks Dec. 31: Treasury million ounces--	----------	1,981	2,014	2,106	2,060	1,992
Consumption in industry and the arts thousand ounces--	98,980	100,000	95,400	85,500	101,000	102,000
Price: Treasury--per troy ounce [2]--	$0.905+	$0.905+	$0.905+	$0.905+	$0.905+	$0.905+
World: Production-----thousand ounces--	215,200	[3] 225,600	230,800	238,500	[3] 221,200	239,500

[1] Excludes coinage.
[2] Treasury buying price for newly mined silver.
[3] Revised figure.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

Estimated world silver production increased 8 percent to 239.5 million ounces, with gains recorded by most of the principal silver-producing countries. Consumption of silver in the free world for industrial uses and coinage was estimated at 319.3 million ounces, a 6 percent increase over 1959. U.S. consumption aggregating 148 million ounces, thus was 46 percent of the total free-world consumption.

Bills to repeal the silver purchase laws, which deal with monetary silver, again were introduced in the 86th Congress (H.R. 11744, S. 3410). The bills were referred to the respective committees on Banking and Currency of the House of Representatives and Senate, but no further action was taken.

DOMESTIC PRODUCTION

Mine production of recoverable silver in the United States declined for the 4th successive year, reaching the lowest level since 1946. Output dropped about 1 percent to 30.8 million ounces, compared with 31.2 million ounces in 1959. Although strikes at major copper mines, which reduced the yield of byproduct silver in 1959, were settled early in 1960, strikes at major silver and silver-lead-zinc mines in Idaho, begun in May and continuing to near the end of the year, were the chief factors in the drop in silver production. The United States maintained its third-place position among leading silver-producing countries behind Mexico and Canada and only slightly ahead of Peru.

Substantial production gains were recorded for Arizona, Colorado, Nevada, New Mexico, North Carolina, Utah and other States (principally Washington), but these gains failed to offset sharp losses in silver output in Idaho and Missouri. Despite the sharp drop in output due to strikes, Idaho maintained its rank as the leading silver-producing State by a wide margin followed in order of output by Utah, Arizona, and Montana. These four States supplied 87 percent of the total domestic output. Missouri's low output was attributed to the lack of desilverization in lead-refining operations.

Nearly two-thirds of the total domestic silver output was recovered as a byproduct of ores mined for base metals and gold. Silver ores in Idaho furnished virtually all of the remainder. Of the 25 leading silver-producing mines, only 4 depended chiefly on the value of silver in the ore. Only 5 of the leading 25 mines produced over 1 million tons each in 1960, and these mines supplied 47 percent of the total domestic output; the 25 leading mines (table 4) contributed 85 percent. Domestic mines contributed about 30 percent of the total silver used in the Nation's arts and industries.

Approximately 4,000 persons were employed in the silver and gold-silver mining industry in 1960 at 400 separate lode and placer mining operations.

TABLE 2.—Silver produced in the United States according to mine and mint returns

(Troy ounces of recoverable metal)

	1951-55 (average)	1956	1957	1958	1959	1960
Mine	38,185,445	38,721,364	38,164,915	34,111,027	[1] 31,194,006	30,766,327
Mint	37,907,493	38,739,400	38,720,200	36,800,000	23,000,000	36,800,000

[1] Revised figure.

TABLE 3.—Mine production of silver in the United States in 1960, by months

Month	Troy ounces	Month	Troy ounces
January	2,096,080	August	2,528,069
February	2,433,198	September	2,504,363
March	3,015,718	October	2,337,581
April	3,015,662	November	2,402,819
May	2,817,302	December	2,519,239
June	2,549,424		
July	2,546,872	Total	30,766,327

TABLE 4.—Twenty-five leading silver-producing mines in the United States in 1960, in order of output

Rank	Mine	District or region	State	Operator	Source of silver
1	Sunshine	Coeur d'Alene	Idaho	Sunshine Mining Co	Silver ore.
2	Utah Copper	West Mountain (Bingham)	Utah	Kennecott Copper Corp	Copper ore.
3	Lucky Friday	Coeur d'Alene	Idaho	Lucky Friday Silver-Lead Mines Co	Lead ore.
4	Galena	do	do	American Smelting and Refining Company.	Silver ore.
5	United States & Lark	West Mountain (Bingham)	Utah	United States Smelting, Refining, and Mining Co.	Gold-silver, lead-zinc ores.
6	Bunker Hill	Coeur d'Alene	Idaho	The Bunker Hill Co	Lead-zinc ore.
7	Silver Summit	do	do	Hecla Mining Co	Silver ore.
8	Iron King	Big Bug	Arizona	Shattuck Denn Mining Corp	Lead-zinc ore.
9	Butte Hill Mines	Summit Valley (Butte)	Montana	The Anaconda Company	Copper ore.
10	Kelley	do	do	do	Do.
11	Berkeley Pit	do	do	do	Do.
12	Copper Queen-Lavender Pit	Warren	Arizona	Phelps Dodge Corp	Do.
13	Morenci	Copper Mountain	do	do	Copper, gold-silver ores.
14	Treasury Tunnel-Black Bear-Smuggler Union.	Upper San Miguel	Colorado	Idarado Mining Co	Copper, lead-zinc ores.
15	Magma	Pioneer	Arizona	Magma Copper Co	Copper, gold-silver ores.
16	Eagle	Red Cliff (Battle Mountain)	Colorado	The New Jersey Zinc Co	Copper, lead-zinc ores.
17	United Park City Mines	Uintah-Blue Ledge	Utah	United Park City Mines Co	Do.
18	Alice Pit	Summit Valley (Butte)	Montana	The Anaconda Company	Zinc ore.
19	Knob Hill & Gold Dollar	Republic	Washington	Knob Hill Mines, Inc	Gold ore.
20	New Cornelia	Ajo	Arizona	Phelps Dodge Corp	Copper, gold-silver ores.
21	Crescent	Coeur d'Alene	Idaho	The Bunker Hill Co	Silver ore.
22	San Manuel	Old Hat	Arizona	San Manuel Copper Corp	Copper ore.
23	Star	Coeur d'Alene	Idaho	The Bunker Hill Co	Lead-zinc ore.
24	Algonquin	Flint Creek	Montana	Trout Mining Co	Zinc ore.
25	Emperius	Creede	Colorado	Emperius Mining Co	Lead-zinc ore.

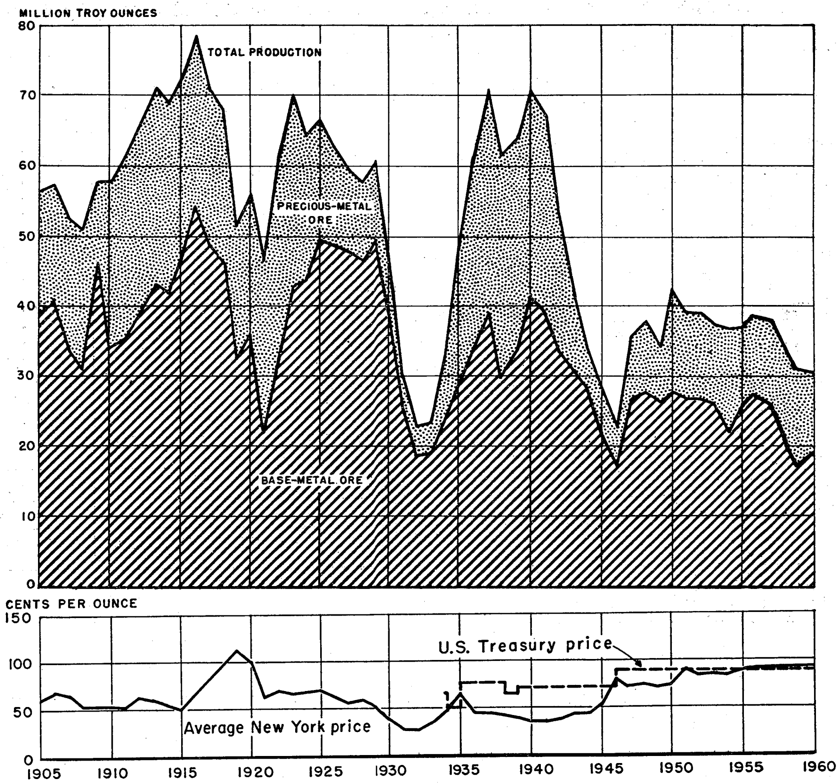

FIGURE 1.—Silver production in the United States and price per ounce, 1905–60.

TABLE 5.—Mine production of recoverable silver in the United States, by States

(Troy ounces)

State	1951-55 (average)	1956	1957	1958	1959	1960
Alaska	33,357	28,360	28,862	23,507	21,358	25,934
Arizona	4,621,347	5,179,185	5,279,323	4,684,580	3,898,336	4,774,992
California	909,001	938,139	522,288	188,260	[1] 172,810	179,780
Colorado	2,798,197	2,284,701	2,787,892	2,055,517	1,340,732	1,659,037
Idaho	14,802,960	13,471,916	15,067,420	15,952,796	16,636,486	13,646,508
Illinois	2,764	1,580	----------	----------	----------	----------
Kentucky	----------	31	56	99	75	----------
Michigan	95,600	379,990	430,000	----------	----------	----------
Missouri	336,646	295,111	183,427	250,917	339,760	15,594
Montana	6,095,968	7,385,908	5,558,228	3,630,530	3,420,376	3,606,991
Nevada	805,106	993,716	958,477	932,728	611,135	707,291
New Mexico	297,620	392,967	309,385	158,758	158,925	303,903
New York	44,520	84,158	63,880	66,738	51,588	49,324
North Carolina	124	753	12,347	15,157	16,319	212,368
Oregon	9,133	13,542	15,924	2,728	242	284
Pennsylvania	9,717	(2)	(3)	(3)	(3)	(3)
South Dakota	143,167	136,118	134,737	152,995	124,425	108,119
Tennessee	55,768	64,878	54,407	44,592	59,739	64,560
Texas	1,256	----------	----------	----------	----------	----------
Utah	6,732,078	6,572,041	6,198,464	5,277,693	3,734,297	4,782,960
Vermont	45,761	[2] 47,800	36,794	5,101	----------	----------
Virginia	958	1,874	1,745	2,023	866	----------
Washington	344,376	448,442	[3] 521,133	[3] 666,278	[3] 606,537	[3] 628,678
Wyoming	21	154	126	30	----------	4
Total	38,185,445	38,721,364	38,164,915	34,111,027	[1] 31,194,006	30,766,327

[1] Revised figure.
[2] Pennsylvania and Vermont combined.
[3] Pennsylvania and Washington combined.

TABLE 6.—Ore, old tailings, etc., yielding silver produced in the United States, and average recoverable content, in troy ounces of silver per ton in 1960[1]

State	Gold ore		Gold-silver ore		Silver ore		Copper ore	
	Short tons	Average ounces of silver per ton	Short tons	Average ounces of silver per ton	Short tons	Average ounces of silver per ton	Short tons	Average ounces of silver per ton
Alaska	136	2.066			2	260.000	60	16.167
Arizona	19,716	1.086	123,351	0.270	106,215	.138	66,087,583	.056
California	134,273	.223			177	20.904	17,450	2.198
Colorado	53,708	.111	1,220	1.405	7,400	3.250	9,649	32.354
Idaho	8,565	.563	604	2.096	358,610	26.531	77,637	.163
Montana	9,187	10.845	9,624	2.842	40,541	6.436	11,974,566	.197
Nevada	165,169	.072	79	8.570	55,881	5.788	11,779,975	.023
New Mexico			51,843	2.749	1,764	4.836	7,556,660	.010
South Dakota	1,767,135	.061					13	1.462
Utah	(5)		160,633	.517	70,728	2.446	28,074,455	.094
Undistributed [6]	109,450	5.445	67	.478	33	76.576	292,217	.081
Total	2,267,339	.387	347,421	.834	641,351	16.100	125,870,265	.075

State	Lead ore		Zinc ore		Zinc-lead, zinc-copper, and zinc-lead-copper ores		Total ore	
	Short tons	Average ounces of silver per ton	Short tons	Average ounces of silver per ton	Short tons	Average ounces of silver per ton	Short tons	Average ounces of silver per ton
Alaska	36	35.361					234	13.009
Arizona	4,280	7.954	19,456	0.079	484,643	[2] 2.008	66,845,244	.071
California	2,294	5.822			3,087	[3] 28.765	157,281	1.107
Colorado	13,864	2.527			722,903	1.770	808,744	2.051
Idaho	150,670	19.119	38,508	.617	470,712	2.568	1,105,306	12.346
Montana	14,095	3.296	261,889	3.049	[4] 7,519	[4] 2.290	12,317,421	.293
Nevada	11,451	8.917	516	.764	131	17.557	12,013,202	.059
New Mexico	12,676	2.377	177,243	.054	33,878	1.219	7,834,064	.039
South Dakota							1,767,148	.061
Utah	350	9.971	52,971	.327	485,952	3.846	28,845,089	.166
Undistributed [6]					2,967,336	[3] .109	[7] 3,369,103	[7] .281
Total	209,716	15.004	550,583	1.546	5,176,161	1.122	135,062,836	.227

[1] Missouri excluded.
[2] Includes silver recovered from uranium ore.
[3] Includes silver recovered from tungsten ore.
[4] Includes manganese ore and silver therefrom.
[5] Less than 1 ton.
[6] Includes New York, North Carolina, Oregon, Tennessee, Washington, and Wyoming.
[7] Excludes magnetite-pyrite-chalcopyrite ore and silver therefrom in Pennsylvania.

TABLE 7.—Mine and refinery production of silver in the United States in 1960, by States and sources

(Troy ounces of recoverable metal)

State	Mine production							Refinery production [1]
	Placers	Dry ore	Copper ore	Lead ore	Zinc ore	Zinc-lead, zinc-copper, lead-copper and zinc-lead-copper ores	Total	
Alaska	22,890	801	970	1,273			25,934	26,600
Arizona	9	69,480	3,696,859	34,045	1,530	[2] 973,069	4,774,992	5,338,300
California	5,609	33,656	38,361	13,355		[3] 88,799	179,780	188,100
Colorado	318	31,742	312,186	35,036		1,279,755	1,659,037	2,069,500
Idaho	92	9,520,406	12,623	2,880,601	23,769	1,209,017	13,646,508	17,813,900
Illinois								23,400
Michigan								6,200
Missouri				[4] 15,594		(4)	15,594	81,400
Montana	31	387,908	2,356,757	46,451	798,629	[5] 17,215	3,606,991	3,969,600
Nevada	556	336,048	265,881	102,112	394	2,300	707,291	703,100
New Mexico		151,061	71,827	30,125	9,585	41,305	303,903	314,500
New York						49,324	49,324	19,800
North Carolina			22,736			[3] 189,632	212,368	177,500
Oregon	101	137	46				284	300
Pennsylvania [6]								8,200
South Dakota		108,100	19				108,119	108,600
Tennessee						64,560	64,560	123,200
Utah		255,946	2,637,193	3,490	17,324	1,869,007	4,782,960	5,131,800
Washington [7]		598,348	9,140			21,190	628,678	696,000
Wyoming		4					4	(8)
Total	29,606	11,493,637	9,424,598	3,162,082	851,231	5,805,173	30,766,327	36,800,000
Percent	0.1	37.3	30.6	10.3	2.8	18.9	100.0	

1 U.S. Bureau of the Mint.
2 Includes silver recovered from uranium ore.
3 Includes silver recovered from tungsten ore.
4 Includes some silver recovered from lead-copper ore.
5 Includes silver recovered from manganese ore.
6 Included with Washington.
7 Includes silver recovered from magnetite-pyrite-chalcopyrite ores in Pennsylvania.
8 Approximately 4 ounces.

TABLE 8.—Silver produced in the United States from ore and old tailings in 1960, by States and methods of recovery, in terms of recoverable metal [1]

State	Total ore, old tailings, etc., treated (short tons)	Ore and old tailings to mills					Crude ore to smelters	
		Short tons	Recoverable in bullion		Concentrates smelted and recoverable metal			
			Amalgamation (troy ounces)	Cyanidation (troy ounces)	Concentrates (short tons)	Troy ounces	Short tons	Troy ounces
Alaska	234	136	281				98	2,763
Arizona	66,845,244	66,037,011	1	35,145	2,160,910	4,216,942	808,233	522,895
California	157,281	152,131	2,852	24,424	4,739	110,403	5,150	36,492
Colorado	808,744	790,009	1,885	2,955	106,018	1,312,279	18,735	341,600
Idaho	1,105,306	1,084,827	439		148,909	13,596,045	20,479	49,932
Montana	12,317,421	12,196,878	5		365,655	3,190,889	120,543	416,066
Nevada	12,013,202	11,920,576	215	329,668	265,036	225,614	92,626	151,238
New Mexico	7,834,064	7,685,890			274,496	151,538	148,174	152,365
South Dakota	1,767,148	1,767,135	80,662	27,438			13	19
Utah	28,845,089	28,544,500			807,221	4,461,417	300,589	321,543
Undistributed [2]	[3] 3,369,103	[3] 3,328,263	13	113,656	[3] 146,057	770,096	40,840	71,352
Total	135,062,836	133,507,356	86,353	533,286	4,279,041	28,035,223	1,555,480	2,066,265

1 Missouri excluded.
2 Includes New York, North Carolina, Oregon, Pennsylvania, Tennessee, Washington, and Wyoming.
3 Excludes magnetite-pyrite-chalcopyrite ore and concentrates therefrom in Pennsylvania.

TABLE 9.—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 from all sources (percent)			
	Amalgamation	Cyanidation	Amalgamation	Cyanidation	Smelting [1]	Placers
1951-55 (average)	93,307	279,604	0.2	0.7	99.0	0.1
1956	87,879	309,158	.2	.8	98.9	.1
1957	95,809	250,232	.2	.7	99.0	.1
1958	90,207	324,705	.3	.9	98.6	.2
1959	92,663	557,034	.3	1.8	97.7	.2
1960	86,353	533,286	.3	1.7	97.9	.1

[1] Both crude ores and concentrates.

CONSUMPTION AND USES

Domestic consumption of silver in the arts and industries increased 1 percent to 102 million ounces, according to the U.S. Bureau of the Mint. About 21 percent of the total requirements came from Treasury stocks under authority of the Act of July 31, 1946. Domestic mines and imports supplied the remainder. Demand for silver solders and brazing alloys for electrical and electronic components decreased; however, the demand for sterling and plated ware was steady, and increased quantities of silver were used for photographic materials and for military applications, partly offsetting the lower demand for manufacturers of appliances and equipment. U.S. industries continued to absorb nearly half of the world output of silver.

TABLE 10.—Net industrial [1] consumption of silver in the United States

(Thousand troy ounces)

Year	Issued for industrial use	Returned from industrial use	Net industrial consumption	Year	Issued for industrial use	Returned from industrial use	Net industrial consumption
1951-55 (average)	125,348	26,368	98,980	1958	121,500	36,000	85,500
1956	130,000	30,000	100,000	1959	142,984	41,984	101,000
1957	133,742	38,342	95,400	1960	151,007	49,007	102,000

[1] Including the arts.

Source: U.S. Bureau of the Mint.

The manufacture of photographic film and sensitized paper, the fabrication of solders and brazing materials, and the manufacture of sterling and plated ware again were the largest silver consumers. New applications of silver in military and civilian products continued to expand. Silver-zinc batteries were used as the principal source of power for the control systems of earth satellites and in the operation of other air and space vehicles. Growing use of silver in brazing honeycomb structures for these services was noted. A swimming pool water purification system using silver electrodes eliminated eye irritation and bleaching of swim suits. Purification is accomplished by silver ions, set free by electrolysis, which kill bacteria. Substantial quantities of silver continued to be used in the production of chemicals, pharmaceuticals, dental alloys and amalgams, mirrors, and medical and scientific devices, and in decorative finishes on ceramics.

Silver absorbed for U.S. subsidiary coinage increased 13 percent to 46 million ounces as demand for silver coins for coin-operated vending machines continue to grow. U.S. silver coins in circulation had increased 25 percent since 1955 to $1.8 billion. U.S. coinage accounted for nearly half of the total free-owned coinage consumption.

The influence of Government policy on silver supply, demand, and price was discussed in two separate issues of a financial publication.[3]

STOCKS

Silver bullion and coin held by the Treasury dropped 67.7 million ounces to 1,992 million ounces at yearend. In addition to lend-lease returns, the Treasury acquired 500,000 ounces of newly mined domestic silver and 3.6 million ounces from withdrawn coins and other sources. Withdrawals from Treasury silver stocks included 21.8 million ounces sold to industrial consumers and other Government agencies and 46 million ounces for subsidiary coinage. The free-silver stock was reduced 51.6 million ounces during the year to 123.5 million ounces on December 31.

At yearend the proportion of silver to the total value of gold and silver in the U.S. monetary stocks was nearly 20 percent.

TABLE 11.—U.S. monetary silver

(Million ounces)

	1956	1957	1958	1959	1960
In Treasury:					
Securing silver certificates:					
Silver bullion	1,708.4	1,711.5	1,736.3	1,741.3	1,741.8
Silver dollars	182.8	169.4	156.8	141.1	124.9
Subsidiary coin	2.0	5.9	10.9	2.4	2.0
Free silver bullion	87.4	127.4	202.2	175.1	123.5
Total	1,980.6	2,014.2	2,106.2	2,059.9	1,992.2
Coinage in circulation:					
Silver dollars	195.1	208.3	220.8	[1] 236.3	252.3
Subsidiary coin	968.0	1,014.6	1,046.2	[1] 1,094.7	1,139.9
Total	1,163.1	1,222.9	1,267.0	[1] 1,331.0	1,392.2
Grand total	3,143.7	3,237.1	3,373.2	[1] 3,390.9	3,384.4

[1] Revised figure.

Source: Compiled from Treasury Bulletin.

[3] Hardy, R. M., Jr., To Demonitize Silver Would Be Economic Folly: Commercial and Financial Chronical, vol. 192, No. 5968, July 14, 1960, p. 12.
Bratter, H. M., What Should Be Done About Monetary Silver Program: Commercial and Financial Chronical, vol. 192, No. 5984, Sept. 8, 1960, pp. 3, 22, 23.

PRICES

The U.S. Treasury buying and selling prices for silver established under authority of the Act of July 31, 1946, continued unchanged at 90.5+ and 91.0 cents a fine troy ounce, respectively. These established prices and the Treasury policy relating to the purchase of domestic production and sales to domestic consumers continued to be the main factors stabilizing the price of silver in the principal world markets.

The price of silver in the New York market remained unchanged at 91⅜ cents a troy ounce, 0.999 fine. This was the price paid by Handy & Harman for silver in unrefined materials and was ¼ cent below the price for refined bar silver offered for nearby delivery. The price in New York was fractionally lower than in other world markets as pressure of world demand brought higher prices abroad. Because prices in New York and in other centers were higher than the Treasury buying price, most of the newly mined domestic silver was sold in New York or other world markets rather than to the Treasury. Domestic consumers were obliged at times to purchase substantial quantities of silver from the Treasury to meet their requirements. Based on the average New York quotation, the price ratio of gold to silver was 38.3 to 1.

Spot prices in the London market, reflecting strong demand, were steady and ranged from a high of 80¼d. at the beginning of the year to a low of 79d. in the middle of March, equivalent to 93.67 cents and 92.37 cents, respectively. The closing price quotation for cash delivery at yearend was 79⅜d., equivalent to 92.73 cents. Forward operations in the London market increased, and changes were more frequent than for cash delivery, reflecting greater demand from speculative and industrial buyers. Quotations for 2 months delivery ranged from ¾d. (0.875 cent) per ounce discount early in the year to a premium of ⅛d. (0.146 cent) in December, the first premium over the spot price since 1942.

FOREIGN TRADE [4]

Imports.—Imports of silver, both refined and unrefined, aggregated 60.6 million ounces valued at $53.9 million, 12 percent less than in 1959. These imports included 4.6 million ounces of lend-lease silver. Canada, Mexico, and Peru again furnished most of the imported silver other than lend-lease returns.

Exports.—Exports of silver from the United States (chiefly refined bullion) increased 53 percent to 26.6 million ounces valued at $24.5 million. The sharp increase in exports was attributed to the influence of higher prices abroad and to the greater supply of available silver, following settlement of strikes which reduced refinery output in 1959. Western European countries and Japan received nearly 94 percent of the shipments.

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[4] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from the records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 12.—U.S. imports of silver in 1960, by countries

(Thousand troy ounces and thousand dollars)

Country	Ore and base bullion		Refined bullion		United States coin value
	Quantity	Value	Quantity	Value	
North America:					
Canada	12,448	$11,146	9,393	$8,620	[1] $1,620
Cuba	121	107			1,008
El Salvador	96	82			
Honduras	2,532	2,314			
Mexico	4,845	4,309	6,123	5,590	
Nicaragua	212	183			
Total	20,254	18,141	15,516	14,210	2,628
South America:					
Argentina	15	13			
Bolivia	2,488	2,260			
Chile	908	819			
Colombia	108	99			
Ecuador	94	83			
Peru	10,135	9,153	1,701	1,555	
Total	13,748	12,427	1,701	1,555	
Europe:					
Portugal	58	52			
United Kingdom	71	63			29
Total	129	115			29
Asia:					
Korea, Republic of	99	89			
Pakistan	4,588	3,262			
Philippines	2,159	1,942	36	32	
Total	6,846	5,293	36	32	
Africa:					
Liberia					820
Morocco	81	73			
Rhodesia and Nyasaland, Federation of	291	263			
Union of South Africa	855	777			
Total	1,227	1,113			820
Oceania: Australia	1,200	1,075			
Grand total	43,404	38,164	17,253	15,797	3,477

[1] Includes foreign coin valued $10,955.

Source: Bureau of the Census.

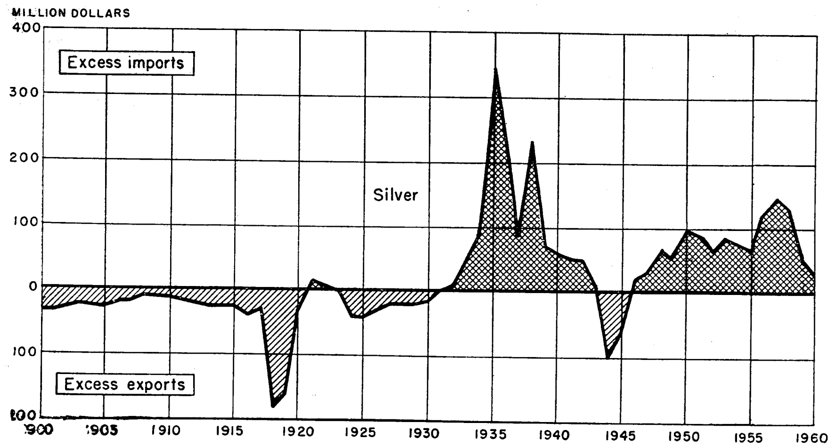

FIGURE 2.—Net imports or exports of silver, 1900–60.

TABLE 13.—U.S. exports of silver in 1960, by countries

(Thousand troy ounces and thousand dollars)

Destination	Ore and base bullion		Refined bullion		United States coin value	Foreign coin value
	Quantity	Value	Quantity	Value		
North America:						
Bahamas					$13	
Bermuda					5	
Canada	(1)	(2)	2,326	$2,132	51	$891
Cuba			2	2		(2)
Guatemala					4	
Haiti					5	
Jamaica					8	
Mexico	8	$8				
Netherlands Antilles					7	
Total	8	8	2,328	2,134	93	891
South America:						
Brazil			8	7		
Colombia			5	4		
Venezuela			10	10		
Total			23	21		
Europe:						
Belgium-Luxembourg	60	55				
France			7,393	6,773		
Germany, West	12	11	5,659	5,309		
Ireland					15	
Italy			518	475		
Portugal			322	295		
Switzerland					1	
United Kingdom	211	192	5,496	5,028		
Total	283	258	19,388	17,880	16	
Asia:						
Israel					2	
Japan			4,540	4,179		
Nansei and Nanpo Islands					5	
Turkey			23	22		
Total			4,563	4,201	7	
Africa: Liberia					280	
Oceania:						
Australia						(2)
New Zealand						(2)
Total						(2)
Grand total	291	266	26,302	24,236	396	891

1 Less than 1,000 troy ounces.
2 Less than $1,000.

Source: Bureau of the Census.

LEND-LEASE SILVER

Pakistan returned 4.6 million ounces of lend-lease silver to the United States as previously agreed, leaving a balance of 9.2 million ounces to be returned in two equal annual installments. At the end of 1960 a balance of 30.5 million ounces of silver remained unpaid of the original 410.8 million ounces supplied to foreign countries under lend-lease agreements. Only Saudi Arabia has made no returns on its lend-lease silver obligations (21.3 million ounces); however, it was reported that negotiations were begun for the settlement of this obligation. The lend-lease silver returned was added to Treasury free stocks.

WORLD REVIEW

World production of silver was estimated at 239.5 million ounces, an increase of 8 percent over 1959. Production gains were recorded in all principal silver-producing countries, and Western Hemisphere countries again contributed two-thirds of the world output. Free-world consumption of silver was estimated at 319.3 million ounces, an increase of 7 percent over 1959. Industrial uses absorbed 226 million ounces, about 5 percent more than in 1959. Silver used for coinage increased about 11 percent to 93.3 million ounces.[5] Part of the increased demand was attributed to new coinage programs in France and Italy. Because consumption of silver in the free world continued to exceed production by a substantial margin, the deficit was supplied from world stocks.

TABLE 14.—World production of silver, by countries [1,2,3]

(Troy ounces)

Country	1951-55 (average)	1956	1957	1958	1959	1960
North America:						
Canada	27,149,908	28,431,847	28,823,298	31,163,470	31,923,969	33,759,454
Central America and West Indies:						
Cuba (U.S. imports)	185,420	216,489	252,728	325,278	215,000	121,415
Guatemala	353,388	533,179	528,436	320,621	[4] 88,000	663,121
Honduras	3,551,179	2,030,008	2,260,433	2,762,932	3,167,376	2,947,021
Nicaragua	236,886	258,521	230,081	304,277	274,993	326,672
Salvador	309,280	161,476	172,305	197,629	[5] 188,000	75,846
Mexico	45,975,818	43,078,040	47,149,513	47,592,358	44,075,291	44,525,563
United States [6]	37,907,493	38,739,400	38,720,200	36,800,000	23,000,000	36,800,000
Total	115,669,400	113,449,000	118,137,000	119,466,600	102,932,600	119,219,100
South America:						
Argentina	1,233,324	1,671,838	1,350,331	1,543,200	1,549,600	1,671,838
Bolivia (exports)	6,244,483	7,547,304	5,375,089	6,051,284	4,503,772	4,887,138
Brazil	138,184	171,524	348,160	185,317	225,050	290,186
Chile	1,490,952	1,821,918	1,555,903	1,504,365	1,767,230	[4] 1,800,000
Colombia	119,030	110,728	106,494	105,162	102,678	134,333
Ecuador	57,221	29,479	28,694	47,600	162,608	126,419
Peru	19,269,894	22,972,766	24,845,257	25,918,353	27,225,216	30,308,665
Total	28,553,100	34,325,600	33,610,000	35,360,000	35,540,000	39,220,000
Europe:						
Austria	4,630	1,286	1,286	-	64,300	64,300
Czechoslovakia [4]	1,608,000	1,608,000	1,608,000	1,608,000	1,608,000	1,608,000
Finland	201,437	318,453	373,592	560,709	522,739	390,374
France	655,522	541,869	703,587	770,257	931,407	[4] 1,000,000
Germany:						
East [4]	4,114,600	4,500,000	4,500,000	4,500,000	4,500,000	4,500,000
West	2,118,052	2,166,446	2,139,407	2,112,304	1,897,730	1,842,077
Greece	74,821	79,091	93,462	99,410	150,000	[4] 154,300
Hungary [4]	61,080	64,300	64,300	64,300	64,300	64,300
Italy	847,069	1,034,129	956,420	1,334,256	1,060,814	943,946
Norway	126,031	54,656	64,301	-	-	-
Poland [4]	109,340	128,600	128,600	128,600	128,600	128,600
Portugal	63,369	57,550	62,308	45,783	54,141	[4] 50,000
Rumania [4]	643,000	643,000	643,000	643,000	643,000	643,000
Spain	1,085,280	1,402,801	1,345,734	1,774,850	2,206,698	1,774,592
Sweden	1,905,401	2,562,382	2,512,163	2,944,301	3,098,070	2,674,942
U.S.S.R.[4]	24,600,000	25,000,000	25,000,000	25,000,000	25,000,000	25,000,000
United Kingdom	28,526	27,878	27,337	20,553	13,655	14,000
Yugoslavia	2,894,011	2,760,013	2,589,742	3,751,702	2,827,336	3,025,160
Total [4]	41,140,000	43,000,000	42,810,000	45,400,000	44,800,000	43,900,000

[5] Handy & Harman, The Silver Market in 1960, p. 19.

TABLE 14.—World production of silver, by countries [1] [2] [3]—Continued

(Troy ounces)

Country	1951–55 (average)	1956	1957	1958	1959	1960
Asia:						
Burma	784,728	1,500,351	1,526,810	1,961,472	2,041,395	1,984,263
China [4]	400,000	480,000	510,000	[7] 510,000	[7] 510,000	[7] 510,000
India	72,406	104,604	125,838	109,828	124,777	132,718
Japan	5,585,568	6,166,962	6,543,673	6,552,032	6,650,928	6,869,938
Korea:						
North [4]	80,000	260,000	320,000	320,000	320,000	320,000
Republic of	39,770	196,409	277,346	247,788	241,898	329,649
Philippines	513,926	541,168	479,216	497,987	504,085	1,133,343
Saudi Arabia	87,233					
Taiwan	36,678	53,894	82,965	52,380	60,974	52,579
Total [4]	7,600,000	9,300,000	9,900,000	10,250,000	10,500,000	11,300,000
Africa:						
Algeria (recoverable) [4] [8]	161,390	230,000	235,000	225,000	400,000	400,000
Bechuanaland	259	215	35	44	42	24
Congo, Republic of the (formerly Belgian)	4,422,154	3,791,891	3,044,868	3,793,788	4,768,180	3,989,907
Ghana (exports)	45,883	28,592	25,390	45,762	16,839	[4] 22,500
Kenya	8,864	54,689	23,051	44,146	46,420	35,797
Morocco: Southern zone [8]	1,919,718	2,204,930	2,411,250	2,411,000	1,234,303	1,097,273
Nigeria	199	111	200			
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia [9]	351,664	610,370	569,949	556,523	948,459	698,127
Southern Rhodesia	80,829	76,870	74,179	264,630	328,947	392,026
South-West Africa (recoverable)	989,839	1,632,287	1,789,323	1,719,990	1,966,955	1,004,921
Tanganyika (exports) [8]	220,822	562,880	521,465	737,802	536,407	614,279
Tunisia	73,490	86,485	113,556	135,194	43,339	34,401
Uganda (exports)	48	52	21	36	54	[4] 50
Union of South Africa	1,245,785	1,598,278	1,767,472	1,795,384	2,020,780	2,226,204
Total	9,520,000	10,880,000	10,580,000	11,730,000	12,310,000	10,520,000
Oceania:						
Australia	12,600,663	14,586,197	15,739,400	16,270,181	15,076,363	[4] 15,250,000
Fiji	21,650	24,302	24,946	25,375	23,652	31,319
New Guinea	52,021	42,457	38,014	24,952	36,796	33,037
New Zealand	64,235	950	1,279	2,339	4,873	[4] 4,900
Total	12,738,600	14,654,000	15,804,000	16,323,000	15,142,000	15,319,000
World total (estimate)	215,200,000	225,600,000	230,800,000	238,500,000	221,200,000	239,500,000

[1] In addition to the countries listed, a negligible amount of silver is produced in Bulgaria, Cyprus, Hong Kong, Panama, Malaya, Sarawak, Turkey, and Sierra Leone, for which countries no estimate has been included in the total.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Data derived in part from the Yearbook of the American Bureau of Metal Statistics and the 47th annual issue of Metal Statistics (Metallgesellschaft) Germany.
[4] Estimate.
[5] Imports into the United States.
[6] Refinery production.
[7] Data represents estimate of 1957 production; however, recent production was probably much greater.
[8] Includes recoverable silver content of lead and zinc concentrates.
[9] Partially recovered from refinery sludges and blister copper.

Compiled by Augusta W. Jann, Division of Foreign Activities.

Australia.—Output of silver in Australia rose slightly in 1960 to 15.2 million ounces as increased tonnages of silver-bearing base-metal ores were treated. Mount Isa Mines, Ltd., treated 773,000 tons of silver-lead-zinc ore containing 6.8 ounces of silver per ton and reported a reserve of 25.6 million tons of ore, a slight increase over the 1959 estimate.

Silver resources, principal silver-bearing deposits, and historical production of silver in Australia were reviewed in a government report.[6]

Canada.—Output of silver in Canada rose for the 5th successive year, reaching a record high of 33.8 million ounces, a gain of 16 percent over the 1959 output. Canada maintained its position as the world's second largest silver producer, surpassed only by Mexico.

Most of the production gain came from British Columbia which recorded an increase of over 1 million ounces. This increase, together with smaller gains in Manitoba and Saskatchewan, Quebec, Newfoundland, and the Northwest Territories, more than offset lower output from the Yukon Territory. British Columbia, Ontario, and the Yukon Territory supplied more than three-fourths of the total output. The Sullivan in British Columbia and the United Keno Hill in the Yukon contributed about one-third of Canada's total output.

About 80 percent of the total silver was recovered as a coproduct or byproduct of base-metal ores, with most of the remainder from silver and silver-cobalt ores.

Exports of refined silver and silver in ores and concentrates aggregated 21.7 million ounces. Over 90 percent of total exports went to the United States. Imports, most of which came from the United States, totaled 3.8 million ounces, about 1 million ounces more than in 1959.

Consumption of silver for coinage rose sharply to about 7.5 million ounces compared with 5.7 million ounces in 1959. The gain in coinage consumption resulted principally from restrictions imposed on the use of U.S. coins, which brought increased demand for subsidiary Canadian coins to replace them. Industrial consumption of silver was about 4.2 million ounces, slightly below the quantity used in 1959.

The Deloro silver-cobalt smelter in Ontario stopped receiving ores in October before closing after 53 years of operations.

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[6] Fisher, N. H., Matheson, R. S., and Ivanac, J. F., Silver, Mineral Resources of Australia: Bureau of Mineral Resources, Geology and Geophysics, Summary Report No. 37 40 pp.

TABLE 15.—Canada: Geographical distribution of silver

Province or territory	Troy ounces	
	1959	1960
Ontario	10,540,856	10,744,730
British Columbia and Alberta	7,463,304	8,746,233
Yukon Territory	7,054,632	6,899,337
Quebec	4,108,241	4,427,893
Manitoba and Saskatchewan	1,561,266	1,660,429
Newfoundland	1,125,110	1,204,469
Northwest Territories	70,560	76,363
Total	31,923,969	33,759,454

Source: Patterson, J. W., Silver, 1960 (Prelim.): Mineral Resources Division, Dept. Min. and Tech. Surveys, Ottawa, Canada, 11 pp.

France.—France continued to import substantial quantities of silver for its coinage program, and mint purchases aggregated about 18 million ounces. Total coinage requirements were reported to be 58 million ounces, of which 40 million ounces had not been acquired.

Germany, West.—Industrial consumption of silver in West Germany increased 20 percent to 40.2 million ounces, with an equal amount imported. Mexico furnished 16 million ounces; the United States, 6.4 million; Netherlands, 5.1 million; Belgium, 3.2 million; Yugoslavia, 2.2 million; China, 1.8 million; Peru, 1.6 million; and other countries, 3.9 million. Exports totaling 16.1 million ounces went to other continental western European countries.

Japan.—Silver production in Japan was estimated at 6.9 million ounces, compared with 6.6 million ounces in 1959. Although production increased moderately, consumption for industrial uses rose to about 21.6 million ounces, an increase of nearly 60 percent over 1959. About 20 percent of the imports needed to meet requirements were supplied by the United States. Coinage absorbed about 4.6 million ounces from Government stocks.

Mexico.—Output of silver in Mexico, the world's largest silver-producing country, was estimated at 44.5 million ounces, about 1 percent more than in 1959. Exports aggregated 34 million ounces, of which 10.3 million ounces went to the United States; 16 million ounces to West Germany; 3.5 million ounces to Belgium; and most of the remainder to other western European countries. About 3 million ounces of demonetized coin was withdrawn from circulation, and approximately 84 million ounces of such coin was estimated to be held by the public.[7]

Silver consumption in the arts and industries of Mexico was about 4 million ounces, compared with 5.4 million ounces in 1959. Silver used in coinage, however, increased to 2.6 million ounces from 1.4 million ounces in 1959.

[7] Handy & Harman, The Silver Market in 1960, p. 18.

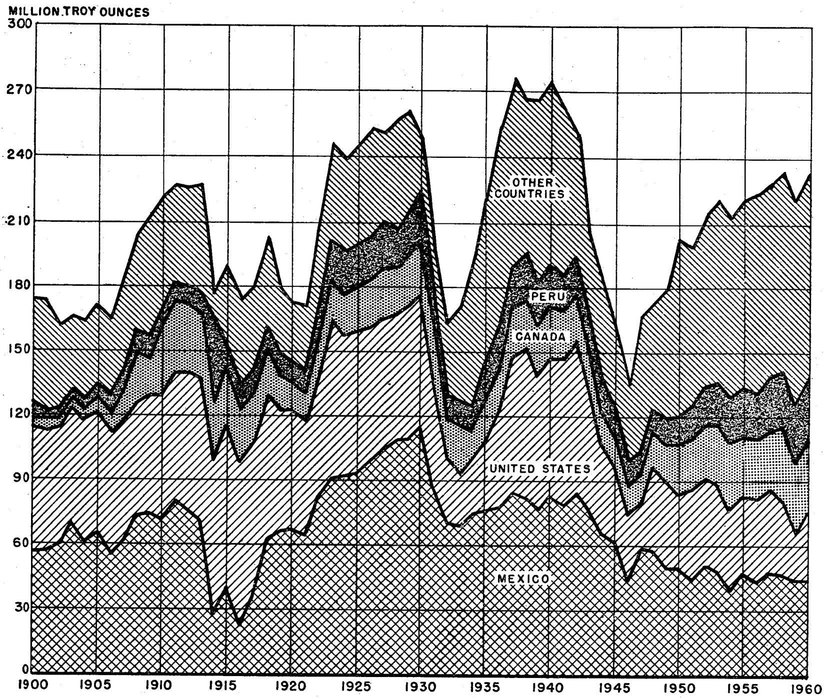

FIGURE 3.—World production of silver, 1900–60.

Peru.—Mine production of silver in Peru, the largest silver-producing country in South America, was about 30.3 million ounces, an increase of 11 percent over 1959. Exports aggregated about 26.1 million ounces valued at $24.2 million, nearly 8 percent more than in 1959. Cerro de Pasco Corp., the largest producer, contributed 14.2 million ounces, nearly 47 percent of the total output. The straight silver mines, Castrovirreyna Metal Mines Co., San Juan de Lucanas S.A., Cia. Minera Caylloma, and Cia. Explotadora Millotengo accounted for nearly 7 million ounces, approximately 23 percent of the total Peruvian silver production.

United Kingdom.—Consumption of silver in the arts and industries of the United Kingdom was estimated at 18.5 million ounces, about 1 million ounces more than in 1959. Imports of silver totaled 29.3 million ounces, compared with 18.3 million ounces in 1959. Of the total silver imports, China suplied about 7.4 million ounces; Australia, 7 million; Peru, 6.6 million; United States, 2.6 million; Mexico, 2.1 million; and other countries, 3.6 million.[8]

The United Kingdom exported 8.6 million ounces of silver, about 3 million ounces less than in 1959. About 70 percent of the exports went to France and Italy.

[8] Samuel Montagu & Co., Ltd., Annual Bullion Review 1960: February 1961, pp. 24, 25, 30.

About 5 million ounces was refined from United Kingdom silver coin withdrawn from circulation, but only about 1 million ounces was released for sale; the remaining silver was retained by the Royal Mint for foreign coinage.

TECHNOLOGY

A method for plating silver onto aluminum by means of a mercury immersion coating was developed that can be used with conventional plating equipment. The new plating procedure requires only two chemical baths and one electro-chemical operation and permits aluminum to be silver-plated even more conveniently than copper.[9]

Silver antimony telluride ($AgSbTe_2$), said to be one of the most efficient thermoelectrical materials, was expected to be used in heat-to-power converters and localized coolers, especially for miniature electronic devices. The material possesses a thermal conductivity as low as 0.0064 w/cm° C. at room temperature, one-hundredth that of germanium, and was reported to have a figure of merit, Z of about 1.75×10^{-3} ° C. over a range of 200° to 500° C., the best yet observed for p-type thermoelements in this range.[10]

A lead solder designated MIL Ag 1.5, containing 1.5 percent silver and 1 percent tin, proved to be the optimum alloy composition for nuclear field service. Its tensile strength was found to be satisfactory at much higher temperatures than the rating of available electronic hardware.[11]

Several patents were issued for silver alloys for use in electrical, mechanical, and chemical equipment. A patent was issued on a process for forming a photographic image by bringing an exposed water-permeable organic colloid layer containing a specially prepared silver nitrate complex into surface contact with an unexposed organic colloid layer containing silver halide, and subjecting the contacting layers to developing solution containing silver halides.[12] Other significant articles pertaining to the technology of silver were published during the year.[13]

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[9] Nelson, V. A., Electroplating of Silver Onto Aluminum: Jour. Electrochem. Soc., vol. 107, No. 8, August 1960, p. 187C.
[10] Journal of Metals, vol. 12, No. 11, November 1960, p. 833.
[11] Materials in Design Engineering, Best Solder for Nuclear Service: Vol. 51, No. 2, February 1960, pp. 88–89.
[12] Blake, R. K., Forsgard, F. C., and Hunt, H. D. (assigned to E. I. du Pont de Nemours Co., Inc., Wilmington, Del.), Process for Forming Silver Images: U.S. Patent 2,292,537.
[13] Cawley, H. E., and Wilson, G. D., The Agnico Mines, Ltd., Cobalt, Ontario: Canada Deco Trefoil, May–June–July 1960, pp. 9-16.
Sullivan, F., and Newton, E. H., Electropolishing in Cyanide Electrolytes: Jour. Electrochem. Soc., vol. 107, No. 11, November 1960, pp. 886–891.

Slag—Iron-Blast Furnace

By Perry G. Cotter [1]

OUTPUT of processed blast-furnace slag increased slightly over 1959 although blast-furnace operation was reduced. Demand remained high and requirements were met by further depletion of reserve stocks. Efforts were directed toward raising the unit value of processed slag by increasing the quality through selective screening and upgrading.

TABLE 1.—Iron-blast-furnace slag processed in the United States, by types

(Thousand short tons and thousand dollars)

Year	Air-cooled				Granulated		Expanded	
	Screened		Unscreened		Quantity	Value [1]	Quantity	Value
	Quantity	Value	Quantity	Value				
1951-55 (average)	23,126	$31,414	1,112	$687	3,081	$1,262	2,363	$5,843
1956	25,572	38,476	2,096	1,280	4,635	1,642	2,990	8,496
1957	25,414	40,203	2,167	1,408	4,318	1,615	2,942	8,435
1958	20,499	34,027	1,411	1,170	3,536	1,373	2,985	8,638
1959	21,816	36,774	1,039	957	2,702	1,396	2,812	8,037
1960	21,908	37,671	1,237	1,049	3,027	1,489	2,626	7,773

[1] Excludes value of slag used for hydraulic cement manufacture.

Source: National Slag Association.

DOMESTIC PRODUCTION

Output of iron-blast-furnace slag totaled about 29 million short tons in 1960, compared with 28 million tons in 1959.

The 39 slag-processing companies reporting operated 62 air-cooled plants, 17 granulated plants, and 23 expanded-slag plants.

New Jersey reported slag processing in 1960, making a total of 16 producing States. Pennsylvania, Ohio, and Alabama led the Nation in processing slag. Pennsylvania was the top producer in volume; Ohio led in sales value.

Recovery of Iron.—In 1960, 461,816 tons of iron slag (about 60 percent iron) was recovered during processing of slag and returned for remelting, a 38-percent increase over 1959.

[1] Commodity specialist, Division of Minerals.

Employment.—A total of 4,090,952 man-hours was worked by 2,010 plant and yard employees in producing commercial slag, compared with 4,187,000 man-hours by 2,049 plant and yard employees in 1959. Output at slag operations was 7.04 tons of processed slag per man-hour, up slightly from 1959.

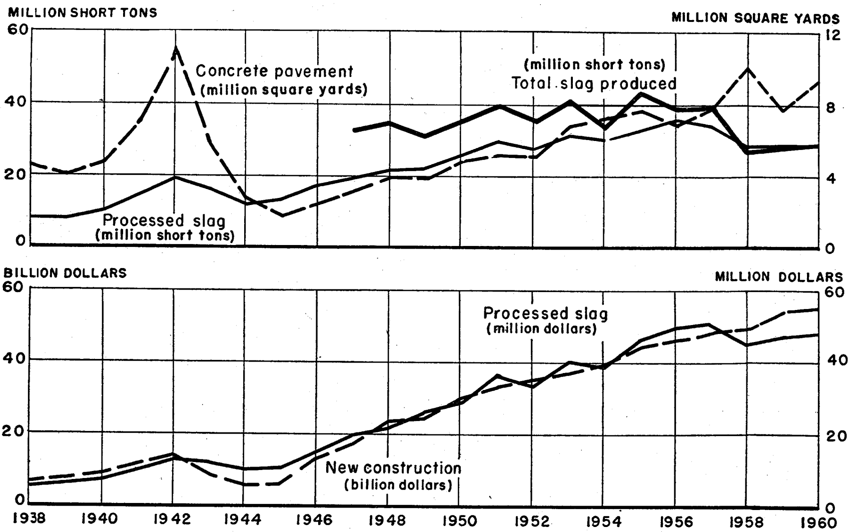

FIGURE 1.—Production of iron-blast furnace slag compared with yards of concrete pavement (contract awards), monthly average, and value of new construction compared with value of processed slag, 1938–60.

TABLE 2.—Iron-blast-furnace slag processed in the United States, by States

(Thousand short tons and thousand dollars)

Year and State	Screened air-cooled		All types	
	Quantity	Value	Quantity	Value
1959:				
Alabama	3,545	$5,429	4,176	$6,608
Ohio	4,126	7,705	5,427	10,739
Pennsylvania	5,496	9,893	7,240	11,847
Other States [1]	8,649	13,747	11,526	17,970
Total	21,816	36,774	28,369	47,164
1960:				
Alabama	2,503	4,301	3,162	5,202
Ohio	5,425	10,016	6,426	12,431
Pennsylvania	5,036	9,266	7,804	11,651
Other States [1]	8,944	14,088	11,406	18,698
Total	21,908	37,671	28,798	47,982

[1] California, Colorado, Illinois, Indiana, Kentucky, Maryland, Michigan, Minnesota, New Jersey (1960), New York, Tennessee, Texas, and West Virginia.

Source: National Slag Association.

Methods of Transportation.—Shipments of processed slag by rail declined slightly although rail and truck transportation, as in other years, accounted for most of the tonnage. Local factors were responsible for a slight increase in the use of water transportation.

TABLE 3.—Shipments of iron-blast-furnace slag in the United States, by methods of transportation

Method of transportation	1959		1960	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Rail	8,669	32	8,379	29
Truck	17,950	66	19,492	68
Waterway	544	2	738	3
Total shipments	27,163	100	28,609	100
Interplant handling [1]	1,206		189	
Total processed	28,369		28,798	

[1] Confined mainly to granulated slag used in the manufacture of cement.
Source: National Slag Association.

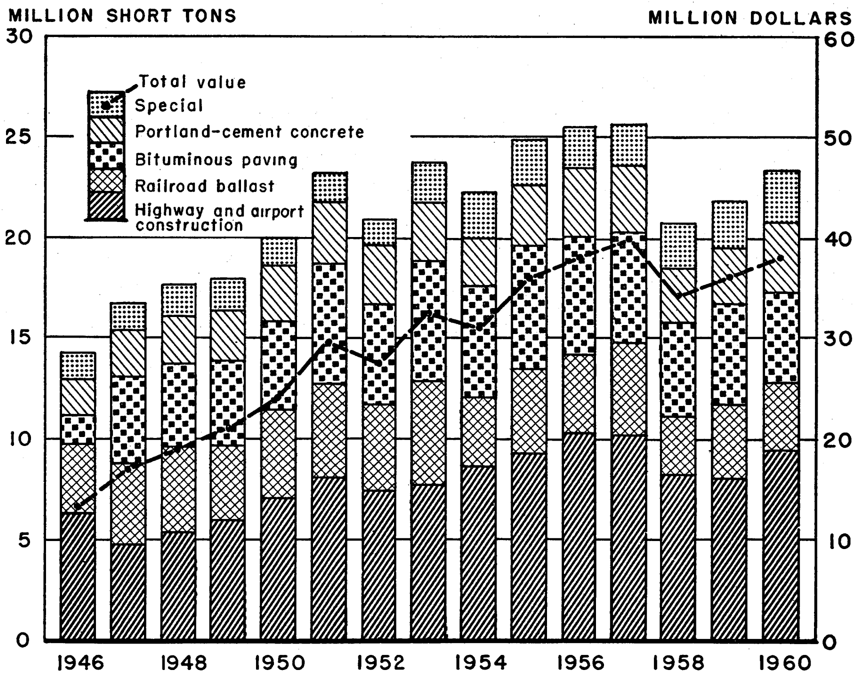

FIGURE 2.—Consumption and value of air-cooled, iron-blast furnace slag sold or used in the United States, 1946–60.

CONSUMPTION AND USES

Screened air-cooled slag, the major type produced by the industry, constituted 76 percent of the total output of processed slag. Production of other types was as follows: Unscreened air-cooled, 4 percent; granulated, 11 percent; and expanded, 9 percent.

Screened Air-Cooled Slag.—Air-cooled slag results when molten slag is deposited in pits or banks for solidification under atmospheric conditions. It may then be further cooled by spraying with water. The product sometimes is called crushed slag. After weathering, it is crushed and screened to size. Its cubical shape after crushing, low coefficient of expansion, and pitted surface, which gives it good frictional qualities, make it a desirable road material. Consumption increased slightly, chiefly because of increased use in highway and airport construction and in portland - cement concrete construction.

Seasonal declines were noted in its use for bituminous construction, manufacture of concrete blocks, railroad ballast, sewage trickling medium, and mineral wool. Slightly more tonnage than in 1959 was used for built-up roofing and for soil beneficiation.

TABLE 4.—Air-cooled iron-blast-furnace slag sold or used by processors in the United States, by uses

(Thousand short tons and thousand dollars)

Year and use	Screened		Unscreened	
	Quantity	Value	Quantity	Value
1959:				
Aggregate in—				
Portland-cement concrete construction	2,839	$5,292		
Bituminous construction (all types)	4,966	8,994		
Highway and airport construction [1]	8,048	13,979	968	$886
Manufacture of concrete block	594	933		
Railroad ballast	3,691	4,456		
Mineral wool	515	858		
Roofing (cover material and granules)	361	891		
Sewage trickling filter medium	53	192		
Agricultural slag, liming	6	10		
Other uses	743	1,169	71	71
Total	21,816	36,774	1,039	957
1960:				
Aggregate in—				
Portland-cement concrete construction	3,388	6,123		
Bituminous construction (all types)	4,538	8,311		
Highway and airport construction [1]	8,684	15,312	676	615
Manufacture of concrete block	504	838		
Railroad ballast	3,355	4,228	9	6
Mineral wool	451	739		
Roofing (covering material and granules)	371	1,147		
Sewage trickling filter medium	19	39		
Agricultural slag, liming	28	53		
Other uses	570	881	552	428
Total	21,908	37,671	1,237	1,049

[1] Other than in portland-cement concrete and bituminous construction.

Source: National Slag Association.

TABLE 5.—Granulated and expanded iron-blast-furnace slag sold or used by processors in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1959				1960			
	Granulated		Expanded		Granulated		Expanded	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Highway construction (base and subgrade)	398	$524			630	$707		
Fill (road, etc.)	485	497			436	342		
Agricultural slag, liming	43	71			57	92		
Manufacture of hydraulic cement	1,338	(1)			1,518	(1)		
Aggregate for concrete-block manufacture	125	121	2,733	$7,778	176	157	2,568	$7,589
Aggregate in lightweight concrete			42	118			22	60
Other uses	313	183	37	141	210	191	36	124
Total	2,702	1,396	2,812	8,037	3,027	1,489	2,626	7,773

1 Data not available.

Source: National Slag Association.

Unscreened Air-Cooled Slag.—Fifty-five percent of the unscreened air-cooled slag was used in highway and airport construction, compared with 93 percent in 1959. In addition to the tonnage reported in table 4, 2,048,000 tons of slag was processed in Utah and used as a special road-filled material.

Granulated Slag.—The principal use for granulated slag was in the manufacture of portland blast-furnace slag cement. This use accounted for 50 percent of the total production of 3,027,000 short tons. Thirty-five percent was used in highway construction as base subgrade and fill. Production increased 12 percent over 1959.

Expanded Slag.—Expanded slag, produced by applying a limited amount of water to molten slag, has a cellular or foamy structure and is used for lightweight concrete block and aggregate in lightweight structural concrete. Consumption was 2.6 million tons, slightly lower than in 1959.

PRICES

The average unit value of processed slag varied from $0.67 to $3.46 per short ton, according to types. Slight increases in price were noted in air-cooled screened slag used for bituminous construction, highway and airport construction, manufacture of concrete block, railroad ballast, roofing, and agricultural slag.

Unscreened air-cooled slag and granulated slag used for highways and airports declined in price, as did granulated slag used for concrete block manufacture.

The value of expanded slag for concrete blocks increased slightly.

TABLE 6.—Average value of iron-blast-furnace slag sold or used by processors in the United States, by uses

(Per short ton)

Use	Air-cooled				Granulated		Expanded	
	Screened		Unscreened					
	1959	1960	1959	1960	1959	1960	1959	1960
Aggregate in—								
Portland-cement concrete construction.	$1.86	$1.81					[1] $2.81	[1] $2.73
Bituminous construction (all types).	1.81	1.83						
Highway and airport construction.[2]	1.74	1.76	$0.92	$0.91	[3] $1.32	[3] $1.12		
Manufacture of concrete block	1.57	1.66			.97	.89	2.85	2.96
Railroad ballast	1.21	1.26		.67				
Mineral wool	1.67	1.64						
Roofing (cover material and granules).	2.47	3.09						
Sewage trickling filter medium	3.61	2.05						
Agricultural slag, liming	1.84	1.89			1.68	1.61		
Fill (road, etc.)					1.02	.78		
Other uses	1.57	1.55	1.00	.78	.59	.91	3.80	3.44

[1] Lightweight concrete. [2] Other than in portland-cement and bituminous construction.
[3] Base and subgrade material.

Source: National Slag Association.

TECHNOLOGY

British farmers used more slag for soil beneficiation from July 1959 to March 1960 than in any similar period of the last 20 years. Expansion in the steel industry resulted in additional supplies being made available to meet the demand.[2]

Interstate Highway 15, in Utah, used 600,000 tons of blast-furnace slag for road fill. The slag was obtained from the Geneva Steel Works' 2-million-ton slag pile.[3]

Fifteen thousand tons of slag from the blast furnaces of United States Steel Corp.'s Gary Works was being used to repave a 3-mile section of U.S. Route 20. This marked the first time blast-furnace slag had been used in bituminous pavement surface in Indiana. Previously slag was utilized only as the base layer.[4]

Slag aggregate was specified for surface skid resistance in nearly 26 miles of the resurfacing started in 1960 on the Pennsylvania Turnpike.[5]

Construction procedures and field experience in the use of slag in bituminous surfaces to provide safe, nonskid pavements were discussed.[6]

All-slag bituminous concrete mixes were described as having higher stability, larger square yard yields per ton, slower loss in skid resistance, and more uniform appearance than natural aggregate mixtures previously used in Detroit. Improvements were made in

[2] Chemical Age (London), vol. 83, No. 2132, May 21, 1960, p. 841.
[3] Intermountain Industry and Engineering, vol. 62, No. 8, August 1960, pp. 14–15.
[4] Scrap Age, vol. 17, No. 11, November 1960, p. 82.
[5] Asphalt Institute Quarterly, Paving the 'Pike': Vol. 12, No. 4, October 1960, pp. 4–6.
[6] Bauman, E. W., Control of Skidding on Pavements: Proc., 14th Ann. Ohio Highway Eng. Conf., Apr. 5–7, 1960, pp. 71–89.

gradations and designs of natural aggregate mixes to approach more closely slag results.[7]

Laboratory investigations of corrosion of prestressed wire in concrete included studies of the effects of factors such as type of cement, type of wire, wire stress, calcium chloride additions, and curing conditions. Portland blast-furnace slag cement was included in the study. Test results indicated no difference in performance between regular portland cement and portland blast-furnace slag cements.[8]

In Japan, studies on the production, handling, and curing of concrete made from blast-furnace-slag portland cement and regular portland cement indicated that (1) the water requirement to produce a given consistency is less; (2) a larger amount of air-entraining agent is required to obtain desired air content; (3) more precautions are necessary in curing, especially at earlier stages, because of hardening of concrete; and (4) bleeding is less.[9]

Laboratory freezing and thawing tests of lightweight aggregate concretes, including expanded slag, indicated that high levels of durability are attained when entrained air is used. Results obtained were considered comparable to those with normal-weight aggregates.[10]

Cements were made from blast-furnace slag containing from 13 to 20 percent magnesia. The properties and performance of concrete made from these slags were reported with respect to workability, shrinkage, dynamic modulus of elasticity, Poisson's Ratio, and compressive and flexural strength. Results showed that sound constructional cement could be made from such slags.[11]

The physical properties and constitution of simple slag systems were determined for the liquid state. Electrical conductivity to 2,300° C. was determined on binary silicates, and viscosity, surface tension, and density determinations were made on liquid binary slags. Descriptive models were made of some of the ions thought to exist in molten silicates.[12]

The hydrothermal reactions between lime and aggregate fines, including both foamed and granulated blast-furnace slags, were studied with autoclaved mixtures subjected to 160 pounds per square inch steam for varying periods. The resultant materials were poorly crystalline tobermorite, dicalcium silicate, alpha-hydrate, and hydrogarnet, when slag aggregate was used. Strengths were high when tobermorite was the main phase.[13]

It was determined that due to its alkalinity, blast-furnace slag aggregate is not corrosive to metals. Service performance over many

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[7] Greenberg, Maurice, Detroit Upgrades Bituminous Mixes: Roads and Streets, vol. 103, No. 7, July 1960, pp. 113, 114, 117–119.

[8] Monfore, G. E., and Verbeck, G. J., Corrosion of Prestressed Wire in Concrete: Am. Concrete Inst. Jour., vol. 32, No. 5, November 1960, pp. 491–515.

[9] Maryuyasy, T., Mizuno, S., and Okbayashi, K., Studies on the Use of Portland Blast-Furnace Slag Cement: Trans. Japan Soc. Civil Eng. (Tokyo), vol. 21, No. 65, Extra Paper 3–1, November 1959.

[10] Klieger, Paul, and Hanson, J. A., Freezing and Thawing Tests of Lightweight Aggregate Concrete: Am. Concrete Inst. Jour., vol. 32, No. 7, January 1961, pp. 779–796.

[11] Stutterheim, Niko, Properties and Uses of High Magnesia Portland Slag Cement Concretes: Jour. Am. Concrete Inst., vol. 31, No. 10, April 1960, pp. 1027–1045.

[12] Bradbury, B. T., and Williams, D. J., Physical Properties and Constitution of Liquid Slags: Metallurgia, vol. 2, No. 374, December 1960, pp. 235–240.

[13] Midgley, H. G., and Chopra, S. K., Hydrothermal Reactions Between Lime and Aggregate Fines: Mag. Concrete Res. (Cement and Concrete Assoc., London), vol. 12, No. 35, July 1960, pp. 73–82.

years had demonstrated repeatedly that blast-furnace slag in concrete has no deleterious action on steel.[14]

A critical discussion of various foaming methods was included in a Russian article which described the production of foamed slags of low density for the building industry. At the Stalingrad plant, molten blast-furnace slag was poured onto a perforated metal plate and water injected below.[15]

Experimental work with slags having from 13 to 21 percent magnesia showed no evidence of periclase formation, and cements made from them yielded sound concrete even after years of storage. The possibility of periclase in cement is remote, and the standard autoclave test can be used on granulates as a routine procedure to insure that none is present.[16]

In a British patent for the manufacture of hydraulic cement, a small amount of a surface tension reducing agent, e.g., polyethylene oxide-alcohol condensation product, is added to the granulated blast-furnace slag before grinding.[17]

In the preparation of alumina cement which will not evolve disagreeable odors when used, powdered blast-furnace slag was treated with superheated steam either during or after grinding.[18]

A Belgian patent described a method for increasing the strength of hydraulic cement consisting mainly of pulverized blast-furnace slag. In this method fluorspar replaces part of the gypsum or calcium chloride usually used.[19]

Residual pitch or oxidized bitumen was used in a process described in a British patent to make lightweight concrete aggregates, such as exfoliated vermiculite or foamed blast-furnace slag, temporarily water-repellant.[20]

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[14] Larrabee, C. P., and Coburn, S. K., Experiences With Blast-Furnace Slag as an Aggregate in Reinforced Concrete: Southeastern Regional Meeting of the Nat. Assoc. of Corrosion Eng., Atlanta, Ga., Oct. 5–8, 1960; Corrosion, vol. 17, No. 4, April 1961, pp. 79–80.

[15] Sauberlich, K., Gunther, J., and Koch, W. [Slag Treatment]: Neue Hütte, vol. 5, 1960, pp. 12–21.

[16] Stutterheim, Niko, The Risk of Unsoundness Due to Periclase in High-Magnesia Blast-Furnace Slags: 4th Internat. Symposium on the Chemistry of Cement, Washington, D.C., Oct. 2–7, 1960.

[17] Mitchell, F. G., and Rule, T. E., Improvement in or Relating to Wet Ground Slag and Cement Products Made Therewith: British Patent 790,628, Feb. 12, 1958.

[18] Serov, V. V., [Aluminaceous Cement from Blast-Furnace Slag]: Russian Patent 120,758, June 19, 1959; Chem. Abs., vol. 54, No. 4, Feb. 25, 1960, col. 3911a.

[19] Belgian Patent 546,884 (assigned to Société Financière de Transports et d'Entreprises Industrielles (Sofina) S.A.), Apr. 30, 1956; Chem. Abs., vol. 54, No. 13, July 10, 1960, col. 13602a.

[20] Watkins, C. M. (assigned to Council for Scientific and Industrial Research), Improvements in and Relating to the Production of Concrete: British Patent 842,592, July 27, 1960.

Sodium and Sodium Compounds

By Robert T. MacMillan [1] and Victoria M. Roman [2]

DECREASED output of manufactured sodium carbonate and sodium sulfate was responsible for lower total production of sodium compounds in 1960. Importance of natural deposits increased as new production of these commodities turned toward natural sources because of smaller investment and production costs.

DOMESTIC PRODUCTION

The tonnage of sodium carbonate (soda ash), produced from natural sources continued to grow in 1960 achieving a 10 percent gain over the 1959 level, while that produced from salt by the ammonia soda process decreased 7 percent. Although most sodium carbonate was produced by the ammonia soda process, the proportion from natural sources increased from 15 percent in 1959 to 18 percent of the total production in 1960.

In California, two companies produced natural sodium carbonate from Searles Lake brines: American Potash & Chemical Corp. operated a plant at Trona on the lakeshore and Stauffer Chemical Co., West End Div., produced sodium carbonate at nearby Westend. Also in California, Pittsburgh Plate Glass Co., Chemical Div., formerly Columbia Southern Chemical Corp., produced sodium carbonate and sesquicarbonate from Owens Lake brine near Bartlett.

In Wyoming, the Intermountain Chemical Co., a subsidiary of Food Machinery and Chemical Corp., mined trona at a depth of 1,500 feet

TABLE 1.—Manufactured sodium carbonate produced and natural sodium carbonates sold or used by producers in the United States

(Thousand short tons and thousand dollars)

Year	Manufactured soda ash (ammonia soda process) [1] [2]	Natural sodium carbonates [3]	
	Quantity	Quantity	Value
1951-55 (average)	4,805	447	$11,072
1956	4,998	653	17,400
1957	4,659	653	17,792
1958	4,324	629	17,032
1959	[4] 4,904	735	19,078
1960	[5] 4,557	809	20,865

[1] 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).
[4] Revised figure.
[5] Preliminary figure.

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.

TABLE 2.—Sodium sulfate produced and sold or used by producers in the United States

(Thousand short tons and thousand dollars)

Year	Production (manufactured[1] and natural)			Sold or used by producers (natural only)	
	Salt cake (crude)	Glauber salt (100 percent $Na_2SO_4 \cdot 10H_2O$)	Anhydrous refined (100 percent Na_2SO_4)	Quantity[2]	Value
1951-55 (average)	701	180	228	257	$3,830
1956	763	143	273	333	6,437
1957	709	128	280	331	6,542
1958	640	106	255	347	6,716
1959	[3] 734	[3] 99	[3] 308	403	7,689
1960	[4] 750	[4] 84	[4] 289	450	8,706

[1] Bureau of the Census.
[2] Includes Glauber salt converted to 100-percent Na_2SO_4 basis.
[3] Revised figure.
[4] Preliminary figure.

from a large bedded deposit near Rock Springs (Sweetwater County). Most of the output was converted to dense soda ash before marketing.

Total production of sodium sulfate from natural and byproduct sources decreased slightly from the 1959 level although the output from natural sources was 12 percent higher. The proportion of the production from natural sources increased from 37 percent in 1959 to 42 percent in 1960.

Natural sodium sulfate was produced in California, Texas, and Wyoming. In California, American Potash & Chemical Corp. and Stauffer Chemical Co., West End Division, produced sodium sulfate from Searles Lake brines at Trona and Westend, respectively; United States Borax & Chemical Corp. produced sodium sulfate as a coproduct in making boric acid from borax. In Texas, natural sodium sulfate was produced from subterranean brines at Monahans and Brownsfield by Ozark-Mahoning Co. In Wyoming, William E. Pratt and the Sweetwater Chemical Co. produced sodium sulfate from semidry lakebeds.

A significant development in the soda ash industry was the start of a new $20 million trona mine and soda ash plant near Green River, Wyo. Trona deposits underlie a large area of southwestern Wyoming. Near the mine site, the beds ranged from 800 to 1,000 feet in depth. The plant was expected to produce from 150,000 to 200,000 tons of finished soda ash annually.

No new ammonia soda plants have been built since 1935. Through the years, ammonia soda plants have been improved technically, and further reduction in production costs in these plants does not appear likely. Soda ash production from trona, with its lower plant investment and production costs, was found to be the answer to this situation by Stauffer Chemical Co., Several other companies, including Diamond Alkali Co. and Allied Chemical Corp., were doing exploratory drilling of the Wyoming trona beds.[3] The cost of new ammonia

[3] Chemical Week, Soda Ash Expansion Spurs Process Shift: Vol. 87, No. 3, July 16, 1960, pp. 91–92.

soda plants was estimated at $30,000 to $35,000 per daily ton of capacity.[4] Plant investment for soda ash from trona was said to be about half as much as from salt and limestone.

Food Machinery and Chemical Corp. was planning a 200,000-ton-per-year expansion at its Green River, Wyo., soda ash plant.[5]

Most sodium sulfate (salt cake) is a byproduct of the production of rayon, cellophane, hydrochloric acid, sodium bichromate, phenol, boric acid, and miscellaneous chemicals. These sources provided about 73 percent of the domestic production of sodium sulfate in 1959 and 71 percent in 1960; natural sources supplied the remainder.

Several factors were responsible for the increasing importance of natural sources in the overall production of sodium sulfate. Rayon production declined in 1960 and was expected to decrease further as nylon tire cord continued to replace rayon. Hydrochloric acid from Mannheim furnaces also declined. Cellophane production was reported capable of yielding 200,000 tons of salt cake annually, but only one company had installed recovery equipment. Changes in technology or lack of growth also affected the byproduct recovery of sodium sulfate in other chemical production areas.[6]

Both American Potash & Chemical Corp. and Stauffer Chemical Co. were reported to be planning expansion of sodium sulfate production at their Searles Lake plants.

Based on figures of the first 10 months published by the Bureau of the Census, metallic sodium production was expected to total 113,428 short tons in 1960, compared with 112,019 tons in 1959.

Sodium was produced by three companies: National Distillers & Chemical Co. at Ashtabula, Ohio; E. I. du Pont de Nemours & Co., Inc., at Niagara Falls, N.Y., and Memphis, Tenn.; and Ethyl Corp. at Baton Rouge, La., and Houston, Tex.

CONSUMPTION AND USES

Most sodium carbonate was used in glassmaking, which consumed an estimated 38 to 40 percent of the total output. Glass containers were the largest outlet. The manufacture of window and plate glass, particularly for automobiles, also consumed important quantities. Chemicals took an estimated 33 to 35 percent of the production. Sodium tripolyphosphate, silicates, bicarbonates, and lime soda caustic were the main outlets for soda ash in the chemicals field.

Other uses of soda ash were in pulp and paper manufacture, water treatment, nonferrous metals production, cleaners, soap, textiles, and dyes.

The Kraft paper industry continued as the leading consumer of sodium sulfate although the efforts of the industry to reduce sulfate losses resulted in an average consumption estimated at less than 120 pounds per ton of pulp. A further reduction in the consumption level was said to be unlikely.

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[4] Sommers, H. A., Soda Ash from Trouna: Chem. Eng. Prog., vol. 56, No. 2, February 1960, pp. 76–79.

[5] Oil, Paint and Drug Reporter, Soda Ash Position Strengthened by FMC: Vol. 177, No. 19, May 2, 1960, p. 3.

[6] Chemical Week, New Opportunity for Natural Salt Cake: Vol. 87, No. 19, Nov. 5, 1960, pp. 97, 98, 100.

Other uses of sodium sulfate, taking about 30 percent of production, were in glass, ceramic glazes, detergents, stock feeds, dyes, textiles, medicines, and miscellaneous chemicals.

Tetraethyl lead (TEL), an antiknock ingredient added to most motor fuels, continued to be the chief outlet for metallic sodium. Makers of motor fuel additives were reported to be considering the advantages of tetramethyl lead (TML) as an antiknock ingredient.[7] TML is more responsive than TEL in gasolines containing more than 30 percent aromatics. The manufacture of TML is similar to TEL, except that the former uses the reaction of methyl chloride instead of ethyl chloride with lead-sodium alloy. Although TML requires more sodium per unit of product, slightly less antiknock fluid is needed in the fuel to achieve equivalent antiknock rating. A mixture of TEL and TML may be the most effective means of utilizing the new product. The effect on the sodium market was not expected to be significant.

Metallic sodium was also used in metal descaling, in ore reduction, and in making sodium peroxide, hydride, amide, cyanide, and borohydride.

PRICES

Prices quoted for sodium carbonate, sodium sulfate, and sodium by Oil, Paint and Drug Reporter remained unchanged from 1959. Prices for these commodities in 1960 were as follows:

Commodity:		*Price*
Sodium carbonate (soda ash 58 percent Na_2O):		
Light, paper bags, carlots	per hundredweight	$1.85
Light, bulk	do	1.55
Dense, paper bags, carlots	do	1.90
Dense, bulk	do	1.60
Sodium sulfate (100 percent Na_2SO_4):		
Technical, anhydrous, bags, carlots	per ton	[1] 54.00
Technical detergent, rayon grade, bags, carlots, works	do	36.00
Technical detergent, rayon grade, bulk, works	do	32.00
Domestic salt cake, bulk, works	do	28.00
N.F.VII, drums	per pound	.22½
Metallic sodium:		
Bricks, lots of 18,000 pounds and over, works	do	.21
Fused, lots of 18,000 pounds and over, works	do	.19½
Bulk, tank, works	do	.17

[1] Delivered east of Mississippi River.

FOREIGN TRADE[8]

Imports of sodium sulfate were 37 percent higher in 1960 than in 1959, and in 1960 were 16 percent of domestic production. The Belgium-Luxembourg area was the chief source, after which came Canada and West Germany. Together, these nations supplied 95 percent of the total imports.

Exports of sodium sulfate increased substantially in 1960; sodium carbonate exports showed a slight gain. Tonnages exported were about 2 percent of U.S. production of each commodity.

[7] Chemical Engineering, Tetramethyl Lead Eyed as Octane Booster: Vol. 67, No. 4, Feb. 22, 1960, p. 56.

[8] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 3.—U.S. imports for consumption of sodium sulfate

(Thousand short tons and thousand dollars)

Year	Crude (salt cake)		Anhydrous		Total [1]	
	Quantity	Value	Quantity	Value	Quantity	Value
1951–55 (average)	84	$1,419	5	$129	89	$1,548
1956	99	2,047	4	127	103	2,174
1957	73	1,450	2	61	75	1,511
1958	95	1,905	2	62	97	1,968
1959	118	2,478	4	97	122	2,580
1960	164	3,411	3	62	167	3,473

[1] Includes Glauber salt, as follows: 1958, 12 tons, at $830; 1959, 227 tons, at $4,839; 1960, 7 tons, at $479.
Source: Bureau of the Census.

TABLE 4.—U.S. exports of sodium carbonate and sodium sulfate

(Thousand short tons and thousand dollars)

Year	Sodium carbonate		Sodium sulfate	
	Quantity	Value	Quantity	Value
1951–55 (average)	149	$5,443	26	$815
1956	242	8,219	30	1,037
1957	174	6,282	24	859
1958	104	4,279	20	786
1959	153	5,644	22	805
1960	155	5,143	31	940

Source: Bureau of the Census.

WORLD REVIEW

Worldwide production figures for soda ash in 1955 and 1959 were published.[9] In the Communist countries, production increased from 2.9 to 4.1 million tons in this period. Output of the free world increased from 11.1 to 11.7 million tons at the same time.

TABLE 5.—World production of soda ash, 1955 and 1959

(Short tons)

	1955	1959
Free world:		
Africa	149,900	121,300
Australia	55,100	104,700
Austria	134,500	168,100
Belgium-Luxembourg	187,400	198,400
Canada	193,100	286,600
Colombia	13,700	18,700
France	798,500	856,500
Germany, West	1,083,700	1,101,200
India	22,000	22,000
Italy	520,200	541,200
Japan	711,200	854,300
Mexico	59,200	88,200
Netherlands	----------	110,200
Norway	14,100	20,900
Pakistan	22,000	22,000
Portugal	35,100	35,100
Taiwan	1,900	5,000
Free world—Continued		
United Kingdom	1,543,200	1,543,300
United States	5,595,400	5,611,900
Total	11,140,200	11,709,600
Communist bloc:		
Bulgaria	77,800	114,600
China	440,900	716,500
Czechoslovakia	98,100	99,200
Germany, East	502,100	616,300
Poland	227,700	493,200
Rumania	56,200	116,800
U.S.S.R.	1,504,700	1,873,900
Yugoslavia	43,200	101,200
Total	2,950,700	4,131,700
Grand total	14,090,900	15,841,300

Source: Oil, Paint and Drug Reporter.

[9] Oil, Paint and Drug Reporter, Soda Ash Industry Corseted by Cost-Price Squeeze in Face of Rising East Bloc Capacity: Vol. 178, No. 10, Aug. 29, 1960, pp. 5, 63.

World production of caustic soda and chlorine set new records in 1959, according to data presented at Barcelona before the 32d Congreso Internacional de Quimica Industrial. A total of 460 caustic plants in 56 countries produced 11.4 million tons of caustic in 1959.[10] A breakdown of caustic soda production capacity by areas follows:

Area:	*Number of plants*	*Capacity, thousand short tons*
North America	61	6, 520
Central and South America	45	255
European Economic Community	70	2, 572
European Free Trade Area	29	1, 365
Europe (other)	37	340
Soviet bloc	36	1, 633
Asia and South Pacific	88	1, 767
Africa	10	35

Brazil.—Companhia Nacional de Alcalis inaugurated its soda ash factory at Cabo Frio on November 3. The new plant had an initial capacity of 130,000 tons per year.[11]

China.—Soda ash was produced from two soda lakes discovered in Inner Mongolia, North China. An estimated reserve of 20 million tons of soda ash was believed to exist in 70 or more similar lakes in the area.[12]

Colombia.—The chemical industry of Colombia had grown remarkably since 1946. Plentiful supplies of salt and limestone enabled soda ash production to reach an estimated 50,000 tons in 1960. Caustic soda was also produced for the soap, textile, and petroleum industries by electrolysis of salt. Excess chlorine from this operation was expected eventually to find an outlet in projected plants for the production of plastics and fertilizer materials.[13]

Rumania.—A new soda ash works at Bovova began producing. Annual capacity of the new plant was 150,000 tons which may be expanded threefold by 1965. Salt deposits of Octnitza supplied the raw material.[14]

U.S.S.R.—Natural soda ash production in the U.S.S.R. was about 5 percent of the total production. Brines of Lakes Tanatar and Kucherpak were clarified and evaporated at the Mikhailovka soda works to produce a sodium carbonate product with an average Na_2CO_3 content of about 80 percent. The product was of inferior grade because no chemical purification process was used in its preparation. Sediments at the bottom of the lake, also contained various sodium compounds. The sediments, containing 9 percent or more Na_2CO_3, were processed to recover soda.

Other sources of native soda in the U.S.S.R. were known, including a deposit at Verkhnii, Chusovsk, and various brine lakes in Siberia.[15]

[10] Chemical Engineering Progress, Chlorine, Caustic Production Figures: Vol. 56, No. 11, November 1960, pp. 76, 80.
[11] Chemical Trade Journal and Chemical Engineer (London), Brazilian Soda Ash Plant in Production: Vol. 147, No. 3835, Dec. 2, 1960, p. 1294.
[12] Mining Journal (London), vol. 254, No. 6492, Jan. 22, 1960, p. 100.
[13] Michelsen, O. P., Chemical Development in Colombia: Chem. Eng. Prog., vol. 56, No. 6, June 1960, pp. 46–49.
[14] Chemical Trade Journal and Chemical Engineer (London), Rumanian Soda Ash: Vol. 146, No. 3791, Jan. 29, 1960, p. 245.
[15] Sedel'nikov, G. S. [Industrial Production of Natural Soda]: The N. S. Kurnakov Inst. of General and Inorganic Chem., Academy of Sciences, U.S.S.R., Apr. 30, 1958, pp. 1696–1701.

TECHNOLOGY

As part of the Intermountain Chemical Co. planned expansion program, a system of continuous mining was to be tried at its trona mine near Green River, Wyo. Instead of drilling and blasting, augers adapted from hard-coal mining were to be used to break the ore from the face. The ore was to be transported to the skip by conveyors and hoisted to the surface. Changes in the refinery technology also were planned.[16]

A method of preparing dense sodium carbonate from crude trona was patented.[17] The process involved dry mining of crude trona; crushing, calcining, and leaching the ore; evaporating some of the water from the clarified liquor; and separating crystallized sodium carbonate monohydrate for calcination to produce dense soda ash. Discarding a portion of the recycled liquor eliminated buildup of impurities in the leach cycles.

An improvement in producing sodium carbonate by the ammonia soda process was the subject of another patent. It involved using an inert, water-immiscible, liquid-hydrocarbon heat-transfer agent to absorb the heat of reaction of carbon dioxide and ammoniated brine in the carbonating tower. On leaving the tower, the heat-transfer agent was separated from the slurry, cooled, and returned to the tower.[18]

A third patent described a method of producing large crystals of sodium bicarbonate by contacting a sodium carbonate solution with carbon dioxide in the presence of sodium chloride. Temperature and concentration of sodium carbonate and salt were controlled to produce crystals having the desired characteristics.[19]

Design problems found in using liquid alkali metals as heat-transfer agents in steam generation were partly overcome according to an industry report.[20] The principles which were established apply to all alkali metals, but most of the operating experience was with metallic sodium. The chemical reactivity of sodium, particularly with water and oxygen, produced leaks between the sodium and the water sides of the boilers, creating a hazardous condition. The tendency for leaks to develop was aggravated by the erosive nature of hot flowing sodium and the large thermal stresses developed in the boilers. Tube-leak detection and gas-filled surge volume cushions helped to control problems resulting from leakage between water and sodium. Refinements of workable liquid alkali metal heat-transfer systems were expected to continue, making the systems even more useful in the atomic age.

The reaction of sodium with oxygen in a fuel cell to produce an electric current directly without going through a mechanical cycle

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[16] Chemical Engineering, New Trona Mining Method Planned in Intermountain's Soda Ash Plant Expansion: Vol. 67, No. 19, Sept. 19, 1960, p. 123.

[17] Seglin, L., and Winniki, H. S. (assigned to Food Machinery and Chemical Corp.), Method for Preparing Dense Sodium Carbonate from Crude Trona: U.S. Patent 2,962,348, Nov. 29, 1960.

[18] Hoff, J. M. (assigned to Wyandotte Chemicals Corp., Wyandotte, Mich.), Continuous Process for Producing Sodium Bicarbonate Slurry: U.S. Patent 2,942,942, June 28, 1960.

[19] Mod, William A., Becker, C. W., and Carlson, E. L. (assigned to The Dow Chemical Co., Midland, Mich.), Process for Producing Large Sodium Carbonate Crystals: U.S. Patent 2,926,995, Mar. 1, 1960.

[20] Ammon, J. H., and Sprague, T. S., Liquid Metals Show New Promise for Nuclear Plants: Power, vol. 104, No. 8, August 1960, pp. 78–82.

was announced.[21] Sodium amalgam flowing over a steel plate formed the anode; a hollow porous metal or carbon plate attached to an oxygen supply acted as the cathode. The electrolyte was sodium hydroxide solution. In open circuit the cell developed about 2 volts, about twice the voltage of the hydrogen-oxygen cell. The depleted sodium amalgam leaving the cell was restored by adding metallic sodium, and the amalgam was returned to the cell in a continuous cycle. The electrolyte was continuously removed, cooled, and returned to the cell; makeup water was added to replenish that used in the reaction.

[21] Oil and Gas Journal, Sodium Reaction Powers New Fuel Cell: Vol. 58, No. 52, Dec. 26, 1960, p. 84.

Stone

By Perry G. Cotter [1] and Nan C. Jensen [2]

Contents

DESPITE a 4-percent drop in physical volume of construction put-in-place, another record in stone output was established in the United States in 1960. Increased demand for crushed stone in roadbuilding and concrete construction was responsible for the gain in output.

Erection of new housing, a principal factor in construction activity, declined 20 percent. Part of this decline was due to a cutback in military housing. In general, areas having the greatest population density showed increased use of stone products, although use in such areas declined slightly.

On road projects, an increase in the number, size, and mobility of portable plants and slight changes in the use of aggregate specifica-

TABLE 1.—Salient stone statistics in the United States [1]

(Thousand short tons and thousand dollars)

	1951–55 (average)	1956	1957	1958	1959	1960
Sold or used by producers:						
Dimension stone	2,273	2,640	2,456	2,522	2,442	2,257
Value	$70,395	$83,473	$83,688	$80,254	$87,571	$86,009
Crushed stone	362,034	504,871	530,967	533,401	581,721	614,771
Value	$495,530	$694,972	$741,714	$746,431	$824,411	$866,862
Total stone	364,307	507,511	533,423	535,923	584,163	617,028
Value	$565,925	$778,445	$825,402	$826,685	$911,982	$952,871
Imports for consumption (value) [2]	$4,937	$7,857	$8,792	$8,312	$11,064	$11,344
Exports (value)	[3] $1,216	$5,602	$6,013	$6,756	$7,292	$6,161

[1] Includes slate. 1951–56 includes Territories of the United States, possessions, and other areas administered by the United States.
[2] Includes whiting.
[3] Excludes crushed, ground, or broken stone not classified separately before Jan. 1, 1952.

[1] Commodity specialist, Division of Minerals.
[2] Supervisory statistical assistant, Division of Minerals.

TABLE 2.—Stone sold or used by producers in the United States, by States

(Thousand short tons and thousand dollars)

State	1959		1960	
	Quantity	Value	Quantity	Value
Alabama	[1] 11,886	[1] $18,728	13,503	$19,970
Alaska	89	377	275	852
Arizona	2,468	3,998	4,249	5,107
Arkansas	8,824	10,424	10,939	13,555
California	32,134	49,090	33,075	49,842
Colorado	2,824	5,537	2,442	4,651
Connecticut	4,462	7,088	5,057	8,313
Delaware	(2)	(2)	(2)	(2)
Florida	[1] 26,917	[1] 35,940	[1] 27,629	[1] 37,419
Georgia	13,771	35,973	14,297	37,033
Hawaii	3,034	5,480	3,535	6,443
Idaho	1,079	1,931	1,318	2,141
Illinois	35,294	45,081	41,721	55,593
Indiana	18,544	37,682	18,956	34,920
Iowa	20,501	25,759	23,185	30,321
Kansas	[1] 13,999	[1] 17,108	[1] 11,814	[1] 15,031
Kentucky	[1] 16,063	[1] 22,215	[1] 15,810	[1] 21,493
Louisiana	5,670	10,874	[1] 4,691	[1] 8,882
Maine	819	2,766	1,012	3,851
Maryland	7,445	15,476	7,944	16,962
Massachusetts	5,102	12,375	5,247	12,782
Michigan	30,095	30,379	31,256	32,274
Minnesota	3,639	9,461	4,234	10,034
Mississippi	[1] 126	[1] 114	807	808
Missouri	26,939	36,435	27,180	37,878
Montana	1,186	1,691	1,183	1,576
Nebraska	3,236	5,235	3,336	5,651
Nevada	840	1,587	579	1,350
New Hampshire	82	488	104	594
New Jersey	10,079	22,133	10,202	22,814
New Mexico	461	542	1,277	1,692
New York	28,640	46,556	29,802	46,955
North Carolina	12,859	20,302	14,721	23,296
North Dakota	48	84	28	44
Ohio	[1] 36,155	[1] 59,326	[1] 35,856	[1] 59,479
Oklahoma	12,683	14,980	[1] 14,054	[1] 16,098
Oregon	13,341	16,126	16,864	19,620
Pennsylvania	43,682	77,421	42,136	74,168
Rhode Island	(2)	(2)	1,810	4,372
South Carolina	[1] 6,247	[1] 8,647	[1] 5,994	[1] 8,178
South Dakota	2,721	7,243	3,149	7,909
Tennessee	18,767	29,094	20,074	29,942
Texas	42,172	47,787	39,029	45,088
Utah	3,338	4,048	1,837	3,087
Vermont	944	17,372	2,114	17,444
Virginia	17,787	31,447	19,651	33,436
Washington	12,278	13,587	13,897	15,796
West Virginia	[1] 5,923	[1] 10,482	[1] 8,001	[1] 14,001
Wisconsin	13,522	23,782	16,486	22,302
Wyoming	1,317	1,791	1,401	2,302
Undistributed	4,131	9,940	3,267	9,522
Total	584,163	911,982	617,028	952,871
American Samoa	178	219	523	261
Canton Island	(3)	1	------	------
Guam	568	1,109	962	2,194
Johnston Island	------	------	2	5
Panama Canal Zone	223	270	203	306
Puerto Rico	2,063	2,878	4,219	7,661
Virgin Islands	14	51	15	51
Wake Island	32	34	36	49

[1] To avoid disclosing individual company confidential data, certain State totals are incomplete, the portion not included being combined with "Undistributed." The class of stone omitted from such State totals is noted in the State tables in the Statistical Summary chapter of this volume.

[2] Figure withheld to avoid disclosing individual company confidential data; included with "Undistributed."

[3] Less than 500 tons.

tions, when cost was the most important factor, tended to keep unit values in the same range as that of previous years. Continuing growth in architects' acceptance of so-called modern design, particularly for large and expensive buildings, expanded the use of substitutes for dressed stone and appeared to present a definite challenge to the former supremacy of the producers of marble and granite in this field.

TABLE 3.—Stone sold or used by producers in the United States,[1] by kinds

(Thousand short tons and thousand dollars)

Year	Granite		Basalt and related rocks (traprock)		Marble		Limestone and dolomite		Shell	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1951–55 (average)	23,116	$54,467	31,185	$48,313	516	$13,460	265,147	$365,303	[2] 13,745	[2] $18,975
1956	29,640	65,995	38,052	63,021	947	18,380	[3] 381,001	[3] 516,687	19,852	28,368
1957	41,636	75,985	43,798	72,869	1,423	23,707	383,022	532,863	19,098	27,563
1958	31,958	69,491	44,605	69,496	1,405	27,656	391,447	535,522	18,916	31,876
1959	37,571	78,416	51,779	80,454	1,895	32,269	433,955	600,497	20,180	34,810
1960	43,041	90,071	57,884	87,699	1,644	31,060	451,253	623,437	18,934	33,706
	Calcareous marl		**Sandstone**		**Slate**		**Other stone [4]**		**Total**	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1951–55 (average)	(5)	(5)	10,264	$30,440	756	$13,151	19,578	$21,816	364,307	$565,925
1956	(5)	(5)	13,447	46,389	645	11,666	23,927	27,939	507,511	778,445
1957	1,916	$1,804	16,294	49,102	632	11,029	25,604	30,480	533,423	825,402
1958	1,803	1,660	24,973	53,677	638	11,459	20,178	25,848	535,923	826,685
1959	2,043	1,926	17,553	46,467	656	11,288	18,531	25,855	584,163	911,982
1960	1,283	1,353	21,013	48,771	532	9,233	21,444	27,541	617,028	952,871

[1] 1951–56 includes Territories of the United States, possessions, and other areas administered by the United States.
[2] Average for 1954–55 only. Data not available, 1951–53.
[3] Includes calcareous marl used in making cement.
[4] Includes mica schist, conglomerate, argillite, various light-colored volcanic rocks, serpentine not used as marble, soapstone sold as dimension stone, etc.
[5] Calcareous marl for agricultural use not included in stone; marl used in making cement, 1954–56, included with limestone.

LEGISLATION AND GOVERNMENT PROGRAMS

A Supreme Court decision on June 27, in the case of the Cannelton Sewer Pipe Co., apparently clarified the long-drawn-out dispute over the cutoff point for depletion allowances. The substance of the decision was that mining was considered to end when the mineral was ready for industrial use or manufacture into another product.[3]

A New Jersey Senate bill (280) proposed to restrict the material going into State roads to crushed stone. Object of the restriction was to protect the State traprock industry from competition from out-of-State slag suppliers, the proposed bill would also exclude the use of gravel, limestone, and dolomite on roads costing more than $2,500. The bill was opposed by the New Jersey State Highway Department, State Contractors Association, and the Concrete and Bituminous Concrete Associations.

[3] Bell, Joseph N., Supreme Court, Congress Rule Against Rock Producers: Rock Products, vol. 63, No. 8, August 1960, p. 39.

A California higher court decision held that a new State, county, or city zoning ordinance cannot stop or modify activities of a plant that was in operation on the date the zoning ordinance became effective.[4]

Despite protests from residents in the area, the Santa Clara County, Calif., Planning Commission extended for 2 years the life of the Page Mill stone quarry of Consolidated Ready-Mix Co. The Commission stipulated strict dust control, limited hours of operation, and ruled that screen planting should be placed between the quarry and the highway.

A favorable tax structure, especially regarding depreciation and capital gains, encouraged private and corporation construction, particularly housing developments, apartment buildings, office buildings, and shopping centers.

The maximum loan-to-value ratios permitted under the 1959 Housing Act were put into effect in 1960. On an appraisal value of $13,500 or less, this higher scale allows loans up to 97 percent.

DIMENSION STONE

Production of dimension stone totaled 2.3 million tons valued at $86 million, a decrease of 8 percent in tonnage and 2 percent in value as compared with 1959. Although there were 587 plants operating in 44 States, most of the tonnage was produced in Georgia, Indiana,

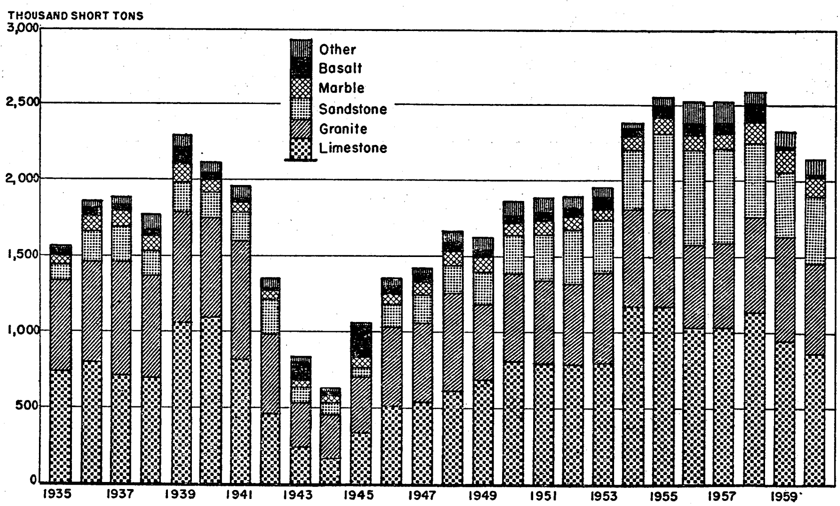

FIGURE 1.—Sales of dimension stone, except slate, in the United States, by kinds, 1935–60.

[4] Pit and Quarry, Legal Decisions on Industry Problems: Vol. 53, No. 7, January 1961, pp. 188, 191.

TABLE 4.—Dimension stone sold or used by producers in the United States, by uses

Use	1959			1960		
	Thousand short tons	Thousand cubic feet	Value (thousands)	Thousand short tons	Thousand cubic feet	Value (thousands)
Building:						
Rough:						
Construction	245		$1,805	200		$1,853
Architectural [1]	354	4,744	6,303	378	5,010	7,112
Dressed:						
Sawed [1]	611	8,063	21,405	555	7,276	20,305
Cut	233	2,968	26,485	183	2,364	23,683
Rubble	360		1,606	330		1,743
Roofing (slate)	29		1,810	25		1,611
Millstock (slate)	21		[2] 3,110	23		3,053
Monumental (rough and dressed) [3]	236	2,840	17,862	221	2,683	19,254
Paving blocks [4]	29		144	31		131
Curbing	155	1,860	3,811	157	1,891	3,929
Flagging [5]	169	2,050	[2] 3,230	154	1,033	3,335
Total	2,442		87,571	2,257		86,009

[1] Includes stone for refractory use to avoid disclosing individual company confidential data.
[2] Revised figure.
[3] Includes stone for precision surface plates.
[4] Includes a substantial quantity of blocks for other uses.
[5] Includes a small quantity of slate for miscellaneous uses.

Massachusetts, Minnesota, New York, Ohio, Pennsylvania, Tennessee, Vermont, and Wisconsin.

Dimension stone was a term applied to stone sold in blocks and slabs of specified shapes and sizes cut by hand or machine. It included material used for building stone, flagging, monumental stone, and ornamental stone. Small amounts of granite were cut for paving blocks. Many types of stone were used in constructing buildings, some of these stones were of extremely local importance. Other stones, because of exceptional beauty or physical properties, were shipped considerable distances. Stocks of finished products were small. Most of the building stone was cut on order; therefore, production and consumption may be considered synonymous.

GRANITE

Sales of dimension granite decreased 8 percent in value in 1960, and 10 fewer plants were operated. Slight increases in volume and value were recorded for dressed monumental granite.

The States in the Appalachian district from Maine to Georgia were the chief producers of dimension granite. Production in the Central States was chiefly from Minnesota, Missouri, Oklahoma, South Dakota, Texas, and Wisconsin. Relatively small amounts were produced in Colorado, Washington, and California.

TABLE 5.—Granite (dimension stone) sold or used by producers in the United States, by uses

Use	1959			1960		
	Thousand short tons	Thousand cubic feet	Value (thousands)	Thousand short tons	Thousand cubic feet	Value (thousands)
Building:						
Rough:						
Construction	81		$638	62		$629
Architectural	14	173	500	30	357	1,031
Dressed:						
Construction	21	248	1,245	20	237	1,255
Architectural	35	415	4,854	33	403	5,294
Rubble	104		390	67		244
Monumental: [1]						
Rough	174	2,091	8,046	157	1,910	7,997
Dressed	48	589	7,153	50	608	8,412
Paving blocks [2]	29		144	31		131
Curbing and flagging	148	1,773	3,618	150	1,814	3,780
Total	654		26,588	600		28,773

[1] Includes stone for precision surface plates.
[2] Includes substantial quantity of blocks for other uses.

TABLE 6.—Granite (dimension stone) sold or used by producers in the United States in 1960, by States

State	Active plants	Short tons	Value	State	Active plants	Short tons	Value
California	8	7,098	$771,714	South Dakota	9	17,915	$3,002,488
Colorado	3	953	109,885	Texas	4	34,958	938,530
Georgia	26	149,070	4,599,036	Washington	5	2,001	19,121
Maine	7	16,614	1,836,884	Wisconsin	8	8,503	1,598,809
Minnesota	24	42,602	3,154,698	Other States [1]	45	292,253	11,592,619
Missouri	1	3,017	231,873				
New York	3	20,845	297,886	Total	148	600,538	28,773,249
Oklahoma	5	4,709	619,706				

[1] Includes Connecticut, 7 plants; Maryland, 3; Massachusetts, 8; New Hampshire, 2; North Carolina, 9; Pennsylvania, 4; Rhode Island, 2; South Carolina, 3; and Vermont, 7.

BASALT AND RELATED ROCKS (TRAPROCK)

Output of basalt totaled 14,000 short tons valued at $365,000; most was produced in Pennsylvania. Other States reporting production, in order of value, were: Oregon, New Mexico, California, Hawaii, Connecticut, and Nevada. Dressed architectural stone, monumental stone, and precision surface plates (1,252 short tons valued at $284,585) declined 9 percent in tonnage and 12 percent in value compared with 1959. Rough construction, curbing, and rubblestone output rose 50 percent in total value, but tonnage remained about the same.

MARBLE

Dimension marble used for building decreased in quantity and value compared with 1959. A small increase was noted in production of monumental stone. The average value of marble per cubic foot increased 45 cents to a total price to $11.70. Average value of monumental marble was $17.25 per cubic foot. These high values, resulting from necessary, costly and time-consuming processing, contributed to the decline in use. Dimension marble was used chiefly for only the most enduring buildings and memorials. Marble substitutes for interior use included colored glass panels, filigree ceramic blocks, stainless steel panels, and colored aluminum plates.

Although the term "marble" is correctly applied only to metamorphosed limestones showing evidence of crystallization, it is commonly used to include onyx marbles, travertine, and the verde antique or serpentine marbles, all of which take a good polish and are sufficiently attractive to be used as ornamental stone.

TABLE 7.—Marble (dimension stone) sold or used by producers in the United States [1]

Use	1959			1960		
	Thousand short tons	Thousand cubic feet	Value (thousands)	Thousand short tons	Thousand cubic feet	Value (thousands)
Building: [2]						
Rough: Architectural	20	241	$760	20	229	$925
Dressed:						
Sawed	48	563	3,456	54	638	3,700
Cut	56	652	11,368	42	493	10,427
Monumental (rough and finished)	13	151	2,501	13	156	2,691
Total	137	----------	18,085	129	----------	17,743

[1] Produced by the following States in 1960 in order of value and with number of plants: Vermont, 8; Georgia, 1; Tennessee, 12; Missouri, 4; Alabama, 2; Arkansas, 1; North Carolina, 1; Colorado, 4; California, 2; Maryland, 1; and Washington, 1.

[2] Includes: 1959—748,000 cu. ft. of building stone, valued at $7,439,000, for exterior use, and 708,000 cu. ft., $8,145,000, for interior use; 1960—748,000 cu. ft., $7,242,000, for exterior use, and 612,000 cu. ft., $7,810,000, for interior use.

LIMESTONE

Hand-cut and shaped limestone blocks were used mainly for building construction. Other uses were for curbing, flagging, and rubblestone. Production of limestone decreased in tonnage by 10 percent and in total value by 17 percent during 1960. Average value decreased $1.80 a ton to $19.93. The Bedford-Bloomington, Ind., stone district continued to produce most (75 percent) of the rough-block and dressed limestone in the United States. As with marble, the high cost of producing dressed or semidressed stone contributed to the develop-

TABLE 8.—Limestone (dimension stone) sold or used by producers in the United States, by uses

Use	1959			1960		
	Thousand short tons	Thousand cubic feet	Value (thousands)	Thousand short tons	Thousand cubic feet	Value (thousands)
Building:						
Rough:						
Construction	67	----------	$248	54	----------	$213
Architectural	223	3,099	3,150	235	3,238	3,378
Dressed:						
Sawed	354	4,809	8,868	303	4,118	7,766
Cut	100	1,351	7,695	62	849	5,006
Rubble	172	----------	518	177	----------	532
Curbing and flagging	36	476	214	29	373	245
Total	952	----------	20,693	860	----------	17,140

TABLE 9.—Limestone (dimension stone) sold or used by producers in the United States in 1960, by States

State	Active plants	Short tons	Value	State	Active plants	Short tons	Value
Illinois	7	6,181	$134,649	Oklahoma	4	2,392	$21,552
Indiana	18	528,855	11,500,267	Texas	8	51,089	1,213,362
Iowa	2	5,471	79,520	Wisconsin	32	106,222	1,371,517
Kansas	8	14,230	136,682	Other States [1]	14	67,561	936,765
Michigan	4	6,801	58,889				
Minnesota	10	42,069	1,586,739	Total	114	860,208	17,140,469
Missouri	7	29,337	100,527	Puerto Rico		36,941	87,276

[1] Includes Alabama, 1 plant; California, 6; Nebraska, 2; Ohio, 4; and Pennsylvania, 1.

TABLE 10.—Limestone sold by producers in the Indiana olitic limestone district, by classes

Year	Construction					
	Rough blocks		Sawed and semifinished		Cut	
	Thousand cubic feet	Value (thousands)	Thousand cubic feet	Value (thousands)	Thousand cubic feet	Value (thousands)
1951-55 (average)	2,529	$2,882	3,515	$5,657	891	$5,023
1956	2,969	3,378	2,801	5,626	812	4,921
1957	2,937	2,928	3,289	6,044	1,007	6,106
1958	2,941	2,967	3,007	5,104	725	4,273
1959	2,719	2,731	3,380	6,037	951	5,443
1960	2,817	2,934	2,846	5,340	528	3,005

Year	Construction—continued			Other uses		Total	
	Total						
	Thousand cubic feet	Thousand short tons	Value (thousands)	Thousand short tons	Value (thousands)	Thousand short tons	Value (thousands)
1951-55 (average)	6,935	503	$13,562	165	$375	668	$13,937
1956	6,582	477	13,925	163	452	640	14,377
1957	7,233	524	15,078	161	388	685	15,466
1958	6,673	484	12,344	168	449	652	12,793
1959	7,050	511	14,211	155	432	666	14,643
1960	6,191	449	11,279	139	413	588	11,692

ment of substitutes such as concrete blocks and poured-concrete walls and foundations.

SANDSTONE

Volume and price of dimension sandstone declined slightly in 1960. Small increases were noted in the volume of stone produced for curbing and for dressed cut building stone. Producing plants numbered 173, 2 less than in 1959. Ohio continued as the leading producing State, followed by Pennsylvania, Tennessee, and New York. Average unit value was $26.29 per ton.

TABLE 11.—Sandstone (dimension stone) sold or used by producers in the United States, by uses

Use	1959			1960		
	Thousand short tons	Thousand cubic feet	Value (thousands)	Thousand short tons	Thousand cubic feet	Value (thousands)
Building:						
Rough:						
Construction	88	-----------	$878	73	-----------	$960
Architectural [1]	97	1,231	1,893	93	1,186	1,778
Dressed:						
Sawed [1]	138	1,855	4,705	125	1,659	4,219
Cut	42	543	2,407	46	613	2,826
Rubble	45	-----------	237	48	-----------	309
Curbing	4	49	149	2	21	67
Flagging	59	718	1,476	52	638	1,382
Total	473	-----------	11,745	439	-----------	11,541

[1] Includes stone for refractory use to avoid disclosing individual company confidential data.

TABLE 12.—Sandstone (dimension stone) sold or used by producers in the United States in 1960, by States

State	Active plants	Short tons	Value	State	Active plants	Short tons	Value
Alabama	1	550	$2,335	New Mexico	1	10	$180
Arizona	11	21,679	292,140	New York	15	47,159	1,343,238
Arkansas	11	20,626	241,875	Ohio	18	132,862	5,843,715
California	8	1,132	11,608	Oklahoma	2	218	2,096
Colorado	14	10,508	196,281	Pennsylvania	27	80,186	733,242
Georgia	2	2,405	20,860	Tennessee	11	52,832	1,384,929
Kansas	2	930	12,063	Utah	4	1,924	37,429
Kentucky	3	2,217	37,204	Virginia	2	401	5,210
Massachusetts	1	1,288	77,800	Wisconsin	10	3,510	57,930
Michigan	6	11,615	97,395	Wyoming	1	960	73,200
Minnesota	1	80	9,460	Other States [1]	12	38,312	908,234
Missouri	3	2,811	41,565				
Nevada	7	4,612	110,611	Total	173	438,827	11,540,600

[1] Includes Indiana, 4 plants; Maryland, 1; Mississippi, 1; Washington, 3; and West Virginia, 3.

SLATE

Pennsylvania, Vermont, Virginia, and New York produced 95 percent of the dimension slate tonnage. Although the total production remained the same as in 1959, value declined slightly. Substitute materials such as cement-asbestos tile, built-up asphalt roofing, and other less expensive products replaced slate roofing in most buildings. Waste slate accounted for as much as 80 percent of gross production in most of the industry and covered some desirable slate deposits. Its disposal presented a major problem. A closely coordinated research project directed towards utilization of this waste material might be rewarding. A limited quantity was used for roofing granules, and a small amount was bloated by heating to make lightweight aggregate.

TABLE 13.—Slate (dimension stone) sold or used by producers in the United States [1]

Use	1959			1960		
	Quantity		Value (thousands)	Quantity		Value (thousands)
	Thousand short tons	Unit of measurement		Thousand short tons	Unit of measurement	
Roofing slate	29	*Thousand squares* 75	$1,810	25	*Thousand squares* 66	$1,611
Millstock:		*Thousand sq. ft.*			*Thousand sq. ft.*	
Electrical, structural, and sanitary slate [2]	17	[3] 2,135	[3] 2,031	20	2,395	2,067
Blackboards and bulletin boards [4]	3	1,246	1,029	3	1,206	939
Billiard tabletops	1	67	50	([5])	60	47
Total millstock	21	[3] 3,448	[3] 3,110	23	3,661	3,053
Flagstones [6]	60	10,933	1,232	59	11,501	1,329
Miscellaneous uses [7]	9		[3] 213	12		326
Grand total	119		6,365	119		6,319

[1] Produced by the following States in 1960 in order of value of output and with number of plants: Pennsylvania, 12; Vermont, 18; Virginia, 2; New York, 11; Maine, 1; North Carolina, 2; California, 4; and Arkansas, 1.
[2] Includes small quantity of slate used for grave vaults and covers.
[3] Revised figure.
[4] Includes small quantity of school slates.
[5] Less than 500 tons.
[6] Includes slate used for walkways and stepping stones.
[7] Includes slate for aquarium bottoms, buildings, fireplaces, flooring, headstones, shims, and unspecified uses.

MISCELLANEOUS STONE

Various types of stone, many of igneous origin, including rhyolite, volcanic tuffs, obsidian, mica schists, soapstone, and greenstone, were used locally where other construction material was not available, or where their physical or chemical properties made them valuable in manufacturing processes. Total production was small, although tonnage and value increased slightly in 1960.

TABLE 14.—Miscellaneous varieties of dimension stone sold or used by producers in the United States [1]

Use	1959			1960		
	Thousand short tons	Thousand cubic feet	Value (thousands)	Thousand short tons	Thousand cubic feet	Value (thousands)
Building:						
Sawed [2]	50	588	$3,131	53	624	$3,365
Rubble	35		448	37		649
Flagging	8	94	139	6	71	114
Total	93		3,718	96		4,128

[1] Produced by the following States in 1960 in order of value of output and with number of plants: Virginia, 2; California, 34; Pennsylvania, 7; Maryland, 1; New Jersey, 1; Oregon, 6; Montana, 1; Nevada, 1; and Hawaii, 1.
[2] Includes rough and cut stone and stone for refractory use to avoid disclosing individual company confidential data.

FOREIGN TRADE [5]

Most of the imports were marbles from specialty quarries in Italy, France, West Germany, Belgium, Spain, Portugal, and England. Small amounts were imported from Pakistan. The use of rare, highly polished imported marbles for tabletops and other furniture increased.

Tables on exports and imports of the various types of stone are given under Foreign Trade in the Crushed Stone section of this chapter.

WORLD REVIEW

Israel.—A technically orientated publication regarding potential development of marble deposits in Israel discussed location, geology, quality of stone, methods of developing the quarries, industrial features, and economic evaluation of the deposits.[6]

TECHNOLOGY

A new publication of importance to the dimension-stone trade was issued. The economic aspects of the dimension-stone industry were discussed in one section with the view of orienting field geologists. Other sections were devoted to the classification of stone by uses, examination of deposits, and the necessity for determining physical and chemical properties. Standard definitions relating to building stones were listed.[7]

Armour Research Institute Foundation conducted research to develop a method for using sheets of marble, ⅝-inch thick, bonded in a sandwich system to insulating core materials, such as foamed glass, paper honeycomb, or wood fiberboard, in an attempt to restore marble to its former importance in building construction. Such panels might be used as curtain walls, fascia, or interior ornamentation.[8]

CRUSHED AND BROKEN STONE

Nearly 615 million short tons of crushed and broken stone, valued at $867 million, was produced in 1960. This output represented a 6-percent increase in quantity and a 5-percent rise in value over 1959. The average value was $1.41 per ton.

Concrete and roadstone increased 8 percent in tonnage and 9 percent in value compared with 1959 and accounted for 63 percent of the total tonnage. The average value of concrete and roadstone was $1.35 per ton.

The total value of construction put-in-place was $55.2 billion, a decline of $1 billion from the record value of $56.2 in 1959. Public construction was virtually the same as in 1959. The $1.5 billion rise

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[5] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

[6] Ministry of Development, Office of the Controller of Mines, Quarrying Prospects at Al Bi'na, the Marble Belt, Western Galilee, Israel. Interim Report, September 1960, 87 pp.

[7] Currier, L. W., Geological Appraisal of Dimension-Stone Deposits: Geol. Survey Bull. 1109, 1960, 78 pp.

[8] Architectural Forum, Technical Briefs: Vol. 113, No. 6, December 1960, p. 116.

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TABLE 15.—Crushed and broken stone sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1959		1960	
	Quantity	Value	Quantity	Value
Agriculture	20,819	$36,038	22,804	$39,260
Cement	91,010	96,901	85,551	91,964
Concrete and roadstone	[1] 357,098	[1] 478,287	387,337	521,006
Fill	4,895	4,971	7,782	6,297
Filtration	316	665	213	472
Flux	28,633	41,682	30,708	44,558
Glass	1,636	4,798	1,504	4,565
Lime and dead-burned dolomite	20,517	31,834	19,724	30,850
Mineral food	658	3,601	571	2,991
Poultry grit	1,059	8,586	1,047	8,628
Railroad ballast	11,314	12,739	11,158	12,780
Refractory	955	7,192	749	6,082
Riprap	[1] 16,904	[1] 20,637	25,033	34,222
Roofing granules, aggregates, and chips	1,863	11,088	1,958	8,962
Stone sand	3,973	5,163	3,200	4,289
Terrazzo	620	6,170	434	5,140
Other uses [2] and unspecified	19,451	54,059	14,998	44,796
Total	581,721	824,411	614,771	866,862

[1] Revised figure.
[2] Includes some uses listed separately in the Limestone and Sandstone sections.

TABLE 16.—Crushed stone sold or used by Government-and-contractor producers in the United States, by uses [1]

(Thousand short tons and thousand dollars)

Use	1959		1960	
	Quantity	Value	Quantity	Value
Concrete and roadstone	38,999	$40,581	52,427	$54,958
Riprap	8,745	10,192	11,159	12,940
Agricultural (limestone)	401	569	357	522
Other uses	1,604	2,578	6,185	5,772
Total	49,749	53,920	70,128	74,192

[1] Figures represent tonnages reported by States, counties, municipalities, and other Government agencies, produced either by themselves or by contractors expressly for their consumption, often with publicly owned equipment; they do not include purchases from commercial producers.

in all other types of construction failed to offset the $2.5-billion decline in private and public residential construction.[9]

Trends in Use.—Concrete and road construction utilized 63 percent of the crushed and broken stone produced in 1960. Manufacture of cement accounted for 14 percent of the output. Minor uses included riprap, fluxstone, agricultural limestone, and manufacture of lime.

Although the benefits derived from the application of limestone and other calcium-containing materials to the soil were recognized by agriculturists, less than 30 percent of the needed requirement was applied to farms in the United States in 1960. However, the total amount used for all agricultural purposes during the year, 23 million tons, represented an increase of 10 percent over that used in 1959.

[9] Derrickson, Gardner F., Construction in 1960: Construction Rev., vol. 7, No. 4, April 1961, p. 6.

TABLE 17.—Crushed stone for concrete and roadstone sold or used by producers in the United States, by States

(Thousand short tons and thousand dollars)

State	1959		1960	
	Quantity	Value	Quantity	Value
Alabama	[1] 4,930	[1] $6,395	[1] 5,731	[1] $6,990
Alaska	12	292	193	720
Arizona	401	420	2,292	2,147
Arkansas	4,682	4,907	[1] 4,408	[1] 6,672
California	10,509	13,458	10,660	13,154
Colorado	366	871	516	736
Connecticut	4,085	5,916	[1] 4,550	[1] 6,821
Delaware	(2)	(2)	(2)	(2)
Florida	[1] 20,878	[1] 26,923	[1] 21,789	[1] 28,314
Georgia	[1] 8,864	[1] 13,201	[1] 10,177	[1] 15,134
Hawaii	2,636	4,968	3,301	6,140
Idaho	618	837	[1] 852	[1] 1,185
Illinois	27,257	34,811	32,420	43,641
Indiana	13,013	16,674	13,245	16,695
Iowa	15,083	18,802	18,066	23,513
Kansas	9,600	12,219	[1] 7,867	[1] 10,622
Kentucky	13,781	[1] 19,167	12,866	17,737
Louisiana	4,227	8,600	[1] 3,402	[1] 6,953
Maine	211	606	403	864
Maryland	5,062	8,584	5,728	9,830
Massachusetts	3,731	6,015	[1] 3,773	[1] 6,125
Michigan	5,937	6,863	5,476	6,283
Minnesota	2,455	2,956	[1] 2,951	[1] 3,391
Missouri	14,492	19,442	[1] 15,474	[1] 21,380
Montana	211	267	275	290
Nebraska	1,385	2,268	(2)	(2)
Nevada	263	322	[1] 20	[1] 12
New Hampshire	(2)	(2)	(2)	(2)
New Jersey	8,935	17,955	8,804	18,469
New Mexico	234	217	856	1,117
New York	19,713	31,271	20,849	33,333
North Carolina	12,611	17,610	14,508	20,651
North Dakota	5	5		
Ohio	[1] 16,743	[1] 21,904	[1] 17,255	[1] 22,473
Oklahoma	9,127	10,055	[1] 9,271	[1] 9,902
Oregon	9,018	11,860	12,062	14,266
Pennsylvania	[3] 20,443	[3] 31,492	20,364	31,284
Rhode Island	(2)	(2)	[1] 348	[1] 587
South Carolina	[1] 5,346	[1] 7,555	[1] 5,196	[1] 7,277
South Dakota	1,537	2,441	1,766	2,962
Tennessee	14,415	18,202	15,426	19,282
Texas	27,590	25,478	[1] 27,772	[1] 27,837
Utah	10	14	135	114
Vermont	424	1,000	1,636	1,986
Virginia	11,221	16,710	13,328	18,625
Washington	8,458	8,600	6,837	6,752
West Virginia	2,328	3,951	[1] 2,748	[1] 4,407
Wisconsin	9,799	10,201	12,990	12,961
Wyoming	361	393	[1] 128	[1] 166
Undistributed	[3] 4,091	5,589	8,623	11,206
Total	[3] 357,098	[3] 478,287	387,337	521,006

[1] To avoid disclosing cofidential information, total is somewhat incomplete, the portion not included being combined as "Undistributed."
[2] Included with "Undistributed."
[3] Revised figure.

Prices.—The unit value of crushed stone ranged from 81 cents a ton for unprocessed material used for fill to $11.84 a ton for carefully graded material used for terrazzo flooring. Increased efficiency in production and competition tended to keep the average unit value of crushed stone from rising. Slag and crushed gravel competed with crushed stone for the construction market.

Size of Plants.—The number of commercial crushed-stone plants operating was 2,888, an increase of 233 over 1959. Of this number, 1,982 produced crushed limestone. Plants producing over 900,000 tons constituted only 3 percent of the total number, but accounted for nearly 25 percent of total production. Plants producing between 100,000 and 400,000 tons supplied 35 percent of the total crushed stone.

Portable plants continued to increase in size and number. These plants primarily were used to produce aggregate crushed at the jobsite. Some large plants were designed so that they might be dismantled and moved to a new location after completion of a specific job.

Transportation.—Transportation continued to be one of the main cost factors, and truck haulage was the principal means of transporting crushed stone to the jobsite. Off-the-road trucks were designed and marketed solely for hauling in quarries and mines. Tractor trucks equipped with high-pressure tires, larger diesel engines, and lightweight aluminum bodies were brought into use. All features were designed to provide greater speed and allow bigger payloads. Some quarries in the Southeast shipped aggregate almost entirely by rail. Some crushed stone was produced near low-cost water transportation.

TABLE 18.—Number and production of commercial crushed-stone plants in the United States, by size of operation

Annual production (short tons)	1959				1960			
	Number of plants	Production: Thousand short tons	Production: Percent of total	Cumulative total, thousand short tons	Number of plants	Production: Thousand short tons	Production: Percent of total	Cumulative total, thousand short tons
Less than 1,000	110	58	0.01	58	140	90	0.02	90
1,000 to 25,000	655	6,434	1.21	6,492	663	6,536	1.20	6,626
25,000 to 50,000	299	10.432	1.96	16,924	342	12,471	2.29	19,097
50,000 to 75,000	196	12,118	2.28	29,042	233	13,830	2.54	32,927
75,000 to 100,000	180	15,599	2.93	44,641	212	18,226	3.35	51,153
100,000 to 200,000	458	65,265	12.27	109,906	477	67,588	12.41	118,741
200,000 to 300,000	215	52,529	9.88	162,435	262	63,933	11.74	182,674
300,000 to 400,000	155	53,463	10.05	215,898	167	57,407	10.54	240,081
400,000 to 500,000	109	48,439	9.11	264,337	110	48,312	8.87	288,393
500,000 to 600,000	69	37,580	7.06	301,917	86	46,488	8.53	334,881
600,000 to 700,000	65	41,766	7.85	343,683	49	31,099	5.71	365,980
700,000 to 800,000	31	22,981	4.32	366,664	35	25,958	4.77	391,938
800,000 to 900,000	18	15,376	2.89	382,040	23	19,347	3.55	411,285
900,000 and over	95	149,932	28.18	531,972	89	133,358	24.48	544,643
Total	2,655	531,972	100.00	531,972	2,888	544,643	100.00	544,643

TABLE 19.—Crushed stone sold or used in the United States, by methods of transportation

Method of transportation	1959		1960	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Commercial:				
Truck	330,904	57	347,822	57
Rail	81,695	14	81,572	13
Waterway	54,611	9	54,687	9
Unspecified	64,762	11	60,562	10
Total commercial	531,972	91	544,643	89
Government-and-contractor:				
Truck [1]	49,749	9	70,128	11
Grand total	581,721	100	614,771	100

[1] Entire output of Government-and-contractor operations assumed to be moved by truck.

GRANITE

Granite production was 42 million tons valued at $61 million, an increase of 15 percent in tonnage and 18 percent in value over 1959. Average value was $1.44 per ton. Output of crushed granite for concrete and roadstone increased 13 percent; that used for riprap increased 132 percent in volume and 290 percent in value. Five States—California, Georgia, North Carolina, South Carolina, and Virginia—produced 83 percent of the total.

TABLE 20.—Granite (crushed and broken stone) sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1959		1960	
	Quantity	Value	Quantity	Value
Concrete and roadstone	31,318	$44,691	35,393	$50,234
Railroad ballast	1,769	2,197	1,424	1,721
Riprap	1,282	1,479	2,977	5,756
Fill	911	1,203	1,236	791
Stone sand	1,474	982	1,227	1,093
Poultry grit	136	1,131	138	1,222
Other uses [1]	27	145	46	481
Total	36,917	51,828	42,441	61,298

[1] Includes stone used for agriculture, filtration, roofing granules, and unspecified uses.

TABLE 21.—Granite (crushed and broken stone) sold or used by producers in the United States in 1960, by States

State	Short tons	Value	State	Short tons	Value
Alaska	249,075	$812,445	North Dakota	28,344	$43,791
Arkansas	362,500	272,000	South Carolina	5,994,404	8,178,158
California	4,201,201	4,636,820	Tennessee	20,000	30,000
Colorado	144,991	422,156	Utah	1,200	1,200
Georgia	10,467,846	15,838,332	Virginia	4,080,947	5,781,046
Idaho	29,847	28,765	Washington	1,001,130	641,840
Massachusetts	740,991	1,286,759	Wisconsin	270,000	67,500
Minnesota	670,665	922,124	Wyoming	258,378	323,021
Missouri	789	1,468	Other States [1]	2,581,809	5,418,146
Nevada	6,435	11,326			
New Jersey	607,876	1,304,761	Total	42,440,549	61,298,463
New Mexico	1,869	2,492	Puerto Rico	96,512	234,524
North Carolina	10,720,252	15,274,313			

[1] Includes Arizona, Connecticut, Delaware, Maine, Maryland, Montana, New Hampshire, New York, Oklahoma, Oregon, Pennsylvania, Rhode Island, Texas, and Vermont.

BASALT AND RELATED ROCKS (TRAPROCK)

The group of igneous rocks of varying composition, generally understood to include basalt, diabase, andesite, gabbro, and diorite, was used extensively for concrete and roadstone. The average value for all uses was $1.51 per ton. Production increased in quantity and value.

TABLE 22.—Basalt (crushed and broken stone) sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1959		1960	
	Quantity	Value	Quantity	Value
Concrete and roadstone	[1] 43,741	[1] $67,495	46,244	$71,165
Railroad ballast	1,835	2,604	1,358	1,864
Riprap	[1] 5,244	[1] 5,873	4,294	7,019
Fill	309	191	5,304	4,620
Stone sand	110	216	82	138
Other uses [2]	526	3,698	588	2,528
Total	51,765	80,077	57,870	87,334

[1] Revised figure.
[2] Includes stone used for concrete blocks, filtration, filler, roofing granules, and unspecified uses.

TABLE 23.—Basalt and related rocks (traprock) (crushed and broken stone) sold or used by producers in the United States in 1960, by States

State	Short tons	Value	State	Short tons	Value
Alaska	25,755	$39,445	New Jersey	8,978,582	$18,794,793
Arizona	647,441	651,845	New Mexico	8,500	13,750
California	1,939,428	2,744,318	North Carolina	1,712,451	2,406,363
Colorado	16,400	25,700	Oregon	12,553,194	15,724,726
Connecticut	4,706,416	7,040,217	Pennsylvania	2,804,310	5,262,842
Hawaii	2,288,474	4,441,345	Virginia	2,370,067	3,622,657
Idaho	815,525	1,141,909	Washington	11,435,361	12,102,060
Maryland	1,425,550	2,529,586	Other States [1]	2,151,557	4,765,708
Massachusetts	3,656,487	5,656,684			
Michigan	49,977	55,530	Total	57,869,927	87,334,135
Minnesota	10,009	12,652	American Samoa	31,362	37,063
Montana	254,943	290,005	Panama Canal Zone	121,670	218,627
Nevada	19,500	12,000	Virgin Islands	14,895	51,287

[1] Includes Maine, New York, Texas, and Wisconsin.

MARBLE

Fractured, stained, and broken marble was utilized at dimension-stone plants for terrazzo, roofing granules, agricultural soil conditioning, and lime burning. Use of terrazzo and roofing granules was closely coordinated with the volume of public and private building.

TABLE 24.—Marble (crushed and broken stone) sold or used by producers in the United States [1]

(Thousand short tons and thousand dollars)

Use	1959		1960	
	Quantity	Value	Quantity	Value
Terrazzo	611	$6,019	412	$4,937
Other uses [2]	1,147	8,165	1,103	8,380
Total	1,758	14,184	1,515	13,317

[1] Produced by the following States in 1960, in order of tonnage: Georgia, Alabama, Missouri, Texas, New York, California, Virginia, Vermont, Tennessee, Washington, Maryland, Arkansas, New Jersey, Arizona, Colorado, Wisconsin, North Carolina, and Nevada.
[2] Includes stone used for agriculture, asphalt filler, concrete and roadstone, poultry grit, roofing, stone sand, stucco, whiting (excluding marble whiting made by companies that purchase marble), and unspecified uses.

LIMESTONE

Production of crushed and broken limestone surpassed the record established in 1959. Use in concrete and road construction accounted for nearly 60 percent of the output. Uses for fluxstone and agriculture each increased 9 percent. The volume of stone produced for riprap increased 76 percent, although this use accounted for only 2 percent of total production.

Agricultural applications totaled 5 percent of the production of limestone and dolomite, the same as in 1959. Most of the calcium carbonate products used for soil beneficiation, including shell, marble, slag, and marl, were finely ground.

TABLE 25.—Limestone and dolomite (crushed and broken stone) sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1959		1960	
	Quantity	Value	Quantity	Value
Concrete and roadstone	251,787	$325,411	267,657	$347,428
Flux	28,206	40,442	30,245	43,328
Agriculture	20,503	35,665	22,518	38,863
Railroad ballast	4,589	5,693	5,428	6,884
Riprap	5,449	6,561	9,584	11,982
Alkali manufacture	3,483	[1] 3,303	2,637	2,961
Calcium carbide manufacture	834	[1] 827	1,016	1,092
Cement-portland and natural	84,354	89,947	79,851	85,652
Coal-mine dusting	526	1,899	424	1,668
Fill material	581	560	476	366
Filler (not whiting substitute):				
Asphalt	2,829	6,905	2,391	5,604
Fertilizer	464	1,046	424	1,036
Other	326	1,645	193	805
Filtration	255	445	169	269
Glass manufacture	1,317	3,979	1,232	3,720
Lime and dead-burned dolomite	19,286	30,034	18,568	29,019
Limestone sand	2,293	3,818	1,845	3,004
Limestone whiting [2]	698	7,184	657	7,101
Mineral food	654	3,578	568	2,972
Paper manufacture	434	1,190	491	2,052
Poultry grit	146	1,096	146	1,106
Refractory (dolomite)	242	441	92	244
Sugar refining	856	2,098	875	2,268
Other uses [3]	1,461	4,194	1,968	5,312
Use unspecified	1,430	1,843	938	1,561
Total	433,003	579,804	450,393	606,297

[1] Revised figure.
[2] Includes stone for filler for calcimine, calking compounds, ceramics, chewing gum, explosives, floor coverings, foundry compounds, glue, grease, insecticides, leather goods, paint, paper, phonograph records, picture-frame moldings, plastics, pottery, putty, roofing, rubber, toothpaste, wire coating, and unspecified uses. Excludes limestone whiting made by companies from purchased stone.
[3] Includes stone for acid neutralization, carbon dioxide, cast stone, chemicals (unspecified), concrete products, disinfectant and animal sanitation, dyes, electrical products, magnesia, magnesite, magnesium, mineral wool, oil-well drilling, patching plaster, rayons, rice milling, roofing granules, stucco, terrazzo, and water treatment.

TABLE 26.—Limestone (crushed and broken stone) sold or used by producers in the United States in 1960, by States and uses

State	Riprap		Fluxing stone		Concrete and roadstone	
	Short tons	Value	Short tons	Value	Short tons	Value
Alabama	625,483	$883,046	1,548,053	$2,444,560	5,731,089	$6,990,419
Arizona	---	---	122,881	182,197	(1)	(1)
Arkansas	77,318	78,161	693,733	849,093	1,167,261	1,727,979
California	(1)	(1)	(1)	(1)	987,348	1,093,916
Colorado	(1)	(1)	317,437	661,071	(1)	(1)
Connecticut	(1)	(1)	(1)	(1)	---	---
Florida	---	---	---	---	21,789,445	28,314,384
Georgia	---	---	---	---	784,357	1,227,942
Hawaii	---	---	---	---	757,606	1,240,679
Idaho	---	---	(1)	(1)	---	---
Illinois	495,430	686,104	(1)	(1)	32,419,572	43,640,563
Indiana	300,130	370,584	90,167	117,864	13,244,570	16,694,692
Iowa	255,672	381,233	(1)	(1)	18,066,099	23,513,429
Kansas	536,690	459,530	---	---	7,842,489	10,618,051
Kentucky	(1)	(1)	(1)	(1)	12,865,591	17,736,683
Maine	(1)	(1)	---	---	(1)	(1)
Maryland	(1)	(1)	(1)	(1)	3,818,456	6,531,397
Massachusetts	---	---	(1)	(1)	(1)	(1)
Michigan	(1)	(1)	12,292,426	13,164,695	5,426,329	6,227,483
Minnesota	52,712	66,103	60	210	2,911,765	3,307,117
Mississippi	---	---	---	---	---	---
Missouri	1,841,942	1,748,152	(1)	(1)	15,474,210	21,379,761
Montana	(1)	(1)	(1)	(1)	(1)	(1)
Nebraska	538,384	646,907	---	---	(1)	(1)
Nevada	---	---	(1)	(1)	(1)	(1)
New Jersey	---	---	(1)	(1)	(1)	(1)
New Mexico	---	---	12,700	11,356	298,770	416,080
New York	245,004	357,092	77,842	169,551	18,328,462	28,744,978
North Carolina	---	---	---	---	(1)	(1)
Ohio	1,280,717	1,893,165	3,696,452	5,743,590	17,255,250	22,473,417
Oklahoma	1,960,463	2,638,981	---	---	8,534,267	9,222,184
Oregon	---	---	(1)	(1)	(1)	(1)
Pennsylvania	(1)	(1)	5,637,623	10,657,545	16,325,169	24,534,866
Rhode Island	---	---	(1)	(1)	---	---
South Carolina	---	---	---	---	(1)	(1)
South Dakota	(1)	(1)	---	---	965,842	1,628,125
Tennessee	18,492	18,398	67,337	81,872	15,329,811	19,101,191
Texas	341,163	494,000	433,238	492,058	18,910,479	15,962,987
Utah	63,532	121,000	630,955	1,000,181	(1)	(1)
Vermont	(1)	(1)	(1)	(1)	(1)	(1)
Virginia	(1)	(1)	622,558	1,071,472	6,650,119	8,872,155
Washington	---	---	(1)	(1)	---	---
West Virginia	(1)	(1)	2,231,617	4,164,780	2,748,488	4,406,920
Wisconsin	92,778	131,778	(1)	(1)	12,917,581	12,811,880
Wyoming	(1)	(1)	(1)	(1)	(1)	(1)
Undistributed	857,812	1,008,086	1,769,719	2,515,584	6,106,263	9,008,392
Total	9,583,722	11,982,320	30,244,798	43,327,679	267,656,688	347,427,670
American Samoa	---	---	---	---	418	380
Guam	50,000	75,000	---	---	911,818	2,118,557
Johnston Island	---	---	---	---	1,500	5,000
Puerto Rico	---	---	---	---	1,949,839	4,326,774
Wake Island	---	---	---	---	36,200	48,870

1 Figure withheld to avoid disclosing individual company confidential data; included with "Undistributed."

TABLE 26.—Limestone (crushed and broken stone) sold or used by producers in the United States in 1960, by States and uses—Continued

State	Railroad ballast		Agriculture		Miscellaneous		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alabama	19,328	$25,550	1,058,304	$1,416,650	4,207,207	$3,883,373	13,189,464	$15,643,598
Arizona	-----	-----	(1)	(1)	1,530,276	1,724,526	1,782,967	2,079,263
Arkansas	-----	-----	216,361	349,013	1,074,760	1,464,821	3,229,433	4,469,067
California	-----	-----	(1)	(1)	12,553,354	20,821,173	14,008,825	22,254,302
Colorado	-----	-----	337	2,696	1,535,411	2,436,191	2,123,194	3,484,757
Connecticut	-----	-----	62,441	286,000	(1)	(1)	151,573	568,122
Florida	(1)	(1)	728,340	2,125,907	(1)	(1)	26,062,799	34,850,890
Georgia	(1)	(1)	(1)	(1)	(1)	(1)	1,697,717	2,758,086
Hawaii	-----	-----	457	823	88,288	113,381	846,351	1,354,883
Idaho	-----	-----	(1)	(1)	(1)	(1)	(1)	(1)
Illinois	261,316	300,091	3,329,200	4,743,848	(1)	(1)	41,714,234	55,452,561
Indiana	418,882	522,930	2,095,455	2,869,949	2,174,119	2,179,901	18,323,323	22,755,920
Iowa	(1)	(1)	1,296,249	1,786,806	(1)	(1)	23,179,635	30,241,918
Kansas	(1)	(1)	385,704	567,309	(1)	(1)	11,431,619	14,762,721
Kentucky	(1)	(1)	1,184,605	1,589,804	(1)	(1)	15,807,496	21,455,692
Maine	-----	-----	(1)	(1)	(1)	(1)	(1)	(1)
Maryland	73,633	118,152	49,222	143,203	1,881,947	4,733,932	5,833,058	11,545,784
Massachusetts	-----	-----	144,254	427,998	428,303	1,554,223	598,538	2,021,534
Michigan	(1)	(1)	572,921	931,486	(1)	(1)	31,028,447	31,970,878
Minnesota	-----	-----	405,974	648,300	41,090	210,735	3,411,601	4,232,465
Mississippi	-----	-----	124,380	111,942	(1)	(1)	(1)	(1)
Missouri	75,280	96,407	2,716,512	4,306,619	(1)	(1)	26,381,197	35,374,314
Montana	(1)	(1)	-----	-----	706,784	966,300	778,985	1,092,503
Nebraska	-----	-----	101,084	189,967	(1)	(1)	(1)	(1)
Nevada	(1)	(1)	-----	-----	(1)	(1)	(1)	(1)
New Jersey	-----	-----	(1)	(1)	(1)	(1)	(1)	(1)
New Mexico	(1)	(1)	-----	-----	(1)	(1)	696,268	927,717
New York	399,785	646,645	499,066	1,466,112	7,425,143	8,437,584	26,975,302	39,821,962
North Carolina	-----	-----	(1)	(1)	-----	-----	(1)	(1)
Ohio	1,051,591	1,279,700	2,242,483	3,818,393	9,602,303	16,043,837	35,128,796	51,252,102
Oklahoma	28,242	27,400	161,450	197,366	1,308,896	1,745,119	11,993,318	13,831,050
Oregon	-----	-----	(1)	(1)	(1)	(1)	1,177,547	1,505,473
Pennsylvania	(1)	(1)	950,509	2,852,574	13,811,889	18,464,549	36,882,991	56,761,119
Rhode Island	-----	-----	(1)	(1)	(1)	(1)	(1)	(1)
South Carolina	-----	-----	(1)	(1)	(1)	(1)	(1)	(1)
South Dakota	96,211	82,740	-----	-----	(1)	(1)	1,578,618	2,501,216
Tennessee	587,318	759,831	1,304,610	1,984,169	2,565,444	2,791,174	19,873,012	24,736,635
Texas	510,588	496,158	52,071	52,477	6,321,601	7,497,303	26,569,140	24,994,983
Utah	(1)	(1)	-----	-----	998,704	1,791,126	1,702,021	2,921,737
Vermont	(1)	(1)	(1)	(1)	(1)	(1)	1,328,462	3,581,286
Virginia	(1)	(1)	761,163	1,601,295	4,106,392	6,576,757	12,355,810	18,382,072
Washington	-----	-----	(1)	(1)	(1)	(1)	1,225,398	2,003,852
West Virginia	(1)	(1)	87,374	223,742	1,459,394	2,827,301	6,988,011	12,261,775
Wisconsin	(1)	(1)	1,215,690	1,718,761	(1)	(1)	14,483,559	15,012,411
Wyoming	(1)	(1)	-----	-----	507,291	1,010,386	974,290	1,616,746
Undistributed	1,906,222	2,528,497	771,929	2,449,786	40,632,180	50,538,586	8,879,526	15,815,649
Total	5,428,396	6,884,101	22,518,145	38,862,995	114,960,776	157,812,278	450,392,525	606,297,043
American Samoa	-----	-----	-----	-----	491,381	223,355	491,799	223,735
Guam	-----	-----	-----	-----	-----	-----	961,818	2,193,557
Johnston Island	-----	-----	-----	-----	-----	-----	1,500	5,000
Puerto Rico	-----	-----	57,924	181,782	1,466,699	1,429,504	3,474,462	5,938,060
Wake Island	-----	-----	-----	-----	-----	-----	36,200	48,870

[1] Figure withheld to avoid disclosing individual company confidential data; included with "Undistributed."

TABLE 27.—Sales of fluxing limestone, by uses

(Thousand short tons and thousand dollars)

Year	Blast furnace		Open-hearth plants		Other smelters [1]		Other metallurgical [2]		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1951–55 (average)	30,194	$36,425	6,293	$8,620	1,046	$1,332	257	$347	37,790	$46,724
1956	28,914	38,939	7,494	11,488	1,006	1,329	375	730	37,789	52,486
1957	29,352	41,733	9,012	12,924	809	1,086	211	370	39,384	56,113
1958	19,427	28,153	4,777	6,641	866	975	546	768	25,616	36,537
1959	19,752	28,683	6,439	8,963	965	1,223	1,050	1,573	28,206	40,442
1960	20,457	29,055	7,409	10,958	997	1,311	1,382	2,004	30,245	43,328

[1] Includes flux for copper, gold, lead, zinc, and unspecified smelters.
[2] Includes flux for foundries and for cupola and electric furnaces.

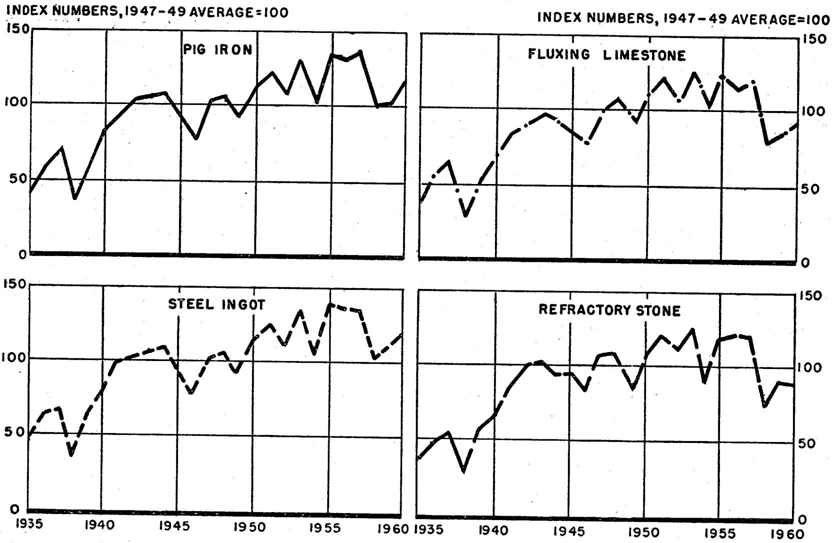

FIGURE 2.—Sales (tons) of fluxing limestone and refractory stone (including that used in making dead-burned dolomite), compared with production of steel ingot and pig iron, 1935–60.

Shell.—Various types of shell were used as substitutes for limestone in 1960. Some of the shell was burned for lime, but the greatest tonnage was used locally for concrete and roadstone. Most of the oystershell was dredged from fossil beds or from recent banks on the Atlantic and gulf coasts. Inland river locations supplied a small quantity of ground mussel shell for agriculture or lime.

TABLE 28.—Shell sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1959		1960	
	Quantity	Value	Quantity	Value
Concrete and road material	11,121	$17,320	12,447	$20,192
Cement	4,695	4,941	4,452	4,823
Lime	1,231	1,800	1,156	1,831
Poultry grit	777	6,359	763	6,300
Mineral food	4	23	3	19
Other uses [1]	2,352	4,367	113	541
Total	20,180	34,810	18,934	33,706

[1] Includes agriculture, asphalt filler, filtration, whiting, and unspecified uses.

TABLE 29.—Shell sold or used by producers in the United States in 1960, by States

State	Short tons	Value	State	Short tons	Value
Florida	1,566,181	$2,568,088	Virginia	13,999	$78,890
Louisiana	4,691,114	8,881,608	Other States [1]	2,358,153	6,361,675
New Jersey	946	17,598			
Texas	10,304,451	15,798,494	Total	18,934,844	33,706,353

[1] Includes Alabama, California, Maryland, Oregon, Pennsylvania, and Washington.

Calcareous Marl.—The material classified as marl is generally an impure mixture of clay, sand, silt, and unconsolidated shell deposits. Much of the fresh-water lake material was used locally in agricultural soil conditioning. Western dry-lake material, or caliche, was used for the manufacture of cement.

TABLE 30.—Calcerous marl sold or used by producers in the United States [1]

(Thousand short tons and thousand dollars)

Use	1959		1960	
	Quantity	Value	Quantity	Value
Agriculture [2]	299	$220	260	$190
Cement	1,744	1,706	1,023	1,163
Total	2,043	1,926	1,283	1,353

[1] Produced by the following States in 1960, in order of tonnage: Mississippi, Virginia, Michigan, Ohio, Indiana, Florida, Minnesota, Wisconsin, Nevada, and West Virginia.
[2] Includes marl used in mineral food.

SANDSTONE, QUARTZ, AND QUARTZITE

Sales of sandstone, quartz, and quartzite declined for use as refractories, abrasives, ferrosilicon, filtration, foundry sand, and glass. The decline may be attributed to several factors: Use of substitutes such as synthetic abrasive materials, cheaper filtration materials, and technological changes. The leading States in production of crushed sandstone were Arkansas, California, Texas, and Wisconsin.

TABLE 31.—Sandstone, quartz, and quartzite (crushed and broken stone)[1] sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1959		1960	
	Quantity	Value	Quantity	Value
Concrete and roadstone	9,882	$12,910	13,356	$19,139
Railroad ballast	615	675	800	1,031
Riprap	1,319	2,075	3,389	4,072
Refractory stone (ganister)	713	6,751	657	5,838
Abrasives	65	320	30	251
Ferrosilicon	152	702	129	532
Filtration	49	145	21	96
Flux	427	1,240	463	1,230
Foundry	430	976	360	895
Glass	319	819	272	845
Other uses [2]	3,109	8,109	1,097	3,301
Total	17,080	34,722	20,574	37,230

[1] Includes ground sandstone, quartz, and quartzite. Friable sandstone is reported in the chapter on sand and gravel.
[2] Includes cement, enamel, fill, filler, porcelain, pottery, roofing granules, stone sand, tile, and unspecified uses.

TABLE 32.—Sandstone, quartz, and quartzite (crushed and broken stone) sold or used by producers in the United States in 1960, by States

State	Short tons	Value	State	Short tons	Value
Arizona	468,660	$882,950	South Dakota	1,031,524	$1,855,179
Arkansas	4,563,107	6,186,029	Tennessee	76,000	151,000
California	3,539,979	5,614,869	Texas	1,816,006	1,035,750
Colorado	50,863	102,166	Utah	74,234	81,186
Illinois	592	5,920	Vermont	106,697	124,160
Maine	340,091	734,985	Virginia	368,646	673,051
Minnesota	47,559	110,365	Washington	102,686	404,826
New Mexico	54	925	West Virginia	1,010,548	1,737,446
New York	476,963	948,583	Other States [1]	3,393,175	6,971,738
Ohio	594,384	2,382,990			
Oklahoma	783,618	868,007	Total	20,574,207	37,230,252
Pennsylvania	1,728,821	6,358,127			

[1] Includes Alabama, Connecticut, Georgia, Idaho, Indiana, Kansas, Kentucky, Maryland, Montana, Nevada, North Carolina, Oregon, South Carolina, and Wisconsin.

CRUSHED AND BROKEN SLATE

Production of granules, the chief factor in utilization of crushed slate, declined 41 percent in volume and 54 percent in value. Total decline in value for all crushed slate was 41 percent.

Unemployment in some areas where crushed slate was produced intensified research for the use of waste slate by local and Federal agencies.

TABLE 33.—Slate (crushed and broken stone) sold or used by producers in the United States [1]

(Thousand short tons and thousand dollars)

Use	1959		1960	
	Quantity	Value	Quantity	Value
Granules [2]	396	$4,208	284	$2,304
Flour	134	690	115	571
Other uses [3]	7	25	14	39
Total	537	4,923	413	2,914

[1] Produced by the following States in 1960 in order of tonnage: Georgia, Pennsylvania, Arkansas, Virginia, California, and New York.
[2] Includes crushed slate used for lightweight aggregates to avoid disclosing individual company confidential data.
[3] Includes asphalt filler and unspecified uses.

MISCELLANEOUS STONE

The miscellaneous stone category includes volcanic rocks, cherts, limestone chats from mining operations, flint conglomerate, and various other varieties. For the most part these miscellaneous stones had local use only. Value and tonnage increased 6, and 16 percent, respectively, in 1960. Average price was $1.10 per ton.

TABLE 34.—Miscellaneous stone (crushed and broken stone) sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1959		1960	
	Quantity	Value	Quantity	Value
Concrete and roadstone	9,249	$10,460	12,240	$12,848
Railroad ballast	2,506	1,570	2,148	1,280
Riprap	3,610	4,649	4,789	5,393
Fill	1,109	1,075	696	466
Other uses [1]	1,964	4,383	1,475	3,426
Total	18,438	22,137	21,348	23,413

[1] Includes stone used for agriculture, filler, filtration, flux, roofing granules, stone sand, and unspecified uses.

TABLE 35.—Miscellaneous varieties of stone (crushed and broken stone) sold or used by producers in the United States in 1960, by States

State	Short tons	Value	State	Short tons	Value
Arizona	1,322,436	$1,142,238	Oklahoma	1,269,875	$755,878
California	8,252,442	11,452,079	Oregon	2,693,570	1,864,548
Colorado	90,952	185,809	South Dakota	520,945	550,469
Hawaii	399,567	645,593	Utah	57,500	45,312
Idaho	57,192	47,497	Washington	109,044	108,379
Kansas	366,864	119,145	Wyoming	167,424	288,856
Maine	2,240	7,064	Other States [1]	4,617,817	4,638,149
Maryland	200,070	400,070			
Missouri	614,287	391,225	Total	21,348,325	23,413,466
Montana	30,612	17,187	Panama Canal Zone	47,376	57,803
Nevada	6,487	14,656	Puerto Rico	611,568	1,401,090
New Mexico	569,001	739,312			

[1] Includes Arkansas, Louisiana, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Texas, Vermont, and Virginia.

FOREIGN TRADE [10]

Imports of crushed limestone were approximately 120,000 short tons in 1960. Some quartzite was imported from Canada, and chalk or whiting for pigment or polishing was imported from Europe.

Exports were virtually limited to border shipments.

TABLE 36.—U.S. imports for consumption of stone and whiting, by classes

Class	1959		1960	
	Quantity	Value	Quantity	Value
Marble, breccia, and onyx:				
Sawed or dressed, over 2 inches thick ... cubic feet	3,544	$25,191	8,512	$48,048
In blocks, rough, etc ... do	154,204	923,189	116,278	773,905
Slabs or paving tiles ... superficial feet	3,420,359	2,626,554	3,436,011	2,861,890
All other manufactures		3,047,945		3,302,944
Total		6,622,879		6,986,787
Granite:				
Dressed ... cubic feet	83,617	870,988	93,591	879,945
Rough ... do	80,784	360,423	102,935	518,985
Paving blocks, wholly or partly manufactured ... number	8,885	107,173	3,242	83,324
Total		1,338,584		1,482,254
Quartzite ... short tons	160,442	545,273	33,340	112,530
Slate		403,427		420,879
Travertine stone (unmanufactured) ... cubic feet	120,901	427,684	126,973	394,176
Stone (other):				
Dressed: Travertine, sandstone, limestone, etc. ... cubic feet	223,369	181,997	85,281	229,008
Rough (monumental or building stone) ... do	4,843	6,875	4,547	8,058
Rough (other) ... short tons	[1] 748,469	[1] 460,151	131,164	304,490
Marble chip or granito ... do	32,678	339,291	32,105	327,249
Crushed or ground, n.s.p.f.		497,586		856,333
Total		[1] 1,485,900		1,725,138
Whiting:				
Chalk or whiting, precipitated ... short tons	1,238	71,322	980	57,612
Whiting, dry, ground, or bolted ... do	10,245	168,042	9,358	161,184
Whiting, ground in oil (putty) ... do	1	604	13	3,226
Total		239,968		222,022
Grand total		[1] 11,063,715		11,343,786

[1] Data revised to include traprock, n.s.p.f., which is included with rough stone, effective Jan. 1, 1960.

Source: Bureau of the Census.

[10] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 37.—U.S. exports of stone

Year	Building and monumental stone		Crushed, ground, or broken				Other manufactures of stone (value)
			Limestone		Other		
	Cubic feet	Value	Short tons	Value	Short tons	Value	
1951-55 (average)	364, 561	$845, 682	(1)	(1)	(1)	(1)	$370, 222
1956	344, 210	975, 777	1, 060, 560	$1, 358, 783	175, 364	$2, 890, 139	377, 407
1957	415, 903	1, 157, 728	1, 088, 004	1, 649, 697	129, 559	2, 699, 023	506, 180
1958	349, 366	1, 236, 205	767, 757	1, 390, 365	173, 340	3, 696, 951	432 072
1959	425, 194	1, 261, 687	1, 085, 553	1, 999, 107	157, 911	3, 388, 372	643, 102
1960	431, 262	1, 250, 365	920, 791	1, 774, 876	153, 106	2, 658, 669	477, 401

1 Not separately classified before Jan. 1, 1952. 1952: Limestone 803,029 short tons ($789,733); other 126,123 short tons ($1,631,358). 1953: Limestone 691,811 short tons ($703,833); other 153,105 short tons ($2,204,139). 1954: Limestone 570,013 short tons ($702,526); other 142,622 short tons ($2,395,903). 1955: Limestone 936,766 short tons ($1,148, 781); other 169,074 short tons ($2,923,813).

Source: Bureau of the Census.

TABLE 38.—U.S. exports of slate, by uses [1]

Use	1951-55 (average)	1956	1957	1958	1959	1960
Roofing	$11,662	$6, 747	$6, 168	$12, 026	(2)	(2)
Structural (including floors and walkways) and granules and flour	234,821	189, 050	(2)	212, 460	$89, 912	$47, 811
Other uses 3	155,569	135, 516	276, 177	84, 629	126, 683	100, 247
Total	402,052	331, 313	282, 345	309, 115	216, 595	148, 058

1 Figures collected by the Bureau of Mines from shippers of products named.
2 Included with "Other uses" to avoid disclosing individual company confidential data.
3 Includes electrical slate, school slate, blackboards, and billiard tabletops.

WORLD REVIEW

Canada.—The Ontario Department of Mines, Toronto, published information on locations of limestone quarries, chemical analyses of the stone, mining equipment used, transportation methods, and end uses of various types of limestone.[11]

The first quarry established by Tough-Rock Quarries, Ltd., as part of its quarrying operations on Hotham and Frechette Islands, Ontario, was expected to be in operation by mid-1961. The quarry was designed to produce 2 million tons of traprock annually.[12]

An Ontario plant completed a drying and grinding unit to produce agricultural limestone from limestone screenings too small to be used in rotary kilns for the production of lime.[13]

India.—Mechanization of the limestone quarries at Nandini was completed. The quarries will supply the Bhilai Steel Project with 7,500,000 tons of metallurgical stone annually.[14]

11 Hewitt, D. F., The Limestone Industries of Ontario: Dept. of Mines, Canada, Ind. Miner. Circ. 5, 1960, 177 pp.
12 Northern Miner (Toronto), Elliot Lake Quarry to Start in Mid-'61: Vol 46, No. 40, Dec. 29, 1960, p. 7.
13 Trauffer, Walter E., Agstone Made from Lime Plant Waste Stone Lines: Pit and Quarry, vol. 53, No. 11, May 1960, pp. 112–115.
14 Journal of Mines, Metals and Fuels (Calcutta), Mechanisation of Nandini Limestone Mines: Vol. 9, No. 6, June 1960, pp. 28–29.

United Kingdom.—The methods and equipment used in England to remove approximately 12 percent of tenacious and insoluble clay from limestone for lime burning were described.[15]

TECHNOLOGY

The problem of adhesion between aggregates and the binder in bitumen macadam in the presence of water was studied. It was concluded that loss of cohesion occurred most readily from mineral aggregates which contained high proportions of quartz and feldspar and less readily, or not at all, from aggregates containing high proportions of more basic components, particularly those containing iron, for example, olivine.[16]

Determination of the factors inducing slipperiness in some limestone aggregates used in bituminous paving mixes was the subject of research by the National Crushed Stone Association. Among other tests, the rate of polish for several types of limestone was ascertained. No general conclusions were drawn from the tests except that slipperiness decreased as the percentage of insoluble sand particles increased.[17]

An article discussed the desirability of a reappraisal of aggregate specifications to allow use of local deposits for some roads although these aggregates might not be of the highest quality.[18]

The mineralogical and ceramic properties of fired compacts consisting of quartz, kaolinite, and mica were studied in relation to composition and firing temperatures.[19]

According to the report of the 14th Annual Frequency Control Symposium, approximately half the papers presented were on quartz. Subjects discussed were leak tests, seals, aging (corrosion and adsorption were believed to be the major cause of aging), and hermetically sealed crystals.[20]

An article discussed in detail the chemical composition of sandstones, including well-known sandstones and quartzites of the Lorain, St. Peter's, Tuscarora, Oriskany, Dakota, and Berea formations.[21]

Drilling and Blasting.—In an article on the behavior of rock under stress, methods for measuring stresses, physical properties of rock in situ, relationship of stress to strain, and the need for continuing experimentation in the field of rock mechanics were discussed. A short bibliography was included.[22]

A paper presented at the 43d Annual Convention of the National Crushed Stone Association itemized some of the studies underway on

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[15] Building Science Abstracts (London), Purification and Classification of Limestones: Vol. 33, No. 7, July 1960, p. 195.

[16] Hughes, R. I., Lamb, D. R., and Pordes, D., Adhesion in Bitumen Macadam: Jour. of Appl. Chem., vol. 10, pt. 11, November 1960, pp. 433–444.

[17] Gray, J. E., and Renninger, F. A., Limestones with Excellent Non-Skid Properties: Crushed Stone Jour., vol. 35, No. 4, December 1960, pp. 6–15.

[18] Reagel, F. V., How Good Is Good Enough: Crushed Stone Jour., vol. 35, No. 1, March 1960, pp. 16–19, 28–29.

[19] Brindley, G. W., and Udagawa, S. High Temperature Reactions of Clay Minerals Mixturets and Their Ceramic Properties: I Kaolinite—Mica Quartz Mixtures with 25 Percent Quartz: Jour. Am. Ceram. Soc., vol. 43, No. 4, February 1960, pp. 59–65.

[20] Flynn, George J., Atomic Clocks and Quartz Crystals: Electronics, vol 33, No. 26, June 24, 1960, p. 38.

[21] Middleton, G. V., Chemical Composition of Sandstones: Bull. Geol. Soc. of America, vol. 71, No. 7, July 1960, pp. 1011–1026.

[22] Rinehart, John S., Rock Mechanics: Min. Cong. Jour., vol. 46, No. 8, August 1960, pp. 50–52.

the seismic effects of blasting.[23] Results of a somewhat similar study were reported in two other articles. The first discussed vibrations usually encountered in construction, blasting, and roadbuilding, particularly in urban localities. The second discussed the safe vibration limits for structures affected by blasting and suggested use of delay caps to control initiation of blasting and, thus, separate pressure fronts, improve rock fragmentation, and reduce the amount of vibrational energy transmitted to surrounding structures.[24]

Nine-inch, down-the-hole drills were installed by a California operator for drilling extremely hard-jointed quartzite after all other currently available drilling methods, including jet piercing, were tried. Tungsten carbide drill bits were used, and the drilling rate for the 9-inch holes was 25 feet per hour. Holes were drilled to 15 feet below the bench and loaded with uncoated agricultural-grade ammonium nitrate treated with diesel fuel. Pentolite boosters, placed at intervals from top to bottom of the explosive column, were used as detonating agents. In extremely hard rock an explosive charge made up of quarry gelatine and emulsified ammonium nitrate oil slurry was used.[25]

The factors to be considered when breaking rock by deep-hole drillings were discussed. The report also gave results obtained by the adoption of lightweight mobile drill rigs for deep-hole drilling using down-the-hole hammers. Holes of 4-inch diameter were drilled to depths of 150 feet. Operation of various other mobile drilling units for drilling toe holes, for horizontal drilling, and for prospecting were illustrated.[26]

The difficulties encountered by a South Carolina quarry operator drilling in a monolithic-type granite gneiss when changing from churn to rotary percussion down-the-hole drills were described. Tests were begun in 1956 and continued, aided by vendors and makers of drilling equipment, until 1959, when satisfactory combinations of pressures, grades of carbide bits, lubrication, and stem-steel diameter were established, and breakage of parts was reduced.[27]

Quarrying and processing operations at a Newfoundland limestone quarry producing fluxstone for blast-furnace and open-hearth use were reported. Drilling was done with a diesel-powered rotary drill, which replaced three churn drills. A 6¼-inch, tri-cone bit was used with a drill pattern of 20-foot spacing and a 15-foot burden. The original face of the quarry was 110 feet high, but because of the difficulty of scaling the face and the hazard of falling rock, the face was benched. One pound of dynamite was used to break 4 tons of rock with plain detonating fuse for a truckline and reinforced detonating fuse for downlines.[28]

The Swedish "Riktad" or "controlled" blasting method was successfully used to solve a difficult blasting problem at the Warragamba

[23] Obert, Leonard, Seismic Effects from Blasting: Crushed Stone Jour., vol. 35, No. 1, March 1960, pp. 24–27.
[24] Leet, L. Don, Vibrations from Construction Blasting: The Explosives Eng., pt. 1, vol. 38, No. 1, January–February 1960, pp. 13–30; pt. 2, vol. 38, No. 2, March–April 1960, pp. 47–53.
[25] Hughes, Martin J., How Kaiser Drills and Blasts: World Min., vol. 13, No. 13, December 1960, pp. 34–35.
[26] Lamming, C. K. G., Aspects of Deep Hole Drilling: Mine & Quarry Eng. (London), vol. 26, No. 4, April 1960, pp. 128–146.
[27] Alfred, Robert C., Granite Tests New Drill Rig: Rock Products, vol. 64, No. 3, March 1961, pp. 81–83.
[28] Gillis, J. N., Quarry Operations at Dominion Limestone Division: Can. Min. and Met. Bull. (Montreal), vol. 54, No. 586, February 1961, pp. 192–194.

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Dam in New South Wales, Australia. Ordinary blasting methods were considered too hazardous because of the danger of rock slippage in the badly disorganized sandstone. In the controlled method, a 7-inch hole was first drilled with a tungsten carbide bit. Ten 2-inch-diameter holes were then drilled around this 7-inch hole and loaded with a small amount of high-density gelatin taped around circular hardwood sticks slightly less than 2 inches in diameter. Where special care had to be taken to avoid excessive fracturing, short-period delay detonators were used.[29]

Mining and Processing.—Selective mining solved the problem of producing metallurgical limestone and cement-grade limestone from a highly folded and faulted deposit at the Cushenbury plant of Permanente Cement Co., located in the Mohave Desert. The limestone had a silicified zone averaging 32 percent silica. This material was mined and blended with high-grade limestone to produce cement rock containing minus 82 percent calcium carbonate ($CaCO_3$). A primary crusher was used from which the operator diverted the crushed rock to either the fluxstone stockpile or to the cement-rock stockpile. Annual production was about 650,000 tons of cement rock and 350,000 tons of metallurgical limestone.[30]

The elements entering into a detailed study of ways to increase production and lower costs at an Ohio limestone quarry were reported. Overburden at this quarry was up to 130 feet thick and consisted of shale and sandrock. Required production, 430,000 tons of limestone per year, had to be obtained from a 6-foot bed. Drilling, stripping, blasting, and hauling requirements were analyzed, and capacities, costs, and expected production of the various types of equipment considered were given.[31]

A new crushed-stone plant in North Carolina achieved the flexibility to produce any desired straight or blended sizes of aggregate by centralized control of an automatic blending and loading system. Crushed rock from the crusher and screens was carried on conveyor belts to storage bins fitted with clamshell gates. The control box for blending had push buttons for each gate and adjustments for each of the desired blends. Gates were operated by air cylinders activated by solenoids and discharged at a preset rate upon conveyor belts leading to storage or trucks for delivery. The system delivered blended material at the rate of 550 tons per hour.[32]

A hammermill with a 50-inch feed opening, designed especially for the aggregate industry, produced a larger volume of cubic material and a minimum of slabs or slivers.[33]

Quarrying and mining techniques employed at a Welsh granite quarry were described. The quarry, established in 1830 to process hand-broken and dressed stone, produced machine-crushed and graded

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[29] Grinrod, J., Shockless Use of Explosives for Sandstone Excavation: Explosives Eng., vol. 38, No. 2, March–April 1960, pp. 55–56, 58.
[30] Conners, E. B., Cement Raw Materials-Variety in Mining: Min. Cong. Jour., vol. 46, No. 12, December 1960, pp. 56–59.
[31] Lewis, David G., Operations Research in Limestone Mining: Min. Cong. Jour., vol. 46, No. 11, November 1960, pp. 86–92.
[32] Trauffer, Walter E., Fast Automatic Blending and Loading Feature at North Carolina Crushed Stone Plant: Pit and Quarry, vol. 53, No. 4, October 1960, pp. 94–97, 108.
[33] Rock Products, Tool Up for Efficiency . . . : Vol. 63, No. 9, September 1960, p. 103.

granite for railway ballast, aggregate, and coated roadstone, and had modern quarry practices and processing equipment.[34]

A 500-ton-per-hour semiportable crushed-stone plant supplied 840,000 tons of aggregate for Dulles International Airport, Chantilly, Va. The aggregate was produced from hard, tough diabase traprock. This aggregate was used for apron paving, jet-fuel-line conduits, storage tanks, and sewage disposal systems.[35] The problem involved in crushing the diabase rock, which had a compressive strength of 55,000 pounds per square inch, were solved by installing an oversized gyratory crusher. The primary crusher opening was 42 x 65 inches, and the crusher could handle 1,000 tons per hour, crushed to 6 inches. A cone crusher was used to reduce rock to 3½ inches.[36]

The processing equipment used to furnish volcanic sand and gravel for the Manjil Dam in Iran and the installation for supplying gray andesite aggregate for the Sefid River Dam were described. Flow sheets for both plants were given.[37]

Methods used to supply standard specification road aggregate from deposits of irregular quality were described.[38]

Replacement of obsolete equipment and installation of a secondary plant enabled a South Dakota producer to nearly double his aggregate production. Two electronic control stations handled production from scalping screens to stockpiling or loading bins.[39]

A new Georgia plant, serving southern Georgia and northern Florida, prepared aggregate in six sizes and stored and blended them to meet any specifications. Aggregate was washed and stockpiled for rail shipment.[40]

Methods of applying switchgear power regulation to crushed-stone plants to avoid excessive power loss and to give better voltage regulation were described.[41]

Stripping practices for removing limestone overburden at an English ironstone mine were outlined. Walking draglines were found most satisfactory at this operation, as the Mineral Workings Act of 1951 required leveling and restoration of land worked. Worked-out areas were leveled by bulldozing, spread with topsoil, and sown with lucerne and grass seed.[42]

A new 1,500-ton-per-hour plant of Midwest Consumers Co., Division of Vulcan Materials Co., McCook, Ill., featured complete electric and electronic controls. The wide range of aggregates demanded for highway, industrial, and home construction in the area necessitated plant flexibility. The plant was designed to follow a trend toward inde-

[34] Mine and Quarry Engineering (London), Recent Developments at Penmaenmawr Quarry: Vol. 6, No. 10, October 1960, pp. 410–419.

[35] Trauffer, Walter E., 500 T.P.H. Semiportable Crushed Stone Plant: Pit and Quarry, vol. 53, No. 6, December 1960, pp. 72–75, 83.

[36] Godfrey, Kneeland A., Jr., Big Gyratories Lick Trap-Rock Problem: Rock Products, vol. 63, No. 5, May 1960, pp. 152–158.

[37] Mine and Quarry Engineering (London), Aggregate Preparation for the Manjil Dam: Vol. 26, No. 12, December 1960, pp. 506–516.

[38] Thomson, Pat, Here's How the West Solves Crushed Rock Shortage: Rock Products, vol. 63, No. 11, November 1960, pp. 94–96, 100.

[39] Herod, Buren C., Production Capacity Soars at Black Hills Operation: Pit and Quarry, vol. 53, No. 5, November 1960, pp. 80–84, 92.

[40] Trauffer, Walter E., Tyrone Rock's New Georgia Plant: Pit and Quarry, vol. 53, No. 5, November 1960, pp. 100–104, 110.

[41] Wilson, R. N., Application of Switchgear to Sand, Gravel, Crushed-Stone Plants: Pit and Quarry, vol. 53, No. 4, October 1960, pp. 102–103.

[42] Dover, T. M., The Development of Strip Mining in the Northampton Sand and Frodingham Ironstone Fields: Mine and Quarry Eng. (London), vol. 26, No. 1, January 1960, pp. 14–19, 20.

pendent operation of quarry and plant. Ground plan and flow diagram were shown. Vibrating feeders installed at drawpoints delivered material to a 42-inch conveyor leading to a transfer tower. Only one man was needed at the control panel to regulate flow from screening-plant bins to load-out bins. Control panels also operated crushers, primary and secondary, and their conveyor belts.[43]

A California producer of crushed stone installed a flanged belt to increase belt-carrying capacity and avoid excessive spillage after 6-inch skirtboards failed to solve the problem.[44]

Electric vibrating feeders installed in plant-storage bins at an Ontario crushed-dolomite plant were used to load conveyor belts for reclaiming and blending aggregate to various specifications. A central control board with start and stop pushbuttons was used to operate all phases of production, from plant-feed storage pile to loading bins and stockpiles, to produce 400 tons per hour.[45]

A method was described for stripping overburden in quarries using crawler tractors in tandem. A table showed the relative efficiency of single and tandem methods.[46]

The need for proper care of compressors to avoid overheating, loss of efficiency, and carbon buildup on valves was stressed in an article which pointed out that carbon deposits are a fire and explosion hazard; attention to lubrication and cleanliness are necessary for safe and efficient operation.[47]

Transportation.—Savings in transportation costs were made by improving all crushed-stone moving equipment. Research on design and construction of conveyor belts, idlers, and power units produced belts which were less susceptible to cracking and failure and which carried larger loads over greater distances with less power consumption. Conveyor systems, 1 mile or more in length, were common for carrying aggregate to dam construction projects. Multiple conveyor systems, many with completely automatic controls, reduced costs of yard haulage and in some plants almost completely replaced trucks. Capacity and speed of over-the-road trucks were increased, and more road construction jobs made use of tractor loaders for short hauls of 300 feet or less. Front-end tractor loaders were used to good advantage in quarries to carry stone to crushers, thus supplementing the regular shovel-truck loading and transporting systems.

Some operators were able to move broken stone to crushers directly with large bulldozers and thus bypass usual loading and trucking operations.

Miscellaneous.—A new soil test for lime deficiency was developed at the Ohio State University Soil Testing Laboratory. The test was based upon the amount of change in pH of a given amount of buffer by a given amount of soil. More than 50,000 soil samples were tested. It was shown that actual lime requirements of acid soil of equal pH

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[43] Herod, Buren C., Automated Control: Pit and Quarry, vol. 52, No. 12, June 1960, pp. 80–88, 149.
[44] Pit and Quarry, Flanged-Edge Rubber Belt Solves Conveyor Problem: Vol. 53, No. 4, October 1960, p. 109.
[45] Trauffer, Walter E., New $1,000,000 Canadian Crushed Stone Plant: Pit and Quarry, vol. 53, No. 1, July 1960, pp. 96–99, 236.
[46] Hancock, R. N., You Can Cut Stripping Costs: Rock Products, vol. 63, No. 10, October 1960, pp. 140–145.
[47] Ziemke, Paul C., Don't Overlook Compressor Maintenance: Rock Products, vol. 63, No. 9, September 1960, pp. 130–135.

value may vary as much as threefold, and that old soil tests indicated lower lime requirements than were necessary.[48]

A gravitational-inertial classifier was used successfully by a Pennsylvania crushed-limestone producer to furnish stone for certain glass-industry requirements which specified not more than 10-percent fines in the overall aggregate.[49]

Increased use was found for underground limestone caves. In addition to the previous uses for storage of frozen foods and raising mushrooms, manufacturing companies, banks, and financial houses utilized them for storing vital records.[50]

An Arkansas quarry operation producing 150 tons per hour of dry limestone aggregate found it economical to use natural gas for power. A natural-gas-powered generator furnished energy to drive jaw and roll crushers, three multideck screens, six conveyors, two screen heating units, and a 300-ampere electric welder.[51]

To expedite inspection of aggregate for Missouri highways, a Kansas City, Mo., producer provided field laboratory service for its customers.[52]

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[48] McLean, E. O., and Shoemaker, H. E., Lime Deficiency Determination Improved by New Soil Test: Pit and Quarry, vol. 53, No. 8, February 1961, pp. 126–127.

[49] Mining Engineering, Successful Application of the Gravitational-Inertial Classifier: Vol. 12, No. 11, November 1960, pp. 1175–1176.

[50] Rock Products, Underground Limestone Caves are Getting More Attention: Vol. 64, No. 2, February 1961, p. 12.

[51] Rock Products, Natural Gas Powers Crushed Stone Plant: vol. 63, No. 12, December 1960, pp. 90–92.

[52] Roads and Streets, Aggregates Supplier Furnishes Lab Setup: Vol. 103, No. 2, February 1960, p. 82.

Strontium

By Albert E. Schreck[1]

STRONTIUM deposits in California and Washington were inactive in 1960, and strontium mineral consumers had to rely on imports.

LEGISLATION AND GOVERNMENT PROGRAMS

Specifiations for stockpile-grade celestite were revised during the last half of the year. National Stockpile Purchase Specification P-10-R2, September 28, 1960, stated that the ore must meet the following chemical and physical requirements: Minimum of 95 percent strontium sulfate ($SrSO_4$); maximum 1.5 percent calcium sulfate ($CaSO_4$); maximum 2 percent barium sulfate ($BaSO_4$); not more than 2 percent by weight of free moisture; and of a physical form normally supplied to and suitable for processing by industry.

The Commodity Credit Corporation, U.S. Department of Agriculture, announced in May that it would consider barter offers for celestite.

DOMESTIC PRODUCTION

No domestic production of strontium minerals was reported in 1960. The celestite deposit of Pan Chemical Co., in the Fish Creek Mountains, San Diego County, Calif., and the deposit of Mineral Products Corp. near La Conner, Skagit County, Wash., were idle.

Strontium chemicals were produced by E. I. du Pont de Nemours & Co., Inc., at Grasselli, N.J.; Foote Mineral Co., at Exton, Pa.; Mineral Products Div., Food Machinery and Chemical Corp., Modesto, Calif.; and Barium and Chemicals, Inc., Willoughby, Ohio.

King Laboratories, Inc., Syracuse, N.Y., produced a small quantity of strontium metal.

TABLE 1.—Strontium minerals sold or used in the United States

Year	Short tons	Value	Year	Short tons	Value
1954	12	$300	1957–59	(1)	(1)
1955	177	4,425	1960	------	------
1956	4,040	77,160			

[1] Figure withheld to avoid disclosing individual company confidential data.

[1] Commodity specialist, Division of Minerals.

CONSUMPTION AND USES

Celestite (strontium sulfate), the principal commercial strontium mineral, was used primarily in manufacturing strontium compounds. Small quantities of strontium minerals also were used in caustic soda refining and in the ceramics and glass industries.

Manufactured strontium salts were used chiefly in the pyrotechnic industry because of the characteristic red color they impart to a flame. Strontium nitrate was used in tracer bullets, distress signal rockets and flares, tactical military signal flares, highway and railroad warning fusees, and fireworks. Other strontium salts were used in ceramics, greases, medicines, plastics, and luminous paints and in manufacturing high-purity electrolytic zinc.

Strontium metal was used as a getter to remove gases from vacuum tubes.

Strontium titanate produced by the flame-fusion process had potential use as an ultraviolet-light filter, as gem stones, and in microwave amplifiers and infrared systems.[2]

PRICES

Oil, Paint and Drug Reporter quoted the following prices on various strontium compounds in 1960, unchanged from 1959: Strontium sulfate, air floated, 90 percent, 325-mesh, bags, works, $56.70–$66.15 per short ton; strontium carbonate, pure, drums, 5-ton lots or more, works, 35 cents per pound, and drums, 1-ton lots, works 37 cents per pound; technical grade, drums, works, 19 cents per pound; and strontium nitrate, bags, carlots, works, $11 per 100 pounds; and less than carlots, works, $12 per 100 pounds. Strontium titanate was quoted at about $1 per carat.

FOREIGN TRADE[3]

Strontium mineral imports in 1960 were almost 2,000 tons less than in 1959. The United Kingdom supplied about 53 percent and Mexico the remainder.

Imports of strontium chemicals (strontium carbonate, nitrate, and oxide) totaled 991 pounds, valued at $779; 92 percent came from Italy and the remainder from West Germany and the United Kingdom.

WORLD REVIEW

The production of strontium minerals was limited to a few countries. The United Kingdom and Mexico were the major producers.

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[2] Beals, M. D., and Merker, L., Three New Single-Crystal Materials: Materials in Design Eng., vol. 51, No. 1, January 1960, pp. 12–13.

[3] Figures on imports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 2.—U.S. imports for consumption of strontium minerals,[1] by countries

Country	1959		1960	
	Short tons	Value	Short tons	Value
Italy	11	$2,700	11	$2,700
Mexico	2,182	39,936	2,880	56,530
United Kingdom	5,946	182,769	3,294	90,476
Total	8,139	225,405	6,185	149,706

[1] Strontianite or mineral strontium carbonate and celestite or mineral strontium sulfate.

Source: Bureau of the Census.

TABLE 3.—Free world production of strontium minerals by countries [1] [2]

(Short tons)

Country [1]	1956	1957	1958	1959	1960
Argentina	489	(3)	240	(3)	(3)
Italy	234	1,226	703	353	[4] 350
Mexico [5]	2,313	1,896	2,336	2,182	2,880
Morocco: Southern Zone	----------	661	1,124	435	(3)
Pakistan	336	956	510	744	[4] 1,700
United Kingdom	10,304	7,728	6,272	[4] 7,000	[4] 5,000
United States	4,022	(6)	----------	(6)	----------
Free world total [1]	17,698	[4] 13,000	11,185	[4] 11,300	[4] 11,400

[1] In addition to countries listed, strontium minerals are produced in Germany, Poland, and U.S.S.R., but data on production are not available; no estimates are included in the total for these countries.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Data not available; estimate by author of chapter included in total.
[4] Estimate.
[5] U.S. imports.
[6] Figure withheld to avoid disclosing individual company confidential data; included in world total.

Compiled by Helen L. Hunt, Division of Foreign Activities.

United Kingdom.—The celestite operation of Bristol Mineral and Land Co., Ltd., near Chipping Sodbury, Gloucestershire, employed 24 persons, of whom 11 were quarrymen, 4 shovel operators, 5 maintenance and office personnel, and 4 treatment-plant workers. The geology of the deposits, land reclamation, and mining method used at the three operating pits were discussed in a journal article.[4] A tractor-scraper removed overburden, and tractor-mounted shovel loaders removed the ore. As the celestite usually broke away from the enclosing material easily, blasting was seldom necessary. When filled, the shovel moved from the working face and spread its contents on either side of the road to the dump. Crews handpicked the celestite and placed it in the center of the road. At intervals, the shovel moved rejects to the dump and loaded the celestite into trucks for haulage to the treatment plant.

Average yield for the area was about 300 to 400 tons of celestite per acre. On this basis, reserves were believed sufficient for 25 years. A ratio of 1 part celestite to 9 parts waste was considered the limit for economic mining.

[4] Mine and Quarry Engineering (London), Celestine Production in Gloucestershire: Vol. 26, No. 9, September 1960, pp. 362–373.

At the treatment plant, the handpicked ore was crushed to 1½ inches and conveyed to a countercurrent rotary washer. The washer, 3 feet 6 inches in diameter and 12 feet long, was equipped with trommels having 3/16- and ¾-inch openings. The minus ¾-inch to plus 3/16-inch washer product was conveyed directly to the stockpile area. Oversize was returned for secondary crushing. Minus 3/16-inch material was dewatered and joined the plus 3/16-inch product on the conveyor. Fines (plus 200-mesh) were recovered from the wash water by a sand cone separator and recycled to the dewaterer. The plant had a capacity of 5 tons per hour.

TECHNOLOGY

Two reports on the heat capacities and entropies of some strontium compounds were published.[5]

Celestite and calciostrontianite were reported in vugs in a horizontal dolomite, one-half mile east of East Stone Gap, Wise County, Va., on State Highway 613, but the deposit was not considered of potential commercial value.[6]

The results of an investigation of strontium in the surface and ground waters of Champaign County, Ohio, were published.[7] Celestite is present in the Silurian limestones and dolomites that form the bedrock of the county and in glacial deposits. This celestite is the source of the strontium in the ground waters, and apparently the concentrations are highest in areas where the water has the longest contact time with the bedrock or glacial deposits. Strontium concentration in surface waters appeared to be related to the ratio of strontium-bearing ground water and strontium-free water which they contain.

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[5] King, E. G., and Weller, W. W., Low-Temperature Heat Capacities and Entropies at 298.15° K. of the Zirconates of Calcium, Strontium, and Barium: Bureau of Mines, Rept. of Investigations 5571, 1960, 3 pp.; Low-Temperature Heat Capacities and Entropies at 298.15° K. of Strontium Sulfide and Barium Sulfide: Bureau of Mines, Rept. of Investigations 5590, 1960, 5 pp.

[6] Mitchell, R. S., and Pharr, R. F., Strontium Minerals from Wise County, Virginia: Virginia Minerals, vol. 6, No. 4, October 1960, pp. 1–4.

[7] Feulner, A. J., and Hubble, J. H., Occurrence of Strontium in the Surface and Ground Waters of Champaign County, Ohio: Econ. Geol., vol. 55, No. 1, pt. 1, January–February 1960, pp. 176–186.

Sulfur and Pyrites

By Leonard P. Larson [1] and Victoria M. Roman [2]

THE YEAR 1960 was marked by record free-world production and consumption of sulfur; record U.S. imports, consumption, and exports; and a firming of sulfur prices.

Free-world consumption of sulfur reached an estimated 17.9 million tons, a gain of almost 1 million tons, or 6 percent, over 1959 and about 2.2 million tons, or 14 percent, over 1958. Most of this gain was met by elemental sulfur, in the face of stiff competition from the pyrites industry. A major expansion occurred during the year in the free world's elemental sulfur capacity.

TABLE 1.—Salient sulfur statistics

(Long tons, sulfur content)

	1951–55 (average)	1956	1957	1958	1959	1960
United States:						
Production	5,429,482	6,484,285	5,578,525	4,645,577	4,639,816	5,037,292
All forms	6,486,200	7,818,112	7,003,888	6,141,169	6,167,740	6,660,541
Imports, pyrites and sulfur	137,802	387,429	668,501	754,987	776,888	884,838
Exports, sulfur	1,446,396	1,675,331	1,592,979	1,602,126	1,635,607	1,786,543
Stocks Dec. 31: Producer, Frasch and recovered sulfur	[1] 3,153,866	4,055,896	4,579,623	4,619,028	3,949,954	3,777,799
Consumption, apparent, all forms	5,047,700	5,744,300	5,553,700	5,262,800	5,917,100	5,859,500
World: Production:						
Sulfur, elemental	(2)	9,175,000	8,735,000	8,350,000	8,985,000	10,095,000
Pyrites	(2)	7,600,000	7,900,000	7,800,000	7,700,000	7,900,000

[1] Frasch sulfur only before 1952.
[2] Data not available.

DOMESTIC PRODUCTION

Production of sulfur in all forms increased 6 percent over 1959, as output rose to 6.7 million tons. About 4,943,000 tons of the total production was Frasch-process sulfur from mines along the gulf coast. Other sources were: 94,357 tons recovered from native ores; 767,000 tons recovered as a byproduct from the purification of sour natural and refinery gases; 416,000 tons from the burning of pyrites; and 440,000 tons in various forms from other sources.

NATIVE SULFUR

Fifteen Frasch-process mines operated during 1960, nine in Texas and six in Louisiana. Three of these mines came on stream during the

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.

year, and two closed. The largest of the plants to come on stream was a new $30-million installation at Grand Isle, La., operated by Freeport Sulphur Co. Next in size was the Lake Pelto mine, also operated by Freeport Co. The other new property, High Island, was operated by United States Sulphur Corp. The two mines which closed were the Clemens Dome (Brazoria County, Tex.) and Starks Dome (Calcasieu Parish, La.) operated by Jefferson Lake Sulphur Co. These changes brought to 13 the number of Frasch mines in operation at the end of the year. Production from the 15 properties in operation during the year totaled 4,943,000, 2,679,000 tons from Texas and the remainder from Louisiana, an increase of 9 percent over 1959. A strong factor contributing to the growth was the increased demand for sulfur by the phosphate-fertilizer industry.

TABLE 2.—Production of sulfur and sulfur-containing raw materials by producers in the United States

(Long tons)

	1951-55 (average)		1956		1957	
	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content
Native sulfur or sulfur ore:						
Frasch-process mines	5,369,071	5,396,071	6,423,883	6,423,883	5,491,212	5,491,212
Other mines [1]	115,671	33,411	212,476	60,402	276,868	87,313
Total		5,429,482		6,484,285		5,578,525
Recovered elemental sulfur:						
Brimstone	307,416	305,977	466,848	464,629	511,936	510,307
Paste	2,172	1,007	287	129	452	204
Total		306,984		464,758		510,511
Pyrites (including coal brasses)	970,083	409,128	1,069,904	431,687	1,067,396	436,012
Byproduct sulfuric acid (basis 100 percent) produced at Cu, Zn, and Pb plants	813,974	265,996	1,064,406	347,954	1,194,230	390,394
Other byproduct sulfur compounds [2]	86,347	74,610	102,300	89,428	102,157	88,446
Total		6,486,200		7,818,112		7,003,888

	1958		1959		1960	
	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content
Native sulfur or sulfur ore:						
Frasch-process mines	4,643,243	4,643,243	4,553,634	4,553,634	4,942,935	4,942,935
Other mines [1]	6,292	2,334	331,237	86,182	379,067	94,357
Total		4,645,577		4,639,816		5,037,292
Recovered elemental sulfur:						
Brimstone	641,890	640,096	688,487	686,407	769,319	766,566
Paste						
Total		640,096		686,407		766,566
Pyrites (including coal brasses)	974,114	403,373	1,056,617	436,871	1,016,263	416,213
Byproduct sulfuric acid (basis 100 percent) produced at Cu, Zn, and Pb plants	1,101,754	359,723	969,678	316,600	1,056,890	345,075
Other byproduct sulfur compounds [2]	106,527	92,400	104,887	88,046	114,359	95,395
Total		6,141,169		6,167,740		6,660,541

[1] Sulfur content estimated for 1951-52.
[2] Hydrogen sulfide and liquid sulfur dioxide. In addition, a quantity of acid sludge is converted to H_2SO_4 but is excluded from the above figures.

Texas Gulf Sulphur Co., the world's largest producer, mined about 2,335,000 long tons of sulfur during 1960, a slight increase over the previous year.[3] Approximately 95 percent was produced at the following four Frasch mines in Texas: New Gulf (Boling Dome), Wharton County; Spindletop and Fannett, Jefferson County; and Moss Bluff, Liberty County. The company also received about 40,200 tons of sulfur as its share of the production from Long Point Dome, Fort Bend County, operated by the Jefferson Lake Sulphur Co. The company announced improvements in its marketing and distribution facilities, most noteworthy of which was the completion of a new terminal at Beaumont, Tex., designed to handle both dry and molten sulfur shipments to customers throughout the world, by tanks, trucks, rail cars, barges, and ocean vessels. Most of the output from the

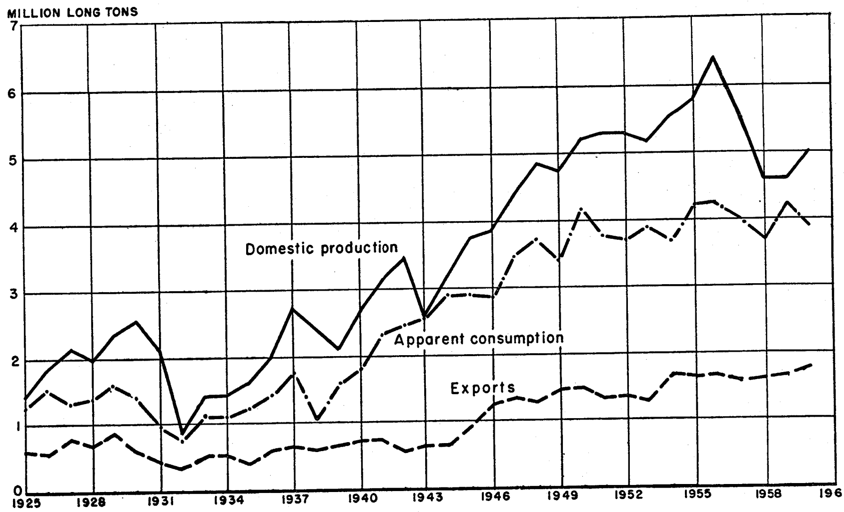

FIGURE 1.—Domestic production, apparent consumption, and exports of Native sulfur, 1925–60.

Company's four Frasch mines was funneled through this terminal in the molten condition. Output from nearby Spindletop was piped directly from producing areas to the terminal, whereas that from Moss Bluff arrived by barge and that from Fannett by truck. Production from the company's largest property at New Gulf (Boling Dome) arrived by rail as both solid and molten sulfur.

Frasch-process mines operated by Freeport Sulphur Co. produced approximately 2.2 million tons of elemental sulfur during 1960.[4] Production came principally from the Grande Ecaille and Garden Island Bay properties south of New Orleans and from a smaller property at Chacahoula, La. The total also included initial production from the two new properties, Grande Isle (March 1960) and Lake Pelto (November 1960).

Grande Isle, the Nation's first offshore sulfur mine, is off the coast of Jefferson Parish, La., in water 50 feet deep. The deposit was

[3] Texas Gulf Sulphur Company, Annual Report, 1960, p. 7.
[4] Freeport Sulphur Co., Annual Report, 1960, p. 5.

discovered by Humble Oil and Refining Co. during drilling for oil in 1949. In 1954, Humble drilled 10 prospect holes, 8 of which encountered sulfur ore and established the presence of a major new sulfur deposit. In September 1960, Freeport acquired the sulfur rights to the deposit. The first construction contract was awarded in December 1957, and offshore erection began in June 1958. Production from the plant was reported June 6, 1960.

Jefferson Lake Sulphur Co. produced 363,120 tons of sulfur from its three Frasch mines, 42,200 tons of which was for the Texas Gulf Sulphur Co. account. The Clemens Dome plant, Brazoria County, Tex., which began operations in May 1937, closed in December after having produced approximately 3 million long tons of high-grade sulfur. The Starks Dome plant, Calcasieu Parish, La., which began producing in June 1951 also closed in December, having produced 900,000 tons of sulfur. Both operations were suspended due to depletion of economically minable sulfur.

United States Sulphur Corp. opened a new multimillion dollar Frasch mine at High Island Dome, 38 miles east of Galveston, Tex. Output was expected to approximate 1,200 tons per day.

Duval Sulphur & Potash Co. continued its operations at Orchard Dome. Production from the deep mining area, started in 1959, contributed materially to the increase in sulfur production in 1960.

The newly formed international research and information organization, the Sulphur Institute, with headquarters in Washington, D.C., opened a European office in London. Dr. Rene Leclercq, formerly director of research for Union Chimique Belge, was to head the office and be responsible for developing a sulfur-use research program in Europe.

TABLE 3.—Sulfur produced and shipped from Frasch mines in the United States

Year	Produced (long tons)			Shipped	
	Texas	Louisiana	Total	Long tons	Approximate value (thousands)
1951–55 (average)	3,685,825	1,710,246	5,396,071	5,304,207	$132,890
1956	3,994,393	2,429,490	6,423,883	5,675,913	150,356
1957	3,366,377	2,124,835	5,491,212	5,035,240	122,915
1958	2,587,760	2,055,483	4,643,243	4,644,021	109,272
1959	2,519,090	2,034,544	4,553,634	5,222,206	121,777
1960	2,678,643	2,264,292	4,942,935	5,002,638	115,494

TABLE 4.—Sulfur ore (10–70 percent S) produced and shipped in the United States [1]

Year	Produced (long tons)	Shipped		Year	Produced (long tons)	Shipped	
		Long tons	Value (thousands)			Long tons	Value (thousands)
1951–55 (average)	115,671	109,218	$828	1958	6,292	153,574	$1,505
1956	212,476	185,532	1,578	1959	331,237	151,932	1,418
1957	276,868	172,169	1,521	1960	379,067	181,422	1,732

[1] California, Nevada (except 1954), Utah (1952 only), and Wyoming (1951–52 only).

RECOVERED SULFUR

Production of recovered sulfur totaled 767,000 long tons, 12 percent higher than the 1959 output. About 459,000 long tons was recovered at oil refineries and 308,000 tons at sour gas plants. Sulfur was obtained from 60 plants in Arkansas, California, Delaware, Illinois, Indiana, Louisiana, Michigan, Minnesota, Mississippi, Montana, New Jersey, New Mexico, North Dakota, Ohio, Oklahoma, Pennsylvania, Texas, Virginia, and Wyoming. Included in this total was the production from six new plants recovering elemental sulfur from sour gas and one plant using refinery gas. Capacity of newly installed plants reportedly totaled 164,000 tons.

Trans-Jeff Chemical Corp. (50 percent owned by Jefferson Lake Sulphur Co. and 50 percent owned by Transcontinental Gas Pipe Line Corp.) constructed a plant near Tilden, Tex., to produce sulfur from concentrated hydrogen sulfide obtained from the nearby Transcontinental gas-processing plant. Production began September 28 at a rate of 600 long tons per month.[5]

Arkansas Louisiana Chemical Corp., subsidiary of Arkansas Louisiana Gas Co., began extracting sulfur from hydrogen sulfide recovered from natural gas at its 3,500-ton-per-year Hamilton plant near Magnolia, Ark.

Lion Oil Co., division of Monsanto Chemical Co., placed a new 15-ton-per-day sulfur recovery unit on stream in September. Molten sulfur obtained from the plant was to be used to manufacture sulfuric acid at Monsanto's chemical plant at El Dorado, Ark.

Tidewater Oil Co. recovered elemental sulfur from hydrogen sulfide by the Girbotol and Claus processes at its new 224-ton-per-day New Hope sulfur recovery plant. The hydrogen sulfide content of the raw gas was reported to be 15 percent by volume. The new plant, 9 miles from Mount Vernon, Tex., came on stream in September.

Warren Petroleum Co. placed on stream a new 45-ton-per-day sulfur recovery plant at Fashing, Tex.

Pan American Petroleum Corp. began production at its 12-ton-per-day Empire Abo sulfur recovery unit near Artesia, N. Mex., on September 10.

Jefferson Lake Sulphur Co. sulfur-recovery plant at Manderson, Wyo., which began producing elemental sulfur from sour gas in March 1955, discontinued operation in August. During the 5¾ years it operated, the plant produced 90,000 long tons of high-purity sulfur.

PYRITES

Production of pyrites (ores and concentrates) totaled 1,016,000 tons, 4 percent less than in 1959.

The quantity of pyrites sold or consumed by producing companies totaled 1,021,446 tons. Of this amount, 150,000 tons having a sulfur content of 72,205 tons and valued at $901,000 was sold; and 871,000 tons having a sulfur content of 346,280 tons and valued at $7,056,238 was consumed.

Tennessee was the largest pyrites-producing State, followed by California, Virginia, Colorado, Arizona, Pennsylvania, Utah, and

[5] Jefferson Lake Sulphur Co., Annual Report, 1960, p. 3.

South Carolina. Tennessee Copper Co. recovered pyrites flotation concentrate in Polk County, Tenn., as a coproduct of copper. The concentrate was roasted, and the recovered gas was used in manufacturing sulfuric acid and liquid sulfur dioxide. General Chemical Division, Allied Chemical Corp., produced a substantial quantity of pyrites at the Gosson mine in Carroll County, Va. Bethlehem Steel Co. recovered pyrites from its Cornwall and Grace mines in Lebanon and Berks Counties, Pa.

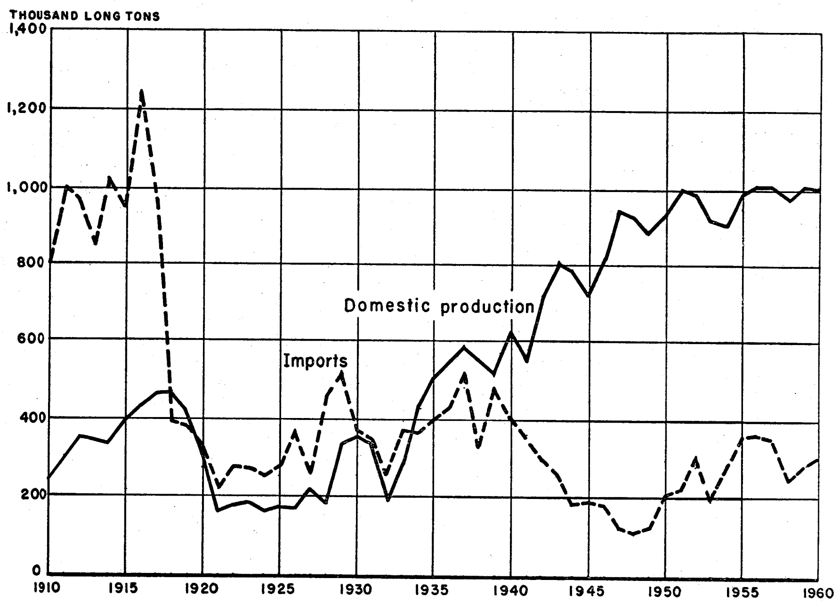

FIGURE 2.—Domestic production and imports of pyrites, 1910–60.

TABLE 5.—Pyrites (ores and concentrates) produced in the United States

Year	Long tons		Value (thousands)	Year	Long tons		Value (thousands)
	Gross weight	Sulfur content			Gross weight	Sulfur content	
1951–55 (average)	970,083	409,128	$6,032	1958	974,114	403,373	$7,987
1956	1,069,904	431,687	9,743	1959	1,056,617	436,871	8,148
1957	1,067,396	436,012	9,087	1960	1,016,263	416,213	7,936

In California, pyrites was produced by Mountain Copper Co., Ltd., at the Hornet mine in Shasta County. In Colorado, pyrites was recovered by Rico Argentine Mining Co. at the Mountain Springs mine, Dolores County, and by Climax Molybdenum Co. from its operations in Lake County. Other pyrites producers were: Commercialores, Inc., York County, S.C.; Ray Mines Division, Kennecott Copper Corp., Pinal County, Ariz.; and United States Smelting, Refining, and Mining Co., Salt Lake County, Utah.

BYPRODUCT SULFURIC ACID

Output of byproduct sulfuric acid (100-percent basis) at copper and zinc plants in the United States totaled 1,184,000 short tons, 9 percent higher than in 1959. The acid reported was that produced only from the sulfur content of the sulfide copper and zinc ores. It excluded acid made from pyrites concentrates in Arizona, Montana, Tennessee, and Utah.

Output of acid at copper plants rose 46 percent to 413,000 tons as plants closed by strikes and mid-1959 resumed full working schedules. Production at zinc plants dropped 4 percent to 771,000 tons because of strikes in 1960.

Byproduct acid was produced at 16 plants in California, Idaho, Illinois, Indiana, Kansas, Montana, Ohio, Oklahoma, Pennsylvania, Tennessee, Texas, Utah, and Washington.

TABLE 6.—Byproduct sulfuric acid[1] (basis, 100 percent) produced at copper, zinc, and lead plants in the United States

(Short tons)

	1951-55 (average)	1956	1957	1958	1959	1960
Copper plants[2]	245,108	384,659	482,181	495,576	282,461	412,845
Zinc plants[3]	666,543	807,477	855,357	738,385	803,578	770,872
Total	911,651	1,192,136	1,337,538	1,233,961	1,086,039	1,183,717

[1] Includes acid from foreign materials.
[2] Includes acid produced at a lead smelter. Excludes acid made from pyrites concentrates in Arizona, Montana, Tennessee, and Utah.
[3] Excludes acid made from native sulfur.

OTHER BYPRODUCT-SULFUR COMPOUNDS

In addition to the elemental sulfur recovered, a small quantity of sulfur dioxide and hydrogen sulfide was recovered from industrial gasses. Virtually all of the hydrogen sulfide was recovered at oil refineries, and the entire production of sulfur dioxide was obtained from smelter gases. Hydrogen sulfide and sulfur dioxide were produced at 10 plants in California, Louisiana, Michigan, New Jersey, Pennsylvania, and Tennessee.

CONSUMPTION AND USES

The U.S. consumption of sulfur in all forms totaled about 5.9 million long tons, slightly less than that consumed during 1959. Approximately 80 percent was used in the manufacture of sulfuric acid; the remainder was used principally by the woodpulp and carbon bisulfide industries.

Consumption of sulfuric acid by the fertilizer industry, which normally accounts for approximately 40 percent of the total acid consumed, increased 3 percent. Consumption by the chemical industry increased 5 percent, as hydrofluoric acid, synthetic detergents, phenol, insecticides, tall oil, and catalysts each increased 10 percent or more during the year. In other markets, steel pickling and nonferrous metal treating increased their requirements. The petroleum industry

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was affected by the trend to jet aircraft which use kerosine-type fuels. This reduced sulfuric acid consumption and the amount of spent acid which is normally regenerated. The pigment industry was affected by reduced demand for paint in residential construction and increased competition in world markets. Output by the rayon industry was lower, as the demand for rayon textiles and cord declined. Nonacid demand was down slightly despite higher pulp and paper production.[6]

TABLE 7.—Production of new sulfuric acid[1] (100 percent H_2SO_4) by geographic divisions and States

(Short tons)

Division and State	1956	1957	1958	1959	1960
New England[2]	201,758	183,092	174,531	195,614	192,664
Middle Atlantic:					
Pennsylvania	815,016	795,929	647,972	764,239	754,703
New York and New Jersey	1,577,476	1,541,278	1,458,124	1,673,150	1,681,302
Total	2,392,492	2,337,207	2,106,096	2,437,389	2,436,005
North central:					
Illinois	1,272,453	1,241,474	1,219,517	1,368,644	1,355,647
Indiana	519,853	493,151	468,993	479,064	485,297
Michigan	220,604	241,587	298,946	334,609	324,318
Ohio	714,454	713,201	607,791	767,089	742,287
Other[3]	789,369	760,127	697,879	849,807	715,137
Total	3,516,733	3,449,540	3,293,126	3,799,213	3,622,686
South:					
Alabama	251,314	314,669	243,899	309,516	312,996
Florida	1,497,155	1,738,945	1,830,104	2,036,707	2,272,039
Georgia	339,751	318,325	302,195	345,552	337,140
North Carolina	137,127	120,207	119,613	149,774	131,221
South Carolina	146,046	131,933	133,748	152,241	142,652
Virginia	527,257	488,707	469,182	504,223	460,098
Kentucky and Tennessee	1,035,739	995,277	893,530	1,014,735	997,379
Texas	1,552,202	1,605,445	1,600,683	1,674,284	1,593,303
Delaware and Maryland	1,325,004	1,094,275	1,081,210	1,153,071	1,119,452
Louisiana	782,330	727,144	653,573	640,180	595,232
Other[4]	402,121	428,682	496,206	541,565	584,181
Total	7,996,046	7,963,609	7,823,943	8,521,848	8,545,693
West[5]	1,630,319	1,834,777	1,882,727	1,950,384	2,288,142
Total United States	15,737,348	15,768,225	15,280,423	16,904,448	17,085,190

[1] Includes information for Government-owned and privately operated plants.
[2] Includes data for plants located in Maine, Rhode Island, and Massachusetts.
[3] Includes data for plants located in Minnesota, Missouri, Wisconsin, and Kansas.
[4] Includes data for plants located in West Virginia, Mississippi, Arkansas, and Oklahoma.
[5] Includes data for plants located in Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Washington, Wyoming, and Hawaii. (Data for Hawaii are not included for 1959.)

Source: U.S. Department of Commerce.

STOCKS

On December 31, 1960, producer stocks of Frasch sulfur totaled 3,668,332 long tons, 4 percent below the 3,809,708 tons on hand December 31, 1959. Of this quantity, 3,316,298 tons was at the mines, and 352,034 tons was elsewhere. Stocks of recovered sulfur in the hands of producers totaled 109,467 tons at the end of 1960, compared with 140,246 tons at the end of 1959. Data on pyrite stocks were not available.

[6] Gittinger, Leonard B., Sulphur: Min. Cong. Jour., vol. 47, No. 2, February 1961, pp. 113-115.

TABLE 8.—Apparent consumption of native sulfur in the United States

(Long tons)

	1951–55 (average)	1956	1957	1958	1959	1960
Apparent sales to consumers [1] [2]	5,315,784	5,730,800	5,090,660	4,663,625	5,225,245	5,129,300
Imports	8,862	212,229	499,401	590,687	642,488	603,276
Total	5,324,646	5,943,029	5,590,061	5,254,312	5,867,733	5,732,576
Exports:						
Crude	1,415,883	1,651,307	1,578,359	1,577,919	[3] 1,612,158	1,775,526
Refined	30,513	24,024	14,620	24,207	[3] 23,449	11,017
Total	1,446,396	1,675,331	1,592,979	1,602,126	1,635,607	1,786,543
Apparent consumption	3,878,200	4,267,698	3,997,082	3,652,186	4,232,126	3,946,033

[1] Production adjusted for net change in stocks during the year.
[2] Includes native sulfur from mines that do not use the Frasch process. A small quantity was consumed before 1954; however, this tonnage was not included in the above figures.
[3] Revised figure.

TABLE 9.—Apparent consumption of sulfur in all forms in the United States [1]

(Long tons)

	1951–55 (average)	1956	1957	1958	1959	1960
Native sulfur	3,878,200	4,267,700	3,997,100	3,652,200	4,232,100	3,946,000
Recovered sulfur:						
Shipments	290,900	432,300	472,700	590,800	709,100	775,200
Imports	(2)	(2)	(2)	(2)	(2)	135,600
Pyrites:						
Domestic production	409,100	431,700	436,000	403,400	436,900	416,200
Imports	128,900	175,200	169,100	164,300	134,400	146,000
Total pyrites	538,000	606,900	605,100	567,700	571,300	562,200
Smelter-acid production	266,000	348,000	390,400	359,700	316,600	345,100
Other-production [3]	74,600	89,400	88,400	92,400	88,000	95,400
Grand total	5,047,700	5,744,300	5,553,700	5,262,800	5,917,100	5,859,500

[1] Crude sulfur or sulfur content.
[2] Data included with imports in table 8. Not separately available before 1960.
[3] Hydrogen sulfide and liquid sulfur dioxide. In addition, a quantity of acid sludge is converted to H_2SO_4 but is excluded from the above figures.

Two major sulfur producers in the United States and one in Mexico undertook programs in 1960 to expand the delivery of liquid sulfur to important market areas east of the Rocky Mountains through the establishment of new storage terminals. The storage terminals were supplied from new facilities near the producing area. Transportation on inland waterways was by heated tank barges and to coastal terminals by converted T–2 tankers. Sulfur was to be shipped to customers in insulated tank cars or trucks from the terminals.

Texas Gulf Sulphur Co., a pioneer in the handling of molten sulfur, established a new storage terminal at Tampa, Fla., in February. Two additional terminals were under construction during the year: One at Norfolk, Va., 20,000 tons capacity, and one at Carteret, N.J., 260,000 tons capacity. The company's other terminal was at Cincinnati, Ohio.

New liquid storage facilities were planned by Freeport Sulphur Co. at Joliet, Ill., 30,000 tons, and at Wellsville, Ohio, 20,000 tons. Also planned were coastal terminals at Tampa, Fla., 30,000 tons; Bucksport, Maine, 20,000 tons; and Everett, Mass., 10,000 tons. At Port Sulphur, La., Freeport added four new 9,000-ton-capacity tanks to bring the capacity of its molten-sulfur storage facilities to almost 60,000 tons.

Terminal facilities operated by Pan American Sulphur Co. at Tampa, Fla., have storage capacity for 20,000 tons of molten sulfur and 50,000 tons of dry sulfur. It was reported that the company was studying construction of similar facilities in other marketing areas.

PRICES

Posted prices of Frasch sulfur in the United States remained unchanged at $25 per long ton f.o.b. Gulf ports for bright sulfur, with a discount of $1 per ton for offcolor material. Posted prices of the Mexican producer, Pan American Sulphur Co., were $23.50 for bright and $22.50 for offcolor sulfur, f.o.b. Coatzacoalcos, Mexico, up $2 on Dec. 19, 1960. Deliveries by Pan American from Tampa, Fla., also were increased $2 per ton. U.S. producers were expected to reduce "competitive allowances" rather than increase the posted price of sulfur.

FOREIGN TRADE [7]

Imports.—Imports of sulfur reached a new high of 739,000 tons, 15 percent higher than in 1959. Of the total quantity imported, 603,000 tons was from Mexico, and 136,000 tons was from Canada. Imports of pyrites from Canada increased 9 percent.

TABLE 10.—U.S. Imports for consumption and exports of sulfur

Year	Imports				Exports			
	Ore		In any form, n.e.s.		Crude		Crushed, ground, refined, sublimed, and flowers	
	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)
1951-55 (average)	6,298	$162	2,564	[1] $85	1,415,883	$39,780	30,513	$2,207
1956	14,750	359	197,479	4,975	1,651,307	48,305	24,024	1,777
1957	14,454	350	484,947	[1] 11,882	1,578,359	43,940	14,620	1,458
1958	18,906	445	571,781	13,106	1,577,919	39,507	24,207	1,932
1959	11,593	255	630,895	13,646	[2] 1,612,158	[2] 39,975	[2] 23,449	[2] 2,025
1960	104,708	2,272	634,130	13,185	1,775,526	40,880	11,017	1,413

[1] Data known to be not comparable with other years.
[2] Revised figure.

Source: Bureau of the Census.

Exports.—Sulfur exports during 1960 increased 9 percent, 151,000 tons over 1959, in spite of growing competition from new sulfur producers. New producers and the tonnage each shipped into areas formerly serviced by U.S. concerns were: Pan American Sulphur Co., Mexico, 437,000 tons; Gulf Sulphur Corp., Mexico, 145,000 tons; and

[7] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

Societe Nationale des Petroles d'Aquitaine, France, 686,000 tons. The gain in exports was attributed to the high level of business activity in many non-Communist countries and the trend toward the use of elemental sulfur rather than other forms of sulfur. The principal countries of export were the United Kingdom, Canada, Australia, India, and Brazil.

TABLE 11.—U.S. exports of sulfur, by countries

Destination	Crude				Crushed, ground, refined, sublimed, and flowers			
	1959		1960		1959		1960	
	Long tons	Value (thousands)	Long tons	Value (thousands)	Pounds	Value (thousands)	Pounds	Value (thousands)
North America:								
Canada	287,500	$7,200	296,548	$6,394	6,886,332	$355	5,464,045	$291
Central America	1,649	57	3,955	127	455,255	20	624,428	24
Mexico	20	1	---	---	461,176	63	280,940	36
West Indies	36,342	829	32,335	713	171,400	13	220,152	13
Total	325,511	8,087	332,838	7,234	7,974,163	451	6,589,565	364
South America:								
Argentina	32,776	821	21,468	509	196,900	43	131,500	28
Bolivia	---	---	---	---	39,600	1	---	---
Brazil	126,391	3,167	129,317	3,041	1,088,968	132	499,100	104
Chile	---	---	---	---	47,298	10	39,250	10
Colombia	314	10	---	---	105,162	15	127,527	15
Ecuador	---	---	---	---	---	---	54,510	2
Paraguay	1,606	41	59	2	---	---	87,800	1
Peru	4,909	133	10,075	232	632,400	26	335,221	17
Uruguay	3,262	82	5,600	139	112,155	4	227,257	7
Venezuela	3,291	110	1,983	66	800,909	57	874,626	60
Total	172,549	4,364	168,502	3,989	3,023,392	288	2,376,791	244
Europe:								
Austria	10,000	250	7,000	165	---	---	---	---
Belgium-Luxembourg	53,675	1,338	79,814	1,887	---	---	24,000	1
Czechoslovakia	10,600	260	18,000	390	---	---	---	---
Finland	12,600	315	13,750	328	---	---	---	---
France	85,945	2,130	62,230	1,457	26,000	2	108,980	3
Germany, West	86,290	2,153	90,237	2,108	446,348	88	883,024	163
Greece	---	---	---	---	27,463,487	564	32,700	1
Netherlands	41,799	1,013	87,334	2,004	131,250	27	21,800	1
Norway	---	---	3,920	88	424,500	12	266,296	8
Portugal	---	---	---	---	57,600	8	11,000	2
Spain	---	---	9,841	216	56,150	11	83,500	17
Sweden	9,825	242	13,203	298	6,000	1	38,800	6
Switzerland	34,700	868	37,984	930	215,450	39	177,300	31
United Kingdom	273,230	6,636	314,274	7,300	---	---	145,600	27
Yugoslavia	2,000	50	---	---	---	---	21,670	1
Other	23,320	569	15,830	377	24,398	3	21,796	1
Total	643,984	15,824	753,417	17,548	28,851,183	755	1,836,466	262
Asia:								
India	124,699	3,119	144,835	3,419	3,354,653	114	4,806,901	161
Indonesia	7,700	189	3,100	76	420,800	24	296,950	13
Iran	2,260	75	2,000	44	---	---	29,270	2
Israel	25,069	615	19,975	449	253,052	16	180,708	19
Japan	---	---	---	---	292,050	54	190,000	36
Korea, Republic of	913	37	1,042	38	4,980,193	99	3,559,884	75
Lebanon	1,000	25	27	2	196,321	8	141,515	5
Pakistan	2,137	71	3,090	78	87,184	3	455,609	10
Philippines	900	32	1,040	38	529,018	31	828,927	30
Taiwan	4,133	100	12,397	289	---	---	---	---
Turkey	---	---	---	---	14,400	3	---	---
United Arab Republic (Syria)	49	3	---	---	217,960	5	---	---
Other	[1] 2,957	[1] 98	2,886	87	[1] 47,692	[1] 3	93,478	5
Total	[1] 171,817	[1] 4,364	190,392	4,520	[1] 10,393,323	[1] 360	10,583,242	356

See footnotes at end of table.

TABLE 11.—U.S. exports of sulfur, by countries—Continued

Destination	Crude				Crushed, ground, refined, sublimed, and flowers			
	1959		1960		1959		1960	
	Long tons	Value (thousands)	Long tons	Value (thousands)	Pounds	Value (thousands)	Pounds	Value (thousands)
Africa:								
Algeria	9,000	$225	2,000	$50	---	---	---	---
Congo,[2] Republic of, and Ruanda-Urundi	---	---	---	---	65,988	$2	230,601	$4
Morocco	---	---	1,766	44	---	---	2,400	(3)
Mozambique	---	---	---	---	---	---	274,400	6
Tunisia	15,833	384	25,250	584	---	---	---	---
Union of South Africa	61,385	1,502	58,000	1,298	1,678,386	90	2,164,975	106
United Arab Republic (Egypt)	36	1	5,060	126	47,900	7	51,120	1
Other	4,920	123	4,428	104	---	---	2,200	1
Total	91,174	2,235	96,504	2,206	1,792,274	99	2,725,696	118
Oceania:								
Australia	123,084	3,000	147,000	3,381	250,575	46	222,989	37
New Zealand	84,039	2,101	86,873	2,002	241,735	26	343,075	32
Total	207,123	5,101	233,873	5,383	492,310	72	566,064	69
Grand total	[1] 1,612,158	[1] 39,975	1,775,526	40,880	[1] 52,526,645	[1] 2,025	24,677,824	1,413

[1] Revised figure.
[2] Effective July 1, 1960; formerly Belgian Congo.
[3] Less than $1,000.

Source: Bureau of the Census.

TABLE 12.—U.S. imports for consumption of pyrites, containing more than 25 percent sulfur, by customs districts

(Long tons)

Customs district	1951-55 (average)	1956	1957	1958	1959	1960
Buffalo	[1] 151,788	[1] 30,214	[1] 40,842	296,002	230,606	242,676
Connecticut	---	18	---	---	262	---
Duluth and Superior	9	---	---	---	---	---
Michigan	[1] 4,922	25,188	20,744	16,768	13,182	11,870
Montana and Idaho	---	---	---	---	---	37
New York	45	---	---	217	---	---
Pittsburgh	136	763	54	---	---	---
Rochester	10	---	208	---	---	---
St. Lawrence	3,788	10,032	---	13,373	14,640	21,338
Vermont	6,294	7,063	8,766	16,523	21,948	28,868
Washington	---	18	18	177	---	---
Total: Long tons	[1] 166,992	[1] 73,296	[1] 70,632	343,060	280,638	304,789
Value	[1] $562,892	[1] $479,950	[1] $408,342	$1,193,973	$868,495	$1,071,214

[1] In addition to data shown, an estimated 232,920 long tons ($627,620) was imported through the Buffalo customs district in 1954; 277,020 long tons ($706,840) through the Buffalo customs district and 840 long tons ($4,900) through the Michigan customs district in 1955; 292,520 long tons ($865,020) through the Buffalo customs district in 1956; and 282,400 long tons ($889,100) through the Buffalo customs district in 1957.

Source: Bureau of the Census.

WORLD REVIEW

NORTH AMERICA

Canada.—Production of sulfur in all forms in Canada in 1959 totaled 926,200 long tons, 87,400 tons more than the 838,873 tons produced in 1958. Of this total, 415,700 tons was sulfur contained in pyrite; 247,300 tons was the sulfur equivalent of smelter gases; and 263,200 tons was elemental sulfur recovered from natural gas and the treatment of nickel sulfide matte at Port Colborne, Ontario.[8]

A preliminary estimate for 1960 indicates that the production of sulfur in all forms was 1,042,400 long tons. Of this total, 395,900 tons was sulfur contained in pyrites; 242,500 tons sulfur contained in smelter gases; and 404,000 tons elemental sulfur recovered from natural gas and nickel sulfide matte.

Exports of sulfur to the United States increased from 23,684 tons in 1959 to an estimated 136,000 tons in 1960. Most of the material shipped was elemental sulfur from the natural gas fields of western Canada.

Imports of sulfur from the United States were estimated at 297,000 tons. Additional tonnages were received from Mexico.

Shipments of Canadian sulfur in all forms totaled 894,642 long tons in 1960, an increase of 15 percent over the 777,679 long tons shipped in 1959. Of the total shipped, 274,107 long tons was elemental sulfur recovered from natural gas; 372,321 long tons was sulfur contained in pyrite and pyrrhotite; and 248,214 long tons represented sulfur contained in smelter gases.[9]

At the end of 1960, eight recovery plants in Alberta and one each in Saskatchewan and British Columbia had a combined annual capacity of 622,902 long tons. Of the 347, 976 long tons of sulfur produced in Alberta during 1960, 208,314 tons was sold, 969 tons was used (field and plant), 135,400 tons was in stock, and the balance, 3,293 tons, was reported lost. In 1959, 86,285 tons was sold, 125,229 tons was stocked, and 1,562 tons was lost.[10]

In addition to the 10 recovery plants in operation, 3 others were being built.

Pan American Petroleum Corp. began constructing a 650-ton-per-day sulfur recovery plant at Windfall Field near Whitecourt, Alberta. Production at this facility was expected to begin late in 1961.

Jefferson Lake Petrochemical of Canada, Ltd., planned two new recovery plants in Alberta, one at East Calgary and the other near Coleman.

The East Calgary plant was to be owned by Mobil Oil of Canada and Jefferson Lake Petrochemicals and operated by the latter company. The 700-ton-per-day plant (285,000 tons annual capacity) is scheduled for completion by November 1961. The proposed Savanna Creek plant near Coleman will recover about 300 tons of sulfur per day.

Shell Oil Co., Canada, Ltd., planned a 1,000-ton-per-day sulfur recovery plant in the Pincher Creek district of southern Alberta. The plant was scheduled for completion in 1961.

Laurentide Chemicals and Sulphur, Ltd., Montreal East, recovered approximately 29,000 long tons of elemental sulfur from oil refinery waste gases in 1959, its first full year of operation. In 1958 the plant operated 9 months and recovered 21,000 tons of sulfur. Output from

[8] Dominion Bureau of Statistics, Industry and Merchandising Division, The Miscellaneous Non-Metal Mining Industry, January 1961, pp. 34–38.
[9] Chemical Week, vol. 88, No. 6, Feb. 11, 1961, p. 60.
[10] Alberta Oil and Gas Industry Monthly Report. Oil and Gas Conservation Board. December 1960, p. 5.

TABLE 13.—World production of elemental sulfur by countries [1] [2]

(Long tons)

Country	1956	1957	1958	1959	1960
Frasch:					
Mexico	758,415	990,118	1,201,483	1,293,181	1,261,574
United States	6,423,883	5,491,212	4,643,243	4,553,634	4,942,935
Total	7,182,298	6,481,330	5,844,726	5,846,815	6,204,509
From sulfur ores:					
Argentina	27,298	28,788	31,545	25,207	[3] 25,000
Bolivia (exports)	3,418	783	392	------------	1,175
Chile	37,272	18,492	24,015	21,676	[3] 20,000
Colombia	4,921	5,905	6,693	8,819	11,811
Greece	1,322	2,826	------------	------------	------------
Italy:					
Crude	168,061	175,982	154,137	119,272	79,703
Ground	22,219	19,904	18,619	21,342	20,932
Japan	243,312	253,548	178,052	215,669	242,732
Mexico	5,000	17,797	35,446	[3] 17,700	[3] 17,700
Philippines	------------	[3] 1,300	1,200	------------	44
Spain	6,200	3,356	3,055	2,851	2,100
Taiwan	7,864	9,433	6,178	5,533	4,797
Turkey	13,681	12,893	12,622	13,174	16,830
United Arab Republic (Egypt Region)	99	------------	7,127	6,013	[3] 6,000
U.S.S.R.[3]	200,000	200,000	295,000	315,000	370,000
United States	60,402	87,313	2,334	86,182	94,357
Total [3] [4]	800,000	840,000	775,000	860,000	915,000
Total native sulfur	8,000,000	7,320,000	6,620,000	6,710,000	7,120,000
Recovered:					
Bulgaria	2,206	2,591	2,800	4,000	[3] 4,000
Canada	29,879	95,962	166,121	263,192	[3] 404,000
France	2,300	27,528	126,542	419,273	778,018
Germany:					
East	92,748	100,190	104,679	106,153	[3] 106,000
West	59,000	78,700	72,800	76,800	82,800
Iran	18,000	16,665	12,800	[3] 19,000	[3] 19,000
Italy [3]	5,000	2,000	4,000	4,000	4,000
Japan	5,429	5,486	7,889	7,829	8,356
Mexico	14,577	41,642	27,641	46,231	46,839
Netherlands	12,200	14,400	20,800	30,700	[3] 30,000
Netherlands Antilles: Aruba	29,022	[3] 30,000	[3] 30,000	[3] 30,000	[3] 30,000
Sweden	30,338	33,310	33,465	37,576	[3] 38,000
Trinidad [3]	5,000	5,000	5,000	5,000	5,000
United Arab Republic (Egypt Region)	2,950	3,445	[3] 3,000	2,403	17,716
U.S.S.R.[3] [5]	200,000	240,000	290,000	370,000	480,000
United Kingdom	52,973	39,142	49,561	53,173	[3] 53,000
United States	464,758	510,511	640,096	686,407	766,566
Total [3] [6]	1,030,000	1,250,000	1,600,000	2,160,000	2,870,000
From sulfide ores:					
Norway	95,382	95,149	89,126	77,111	71,254
Portugal	16,922	16,675	17,373	15,888	10,884
Spain	51,800	50,200	25,251	25,719	21,696
Total [6]	164,104	162,024	131,750	118,718	103,834
World total (estimate)	9,175,000	8,735,000	8,350,000	8,985,000	10,095,000

[1] This table incorporates some revisions.
[2] Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Estimate.
[4] In some years Iran produces mined sulfur equivalent to 250–1,500 tons of sulfur. No estimate in total.
[5] Sulfur equivalent recovered from sulfide ores, natural gas, petroleum, anhydrite, and gypsum.
[6] U.S.S.R. production from sulfide ores included with recovered sulfur data.

Compiled by Helen L. Hunt, Division of Foreign Activities.

this source is not included in Canadian sulfur statistics because it is derived from foreign crude oils.[11]

Transportation costs for elemental sulfur to the nearest waterways, westward to the Pacific Ocean or eastward to the Great Lakes, were

[11] Bartley, C. M., Sulphur: Canadian Mineral Industry 1959 (Preliminary), Dept. Min. and Tech. Surveys, Ottawa, June 1960, 14 pp.

TABLE 14.—World production of pyrites (including cupreous pyrites) by countries[1 2]

(Thousand long tons)

Country [1]	1951–55 (average) gross weight	1956		1957		1958		1959		1960	
		Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content
North America:											
Canada (sales)	531	935	423	1,041	460	1,064	458	982	416	897	379
Cuba	[3] 62	65	32	36	17	33	17	[4] 25	[4] 12	(5)	(5)
United States	970	1,070	432	1,067	436	974	403	1,057	437	1,016	416
South America: Venezuela	-----------	59	14	15	4	14	4	4	1	-----------	-----------
Europe:											
Bulgaria	146	107	[4] 45	107	[4] 45	69	[4] 29	31	[4] 13	37	[4] 16
Czechoslovakia	243	333	[4] 140	364	[4] 153	379	[4] 143	365	[4] 144	394	[4] 155
Finland	253	289	128	292	[4] 126	249	[4] 105	254	107	255	107
France	344	374	142	402	146	420	149	289	121	273	[4] 115
Germany:											
East	119	157	53	157	53	153	51	[4] 153	[4] 51	[4] 153	[4] 51
West	523	634	253	596	237	557	224	462	189	527	219
Greece	208	237	[4] 104	231	102	160	71	197	87	[4] 128	[4] 56
Italy	1,150	1,349	634	1,448	652	1,490	676	1,498	674	1,521	692
Norway	746	840	363	830	360	780	339	732	320	798	349
Poland	126	152	61	207	76	208	75	217	79	[4] 217	[4] 80
Portugal	708	659	297	656	302	589	271	622	286	645	297
Rumania	[4] 127	178	71	174	70	202	81	231	93	[4] 231	[4] 93
Spain	2,048	2,259	1,084	2,225	1,068	2,014	931	2,086	961	2,086	1,001
Sweden	394	486	239	494	245	329	163	343	169	412	[4] 204
United Kingdom	10	4	2	4	1	3	[4] 1	1	(6)	[4] 1	(6)
Yugoslavia	176	252	131	308	123	326	130	285	114	410	164
Asia:											
China [4]	(5)	(5)	(5)	(5)	(5)	492	221	689	310	985	445
Cyprus	1,083	1,603	[4] 770	1,650	[4] 792	1,658	[4] 796	1,226	[4] 589	[7] 1,064	[7] 515
Japan	2,487	3,049	1,296	3,324	1,404	3,306	1,378	3,336	1,396	[4] 3,445	[4] 1,447
Philippines	[3] 9	-----------	-----------	18	8	19	8	25	[4] 11	25	[4] 11
Taiwan	23	29	11	33	12	32	12	33	13	42	16
Turkey	18	19	[4] 9	48	23	80	39	87	42	42	20
Africa:											
Algeria	28	6	3	19	8	24	11	29	13	38	17
Morocco, Southern zone	2	2	(6)	6	2	18	6	14	5	13	[4] 5
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	28	19	8	20	8	58	24	40	17	49	19
Union of South Africa	147	430	[4] 163	388	160	493	205	495	195	492	[4] 197
Oceania: Australia	191	172	82	229	109	227	109	223	107	[4] 219	[4] 105
World total (estimate)[1 2]	15,000	18,200	7,600	18,900	7,900	18,600	7,800	18,300	7,700	18,700	7,900

[1] Pyrites is produced in North Korea and U.S.S.R., but production data are not available; estimates for these countries are included in the totals. Negligible quantities are produced in Austria, Brazil, India, Republic of Korea, and Tunisia.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Average for 1952–55.
[4] Estimate.
[5] Data not available; estimate included in total.
[6] Less than 500 tons.
[7] Exports.

Compiled by Helen L. Hunt, Division of Foreign Activities.

reported to approximate $9 and $11.40 per short ton, respectively. In order to reduce these charges and make Canadian sulfur competitive with gulf coast and Mexican sulfur, Pembina Pipeline Ltd., Calgary, Alberta, was investigating the possibility of using a 14-inch, 1,300-mile pipeline to transport sulfur in a water slurry, as liquid SO_2, as H_2S, or as sulfuric acid. As planned, the pipeline would run southeast through the province of Saskatchewan into North Dakota (via Fargo), Minnesota (north of Minneapolis), and Wisconsin (near Milwaukee) to a separation plant near Chicago, Ill.[12]

Mexico.—Production of sulfur in all forms in Mexico totaled 1,282,000 long tons, 6 percent below the 1,358,000 tons produced in 1959. Of this total, 1,231,000 tons (96 percent) was produced at three Frasch mines, 18,000 tons (1 percent) from volcanic sulfur, and 33,000 tons (3 percent) from oil refineries. The lower level of sulfur production in 1960 may be accounted for by the closing of Nopalapa Dome in February without reported production for the year.

Stocks in the hands of producers on December 31, 1960, totaled 971,000 tons, 11 percent more than the 880,000 tons on hand December 31, 1959. Of the sulfur on hand, 970,000 tons was Frasch sulfur, and 1,000 tons was sulfur from volcanic sources.

Exports of sulfur from Mexico totaled 1,172,249 long tons, about 1.4 percent higher than the 1,030,000 tons reported for 1959. Half of the exports, 590,000 tons, went to the United States. Exports of sulfur to France increased 10 percent despite increased output of sulfur in France from sour gas.

Compania de Azufre Veracruz, S.A., an operating subsidiary of Gulf Sulphur Corp., Houston, Tex., produced approximately 203,000 long tons of Frasch sulfur from the Las Salinas Dome, 28 percent less than the 281,000 tons produced in 1959. Shipments of sulfur to world markets totaled 263,000 tons, 32 percent higher than the 200,000 tons produced in 1959. Stocks of sulfur on hand December 31, 1960, were estimated to be 42,000 tons.

Output of sulfur by Azufrera Panamericana, S.A., de C.V. (a Mexican corporation), an operating subsidiary of Pan American Sulphur Co., totaled 1,028,000 long tons of Frasch sulfur during 1960, 16 percent above the production reported for 1959. Shipments by the company to world and domestic markets totaled 942,000 tons, 10 percent more than in 1959. Of the total shipments, 909,000 tons, 96 percent, was exported and 33,000 tons, 4 percent, was used domestically; 183,000 tons was moved through Pan American's Tampa, Fla., terminal. Yearend stocks totaled 660,000 tons.

Output of recovered sulfur by Petroleos Mexicanos was 33,487 long tons, 28 percent below the 46,231 tons produced in 1959. The decline was attributed to the closing of the sulfur plant in October for repairs. Production capacity of the company was increased to 195 tons a day with the construction of two new plants, a 25-ton-a-day plant in Mexico City and a 30-ton-a-day plant in Tampico. Production from the company's Rosa Rico 140-ton-per-day plant was marketed only in Mexico.

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[12] Chemical Engineering, Canadian-U.S. Chemical Pipeline Planned: Vol. 67, No. 10, May 16, 1960, p. 74.
Canadian Mining Journal, vol. 82, No. 2, February 1961, pp. 148–149.

TABLE 15.—Mexico Exports of Frasch sulfur by country of destination in 1960

Destination	Pan American Sulphur Co. (long tons)	Gulf Sulphur Corp. (long tons)	Total 1960 (long tons)
Australia	40,616	33,580	74,196
Austria	4,501	----------	4,501
Belgium	51,501	17,942	69,443
Brazil	7,980	----------	7,980
Cuba	----------	4,348	4,348
Finland	2,171	----------	2,171
France	58,608	3,324	61,932
Germany, West	13,443	41,622	55,065
India	25,000	5,508	30,508
Indonesia	1,400	----------	1,400
Ireland	3,185	----------	3,185
Israel	----------	35,289	35,289
Netherlands	----------	2,008	2,008
New Zealand	45,908	----------	45,908
Peru	798	----------	798
Poland	3,702	----------	3,702
Portugal	1,969	----------	1,969
Tunisia	20,838	----------	20,838
Union of South Africa	66,584	----------	66,584
United Kingdom	89,038	----------	89,038
United States	471,832	118,078	589,910
Uruguay	----------	1,476	1,476
Total exports	909,074	263,175	1,172,249

Compiled from company figures.

Negociacion Minera S.A. produced 17,716 tons of refined elemental sulfur from surface mines at Gerritos, San Luis Potosi. Refined in autoclaves and filtered to remove most of the ash, the refined product reportedly contained 99.9 percent sulfur, 0.05 percent ash, and 0.02 percent carbon. Output averaged about 1,500 tons per month and was sold locally and in the Tampico district for making sulfuric acid and carbon disulfide.

SOUTH AMERICA

Argentina.—Parsons Powergas received an order to design, engineer, and supply a 42-ton-per-day sulfur recovery unit for Argentina. The plant was to be designed to handle an acid feed gas and to produce a product having a minimum purity of 99.5 percent at a recovery efficiency of not less than 95 percent.[13]

Colombia.—Frontino Gold Mines, Ltd., a subsidiary of South American Gold and Platinum Co. of New York, contracted to sell 40,000 tons of pyrites annually to Compania Quimica Industrial, S.A. (QUIM). The pyrites obtained as a byproduct from gold mining operations in Antioquia were to be used to produce sulfuric acid to supply the QUIM superphosphate plant. Almost all of Colombia's sulfur requirements previously were met by Cia. Azufrera Purace, S.A,. which produced about 8,500 tons of sulfur annually by refining native sulfur ores.[14]

Peru.—Cia Minera Raytex, S.A., planned to develop sulfur deposits on the slopes of the Tutupaca volcano in Canadarave, Tacna, and the Ticasani volcano in Cuchubay and Carumas, Moquegua.[15]

[13] Chemical Age (London), vol. 84, No. 2163, Dec. 24, 1960, p. 1047.
[14] Sulphur (London), vol. 30, September 1960, p. 32.
[15] Mining World, vol. 22, No. 8, July 1960, p. 73.

Uruguay.—The Administracion Nacional de Combustibles Alcohol Portland (A.N.C.A.P.) Montevideo announced plans for the construction of a sulfur recovery unit at its refinery at La Teja. Acid gas produced by diethanolamine scrubbing at the refinery contains 95–99 percent H_2S, 1–5 percent C_2H_6 and C_3H_8, and 1–5 percent H_2O. Design capacity of the plant was expected to be 10 tons of elemental sulfur daily.[16]

EUROPE

Belgium.—Societe Industrielle Belge des Antwerp refinery was to undergo a 2-year, $30-million expansion to increase output of liquified petroleum gas and to recover up to 60 tons of sulfur per day. The refinery, jointly owned by British Petroleum and Petrofina, was expected to go on stream in 1963.[17]

France.—Societe Nationale des Petroles d'Aquitaine (Lacq), the State-controlled company formed in 1941, completed the fourth and fifth sections of its 1,400,000-ton-per-year sulfur recovery plant at Lacq. The first section, with 200-ton-per-day capacity, was completed in 1957. In 1959 the second stage was completed, increasing capacity to 1,000 tons per day. Early in 1960 the third stage, a 1,100-ton-per-day unit, was added, bringing the total capacity of the plant to 2,100 tons per day. The fourth and fifth sections, completed late in 1960, had a combined capacity of 2,000 tons, increasing the plant to 4,100 tons per day. As evidence of this increased production capacity, production rose to 778,015 long tons during the year, up 86 percent over the 419,272 tons reported for 1959.

The Girbotol process is used for desulfurizing gas in the first section of the gas-purification plant erected by Societe Nationale des Petroles d'Aquitaine at Lacq. In the subsequent sections the acid gas is first treated in a water-absorption stage before the amine wash. Following the amine wash, the last traces of acid gas and the mercaptans are removed by a soda wash. Sulfur is recovered from H_2S by the Claus process in which part of the hydrogen sulfide is burnt to SO_2 using air as the oxidizing agent. The sulfur dioxide-hydrogen sulfide mixture is passed through catalytic chambers charged with activated bauxite where the two gases react to form sulfur in the gaseous state. The gas is then condensed to the liquid form and transferred through heated lines to central dispatch and storage area.[18]

The composition of the gas at Lacq is unusual, for in addition to methane it contains 15.2 percent H_2S, 9.6 percent CO_2, some ethane, and a considerable amount of condensable hydrocarbons. The gas is moist and occurs at a temperature of 140° C. and pressure of 670 atmospheres; this makes it highly corrosive, rapidly producing a form of embrittlement in steel. The corrosion problem was greatly reduced by adopting a new alloy steel containing small amounts of chromium, aluminum, and molybdenum. The treatment of the gas includes the separation of hydrogen sulfide and carbon dioxide, the recovery of sulfur from hydrogen sulfide, and the removal of gasoline from methane.

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[16] Work cited in footnote 14, p. 32.
[17] Chemical Week, vol. 88, No. 9, Mar. 4, 1961, p. 24.
[18] Minchin, Leslie T., French Natural Gas Wells at Lacq: Chem. and Ind. (London), No. 38, Sept. 17, 1960, pp. 1178–1181.

Sulfur shipments through the port of Bayonne totaled 515,724 long tons, 118,105 tons to ports in France and 397,619 tons for export to foreign countries.[19]

TABLE 16.—France: Shipments of recovered sulfur from Lacq in 1960 by countries of destination

Country	Long tons	Country	Long tons
Algeria	31,648	Norway	200
Austria	26,260	Poland	3,000
Belgium	35,636	Portugal	4,935
Denmark	5,247	Saudi Arabia	800
Egypt	2,000	Spain	12,365
Finland	40,379	Sweden	24,380
France	276,398	Switzerland	23,463
Germany, West	46,541	Tunisia	5,348
Iran	5,695	United Kingdom	107,254
Lebanon	1,734	Yugoslavia	3,015
Morocco	7,500		
Netherlands	21,649	Total	685,447

Germany, East.—Production of sulfuric acid in East Germany was still insufficient to meet demands even though 6 percent of all investments from 1950 to 1956 were devoted to the reconstruction or expansion of plants.[20] Two new factories were planned. Combined output of two Glover Tower plants in operation at Oranienburg and at Salzwedel was 48,500 short tons per year. A plant near Premnitz, which utilized local pyrites, was being rebuilt to a capacity of 24,300 short tons. A plant having a larger capacity was being built at Freiburg.

Scheduled for completion in 1961 was the sulfuric acid plant at Coswig (Anhalt), which will produce sulfuric acid by the Muller-Kuhne process from local anhydride. Partly in operation, the plant was expected to produce 60,000 tons of acid in 1960, rising to 220,000 tons in 1963, and 300,000 tons in 1965. Construction of another plant of similar capacity was scheduled to be built before 1965.

Consumption of sulfuric acid in East Germany totaled 270,066 short tons of SO_3 in 1950, 497,142 tons in 1955, and 580,477 tons in 1958; it was estimated that 760,595 tons would be consumed in 1960 and 1,102,311 tons in 1970.

Greece.—Chemical Construction (G.B.), Ltd., a subsidiary of Chemical Construction Corp., New York, was to construct a 370-ton-per-day sulfur-burning sulfuric acid plant at Ptolemais in northern Greece. The plant, constructed for the Greek Ministries of Industry and Coordination, will be the largest single-unit sulfuric acid plant in Greece.

Ireland.—Pyrites from the St. Patrick's copper mines at Avoca was to be used in making 115,000 tons per year of sulfuric acid at a new chemical plant at Kilmokea, County Wexford.[21]

Netherlands.—Albatros Sulfuric Acid and Chemical Works announced plans to construct a contact sulfuric acid plant having a

[19] Mines et Metallurgie, No. 3548, February 1961, p. 98.
[20] Chemical Age (London), Crosfield Survey Shows Rapid Growth of East German Chemical Industry: Vol. 83, No. 2125, Apr. 2, 1960, p. 575.
[21] Chemical Trade Journal and Chemical Engineer (London), vol. 148, No. 3840, Jan. 6, 1961, p. 19.

capacity in excess of 100,000 tons per year and designed to use pyrites. The company also announced plans for the construction of a plant designed to decompose 56-percent sulfuric acid refinery sludge.[22]

Norway.—Folldal Verk A/S began sinking a shaft at its new pyrites mine at Tverrfjeld near the Hjerkinn railroad station.[23]

It was reported that the Gjersvik cupreous-pyrites ore deposit north of Trondheim was to be developed. This ore deposit, containing 1.7 million tons of ore, was acquired by the Norwegian State in 1918, together with the Joma deposit. Initial production at a rate of 200,000 tons a year was scheduled for 1963. Ore from this deposit will be used to replace that obtained from the Bjokassen pyrites mine, which will have been worked out.[24]

Orkla, Grube A/S joined other pyrites producers in establishing a research institute to find new uses for pyrites. The company opened a new department for industrial research, particularly on uses of sulfur in metallurgical fields.[25]

Norske Sing og Blygruber A/S, a Norwegian lead and zinc producer, announced that it will begin developing the Mofjellet ore deposit. The initial production from the property was expected to total 70,000 tons, with output increased to 92,000 tons in 1962.[26]

Poland.—Production of sulfur began in December at the Polish chemical plant at Machow near Tarnobrzeg. Shipments to industrial plants also began, and deliveries to Czechoslovakia were expected to begin shortly. By the end of 1961, the Machow plant was expected to produce about 116,000 tons per year of pure sulfur, of which 40,000 tons would be exported.[27]

ASIA

Afghanistan.—Sulfur deposits in Northern Afghanistan were investigated. The largest deposits, in the Elburs mountains near Mazar-i-Sherriff, contain an estimated 500,000 tons of 40-percent sulfur ore. Sulfur consumption, mostly for insecticides, was 500 to 1,000 tons per year.[28]

Cyprus.—The production and stocks of the three companies mining pyrites in Cyprus during 1958 and 1959 are shown in table 17.

TABLE 17.—Cyprus: Production and stocks of pyrites

(Long tons)

Company	Production		Yearend stocks	
	1958	1959	1958	1959
Cyprus Mines Corp.:				
Cupreous pyrites	193,180	181,892	57,311	13,841
Flotation pyrites	434,304	453,115	693,958	681,980
Cyprus Sulphur & Copper Co., Ltd.: Cupreous pyrites	55,084	116,375	26,366	22,201
Hellenic Mining Co., Ltd.: Iron pyrites	323,544	166,085	39,287	18,316
Total	1,006,112	917,467		

[22] Chemical Trade Journal and Chemical Engineer (London), vol. 146, No. 3802, Apr. 15, 1960, p. 877.
[23] Mining World, vol. 22, No. 12, November 1960, p. 74.
[24] Canadian Mining Journal (Quebec), vol. 81, No. 4, May 1960, pp. 115–116.
[25] Mining Journal (London), vol. 255, No. 6524, Sept. 2, 1960, p. 262.
[26] Mining Journal (London), vol. 254, No. 6507, May 6, 1960, p. 522.
[27] Mining Journal (London), vol. 256, No. 6548, Feb. 17, 1961, p. 187.
[28] Sulphur (London), No. 31, December 1960, p. 40.

Cyprus Mines Corp. and the Cyprus Sulphur & Copper Co., Ltd., increased production in 1959, but output of the Hellenic Mining Co., Ltd., decreased almost 50 percent as a result of the closing of its open-pit mine at Mitsero in February 1959.[29]

India.—The Indian Bureau of Mines reported that the pyrites deposits of Amjor in Sahabad district, Bihar, contain 154 million tons of sulfur-equivalent of pyrites in a 38.69 square-mile area. Sulfur will be produced by the Orkla process.[30]

Iran.—The Ministry of Industry and Mines was negotiating with foreign experts for beneficiating sulfur deposits near Shiraz. The sulfur was to supply a chemical fertilizer plant under construction in Shiraz and the local oil industry. Surplus sulfur was to be exported.[31]

Jordan.—A pyrites deposit was discovered near Sweileh. The extent of the deposit was unknown.

Philippines.—Hixbar Mining Co., Inc., a small copper producer, began operating its open-pit mine and mill on Rapu-Rapu Island in July 1957 and produced 4,992 tons of pyrites concentrates by March 1958 when operations were suspended. Sales of 4,592 tons valued at $50,319 were made to the National Power Corp. The company expected to resume operations if world copper prices were sustained.

Surigao Consolidated Mining Co., Inc., stockpiled zinc-pyrites tailing from its basic operations in 1958. No tailing was sold in 1958, and at yearend stocks were 74,942 tons containing 9.01 percent Zn, 30.6 percent Fe, and 38.9 percent S. In 1959, the company continued to stockpile its tailing, but part of the supply was lost due to heavy storms, and only 60,000 tons remained in the stockpile at yearend. In December 1959, the company contracted to sell tailing from the stockpile. Deliveries during the first quarter of 1960 were 3,286 tons.[32]

Turkey.—Maden Tetkik ve Arama Enstitusu, Turkey's Mineral Research and Exploration Institute, announced the discovery of copper pyrite ore bodies at Lahanos in northeastern Turkey. Proven reserves of the pyrites ore, which contains copper, zinc, and a little lead (Cu: Zn ratio of 3:2), totaled 8.6 million tons in the 37 acres drilled. The host rock is a highly silicified and brecciated dacitic lava flow 2,300 feet above sea level. The ore occurs 160 to 200 feet below the surface of the lava and is approximately 35 feet thick. Ore enrichment in the Lahanos region always is found at the hanging wall contact against an overlying tuff series.[33]

AFRICA

Morocco.—Cie. Miniere et Metallurgique, Kettara mine produced 14,190 long tons of iron pyrites containing 38 percent sulfur in 1959. Total output was for domestic consumption; no stocks were reported at the end of the year. Production in 1958 totaled 18,159 tons.[34]

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[29] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 6, June 1960, p. 36.
[30] Mining Journal (London), India's Mineral Industry: Vol. 255, No. 6538, Dec. 9, 1960, pp. 684–685.
[31] Mining World, vol. 22, No. 7, June 1960, p. 77.
[32] Bureau of Mines, Mineral Trade Notes: Vol. 51, No. 5, November 1960, pp. 50–51.
[33] Mining World, Copper Deposits Located in Northeastern Turkey: Vol. 22, No. 6, May 1960, p. 95.
[34] Bureau of Mines, Mineral Trade Notes: Vol. 51, No. 6, December 1960, p. 56.

The State Mining Research Office intensified its research for pyrites in the Safi region after traces of copper-bearing pyrites were discovered near Djebilets, 40 miles east of Safi. Also, important deposits of pyrrhotite were discovered in Kettara, 70 miles east of Safi. Other pyrrhotite deposits could supply about 70 million tons of pyrrhotite to the $50-million chemical industry to be established by the Moroccan Government at Safi.[35]

United Arab Republic (Egypt Region).—Production of sulfur began at the Ras Gemsa mine at Gemsa on the Red Sea. The plant was reported to have a capacity of 200 tons of sulfur flotation concentrate per day.[36]

TECHNOLOGY

The results of an investigation into the formation of sulfur through transformation of fumarolic hydrogen sulfide at Lake Ixpaco, located about 30 miles south of Guatemala City, Guatemala, were presented.[37] Information was given on the mineralogy of the eastern and northeastern shores and sulfur muds of the lake bottom, the temperature and chemistry of waters and vapors, the sulfur bacteria, and the core drillings on the shores of the lake.

A new process for recovering pure sulfur from hydrogen sulfide in petroleum, coal, and other gases was developed in Britain by Clayton Aniline Co. and the North Western Gas Board.[38] Key to the new process, called the Stretford process, are two specially reactive disulfonic anthraquinone acids. In the first of three steps sodium carbonate (Na_2CO_3) and sodium bicarbonate ($NaHCO_3$) in the absorbent solution react with hydrogen sulfide (H_2S) in the gas to produce sodium hydrosulfide (NaHS); in the second step, anthraquinone disulfonic acid salts in the absorbent solution react with the NaHS to give free sulfur and hydroquinone; and in the third step, hydroquinone is converted back to the original anthraquinone disulfonic acids. The free sulfur formed in the second step is removed from the tower in a finely divided form and fed to a rotary vacuum filter for recovery. Adsorbent solution is returned to the washer. The new process reduces operating costs to about two-thirds those of the conventional iron-oxide purification systems; purifies gases to fractional parts per million of residual H_2S; produces sulfur free from arsenic and iron oxide; employs absorbents that are stable, nontoxic, and easily handled, and presents no unusual corrosion problems.

The chemistry and use of the Giammaico-Vetrocoke process of scrubbing hydrogen sulfide (H_2S) and carbon dioxide (CO_2) from natural gas were described, and a flowsheet was presented.[39] Potassium or sodium carbonate solutions activated by salts of multivalent metals, such as arsenic, and an undisclosed organic compound were used. A wide variety of gas streams can be treated. The solution oxides the hydrogen sulfide to free sulfur and water. The treating solutions will not corrode carbon steel, are unaffected by contaminants such as oxy-

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[35] Chemical Week, vol. 87, No. 13, Sept. 24, 1960, p. 24.
[36] Mining World, vol. 22, No. 7, June 1960, p. 78.
[37] Ljunggren, Pontus, A Sulfur Mud Deposit Formed Through Bacterial Transformation of Fumarole Hydrogen Sulfide: Econ. Geol., vol. 55, No. 3, May 1960, pp. 531–538.
[38] Chemical Engineering, New Absorbents Cut H_2S Removal Costs: Vol. 67, No. 26, Dec. 26, 1960, pp. 44–46.
[39] Chemical Engineering, Sweet-Gas Process Makes U.S. Debut: Vol. 67, No. 19, Sept. 19, 1960, pp. 166–169.

gen, cyanides, or tars, and do not undergo degradation from side reactions. Equations were presented to show the removal of H_2S and CO_2 by arsenic-activated potassium carbonate (K_2CO_3) solution. The process can economically lower the carbon dioxide content to 0.05 percent and can selectively extract the gas from a mixture bearing H_2S.

Air-polluting sulfur compounds are removed from flue gases by an ammonia injection process developed by Chemical Construction (Great Britain) Ltd.[40] Ammonia injected into the flue gas removes over 90 percent of the sulfur in ammonium sulfur compounds consisting essentially of ammonia sulfite, bisulfite, sulfate, and thiosulfate. The ammonium sulfur salts are removed from the gas stream by electrostatic precipitation and dissolved in water. Oxidation converts sulfites in solution to sulfate, and an evaporation-crystallization step produces ammonium sulfate slurry. Cleaned gas is vented and fly ash is removed in a rotary vacuum filter.

Synthetic zeolite (calcium aluminosilicate) pellets are used to absorb hydrogen sulfide from sour natural gas in a newly developed process by Krell and Associates.[41] The process was reported to eliminate two potential disadvantages of the one-step process operating on the liquid phase. By operating over a solid catalyst, it avoids the formation of colloidal solutions of free sulfur and the contamination of the sulfur product with organic products. In the adsorption cycle, sour gas enters the bottom of the first of three parallel reactors, where it flows upward through the zeolite pellets that adsorb the hydrogen sulfide. Sweetened gas passes out the tower and through a cooler to a second reactor to cool freshly regenerated adsorbent. From the second reactor, the sweet gas passes through a cooler to the main product line. During the adsorption cycle, the third reactor is being regenerated by passing a stream of sulfur dioxide at 60° F. downward through the loaded adsorbent. Here the sulfur dioxide reacts with the hydrogen to form sulfur and water. Sulfur vapor from the reactor is condensed, and one-third of the sulfur is burned to sulfur dioxide (SO_2) to provide the regeneration gas. When the first reactor is loaded with hydrogen sulfide, all three are switched. The cooled reactor goes into hydrogen sulfide adsorption, the regenerated reactor goes into cooling and the loaded reactor goes into regeneration.

A process for recovering iron and acid from ferrous sulfate-bearing effluents was described.[42] Monohydrate coke obtained by the treatment of spent steel pickle liquor by the Nordac submerged combustion system is dried in a two-compartment fluidized bed roaster to a free-flowing powder. Decomposition is carried out at 700° C. in the lower compartment. Sulfur dioxide-bearing products, generated in the lower compartment after being cleaned, pass to the upper compartment where they are used to fluidize another bed and to drive off the surface water in the wet feed. Gases leaving the system at 300° C. will contain over 14 percent sulfur dioxide measured on a dry basis.

Elemental sulfur may be recovered from ores by a solvent extraction process using diesel fuel with a boiling range of 400° to 600° F. as the

[40] Chemical Engineering, vol. 67, No. 8, Apr. 18, 1960, p. 84.
[41] Chemical Week, Sour Gas Shift Spurs New Sulfur Processes: Vol. 88, No. 1, Jan. 7, 1961, pp. 33–35.
Chemical Engineering, Sulfur Recovery Process Goes Into Pilot Plant: Vol. 67, No. 25, Dec. 12, 1960, pp. 86–88.
[42] Chemical Age (London), Dorr-Oliver Process Recovers Sulphuric Acid and Iron From Effluents: Vol. 84, No. 2164, Dec. 31, 1960, p. 1075.

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solvent.[43] Salient features of the process are elimination of moisture, both atmospheric and that contained in the ore itself.

Similarity between the X-ray diffraction patterns for crystalline sulfur and amorphous sulfur was the basis of a new structural theory for sulfur.[44] The X-ray diffraction pattern for the crystalline form of elemental sulfur has extra lines beyond those tested by the American Society for Testing Materials. According to scientists at Baylor University, Waco, Tex., the insoluble form exists as a polymer of coiled chains with eight atoms to a loop or coil.

Technical evaluation and preliminary cost estimates indicated the feasibility of using underground nuclear blasts to exploit Frasch-type sulfur deposits.[45]

A method was described for producing sulfur that contains less than 1.3×10^{-5} mole fraction of liquid-soluble solid-insoluble impurities as determined by the freezing-point depression. This corresponds to a purity of 99.999 mole percent. Many of the impurities, including organic matter, are removed by oxidation with sulfuric and nitric acids. The nonvolatile impurities are removed by distilling the sulfur. The residual sulfuric acid is removed by a special extraction with distilled water.

Methods were described for determining small amounts of selenium, tellurium, arsenic, iron, carbon, sulfuric acid, and residue after ignition.[46]

Preliminary tests conducted by the Southwest Research Institute indicate that the ultimate tensile strength of compressed sulfur is 160 pounds per square inch, ultimate compressive strength, 3,300 pounds per square inch.[47]

The isotopic composition of sulfides and sulfates from various types of sulfide formations were determined. A description of the preparation of sulfurous minerals for mass-spectrometric analysis and the mass-spectrometic procedure was given.[48]

A method of graphically representing the relevant thermodynamic data, condition of temperature, and gas composition under which different products will form in sulfied roasting was presented.[49]

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[43] Sulphur (London), New Sulphur Extraction Process Developed by Delhi-Taylor: No. 31, December 1960, pp. 33–34.

[44] Chemical and Engineering News, Sulfur May Have Helical Structure: Vol. 38, No. 36, Sept. 5, 1960, p. 44.

[45] Dale, J. M., and DeHart, R. C., Nuclear Fire and Brimstone: Chem. Eng. Prog., vol. 56, No. 7, pp. 90, 92, 93.

[46] Murphy, Thomas J., Clabough, Stanley W., and Gilchrist, Raleigh, Preparation of Sulfur of High Purity: Jour. of Res., National Bureau of Standards, vol. 64A, No. 4, July–August 1960, pp. 355–358.

[47] Chemical Engineering News, vol. 38, No. 18, May 2, 1960, p. 43.

[48] Gavelin, S., Parivel, A., and Ryhage, R., Sulfur Isotope Fractionation in Sulfide Mineralization: Econ. Geol., vol. 55, No. 3, May 1960, pp. 510–530.

[49] Kirkwood, D. H., and Nutting, J., The Graphical Representation of Roasting Equilibria: Trans. of the Metallurgical Society of AIME, vol. 218, No. 1, February 1960, pp. 190–191.

Talc, Soapstone, and Pyrophyllite

By Harold J. Drake [1] and Betty Ann Brett [2]

DOMESTIC mine production and sales of talc, soapstone, and pyrophyllite in 1960 declined 7 and 8 percent, respectively, from their 1959 peaks. World output reached a new high, 8 percent above the record set in 1959.

TABLE 1.—Salient talc, soapstone, and pyrophyllite statistics

(Thousand short tons and thousand dollars)

	1951–55 (average)	1956	1957	1958	1959	1960
United States:						
Mine production	644	739	684	718	[1] 792	734
Value [2]	[3] $3,844	$4,859	$4,796	$4,718	[1] $5,641	$5,378
Sold by producers	631	735	692	694	782	722
Value	$12,382	$15,026	$14,411	$14,206	$17,068	$16,073
Imports for consumption	23	23	20	23	25	24
Value	$760	$749	$701	$785	$861	$849
Exports [4]	26	42	40	59	59	60
Value	$795	$1,083	$1,265	$1,451	$1,707	$1,893
World: Production	1,780	1,930	2,080	2,030	2,260	2,450

[1] Revised figure.
[2] Partly estimated.
[3] Average for 1953–55 only.
[4] Excludes powders—talcum (in package), face, and compact.

DOMESTIC PRODUCTION

For the 10th consecutive year New York, California, and North Carolina ranked first, second, and third, respectively, in the quantity of talc, soapstone, and pyrophyllite produced. The greatest production of pyrophyllite came from North Carolina, followed by Pennsylvania (sericite schist) and California. Talc and soapstone were produced in 14 States at 79 mines, and pyrophyllite was produced in 3 States at 13 mines.

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.

TABLE 2.—Talc, soapstone, and pyrophyllite sold by producers in the United States, by classes

Year	Crude			Sawed and manufactured		
	Short tons	Value at shipping point		Short tons	Value at shipping point	
		Total	Average per ton		Total	Average per ton
1951-55 (average)	24,740	$226,250	$9.15	1,066	$345,486	$324.10
1956	42,085	265,631	6.31	1,052	441,848	420.01
1957	57,382	330,131	5.75	1,212	519,664	428.77
1958	61,287	349,471	5.70	801	400,453	499.94
1959	64,856	349,484	5.39	710	416,144	586.12
1960	44,477	240,077	5.40	860	410,194	476.97
	Ground [1]			Total		
	Short tons	Value at shipping point		Short tons	Value at shipping point	
		Total	Average per ton		Total	Average per ton
1951-55 (average)	605,688	$11,810,235	$19.50	631,494	$12,381,971	$19.61
1956	691,661	14,318,414	20.70	734,798	15,025,893	20.45
1957	633,330	13,561,497	21.41	691,924	14,411,292	20.83
1958	631,804	13,455,650	21.30	693,892	14,205,574	20.47
1959	716,837	16,302,657	22.74	782,403	17,068,285	21.82
1960	676,344	15,423,193	22.80	721,681	16,073,464	22.27

[1] Includes some crushed material.

TABLE 3.—Pyrophyllite [1] produced and sold by producers in the United States

Year	Production (short tons)	Sales					
		Crude		Ground		Total	
		Short tons	Value	Short tons	Value	Short tons	Value
1951-55 (average)	130,829	6,898	$42,537	[2] 120,745	$1,692,952	127.643	$1,735,489
1956	167,756	20,847	121,497	141,143	1,808,502	161,990	1,929,999
1957	160,538	26,414	127,865	135,368	1,925,973	161,782	2,053,838
1958	155,476	20,732	135,790	122,419	1,886,531	143,151	2,022,321
1959	[3] 151,175	31,615	186,090	123,236	1,936,397	154,851	2,122,487
1960	124,631	9,849	57,269	122,508	1,792,387	132,357	1,849,656

[1] Includes sericite schist, 1953-60.
[2] Includes a small quantity of sawed material for 1955 only.
[3] Revised figure.

TABLE 4.—Crude talc, soapstone, and pyrophyllite produced in the United States

State	1959		1960	
	Short tons	Value [1] (thousands)	Short tons	Value [1] (thousands)
California	[2] 144,816	[2] $1,490	130,539	$1,396
Georgia	53,692	107	40,200	88
Maryland and Virginia	28,817	75	32,789	95
Nevada	5,824	50	4,882	30
North Carolina	127,296	647	100,593	549
Texas	60,945	283	67,031	336
Washington	4,073	23	2,406	12
Other States [3]	366,095	2,966	356,033	2,872
Total	[2] 791,558	[2] 5,641	734,473	5,378

[1] Partly estimated.
[2] Revised figure.
[3] Includes Alabama, Arkansas, Montana, New York, Pennsylvania, and Vermont.

CONSUMPTION AND USES

In 1960, ceramics, paint, insecticides, roofing, rubber, asphalt filler, and paper consumed 83 percent of talc and soapstone sold by producers, compared with 82 percent in 1959. Ceramics continued to be the largest single consumer, and ceramics, paint, and roofing—the three largest uses—accounted for 62 percent of total consumption. Sales of pyrophyllite for ceramics and insecticides declined from 55 percent in 1959 to 53 percent in 1960.

TABLE 5.—Talc, soapstone, and pyrophyllite sold or used by producers in the United States, by uses

(Short tons)

Use	Talc and soapstone		Pyrophyllite	
	1959	1960	1959	1960
Asphalt filler	29,034	18,822	(1)	(1)
Ceramics	213,185	206,843	47,868	36,525
Crayons	635	654		
Foundry facings	6,964	6,264		
Insecticides	51,073	47,554	37,436	33,831
Paint	120,780	108,407	1,677	844
Paper	21,848	26,302		
Plaster products			8,205	6,658
Rice polishing	1,969	2,231		
Roofing	50,453	51,599	502	
Rubber	30,728	27,828	11,459	7,319
Textile	11,936	9,351		
Toilet preparations	9,634	10,237		
Other	[2] 79,313	[2] 73,232	[3] 47,704	[3] 47,180
Total	627,552	589,324	154,851	132,357

[1] Figure included with "Other" to avoid disclosing individual company confidential data.
[2] Includes adhesive, composition floor and wall tile, exports, instrument wire and cable, joint cement, refractories, stucco, vault manufacturing, and miscellaneous products.
[3] Includes uses indicated by footnote 1 and battery, joint cement, refractories, and related products.

PRICES

With one exception, the talc price quotations in trade journals remained unchanged through 1960. The minimum price for ordinary California talc rose $1 per ton. Quotations in the journals indicate the range in prices; actual prices are negotiated between buyer and seller and are based on a wide range of specifications.

TABLE 6.—Prices quoted on ground talc, in bags, carlots, in 1960

(Per short ton)

Grade	1960
Domestic, f.o.b. works:	
Ordinary:	
California	$34.00–$39.50
Vermont	19.40
Fibrous (New York):	
Off-color	28.00
325-mesh:	
99.5 percent	31.00
99.95 percent, micronized	38.00
Imported (Canadian), f.o.b. mines	20.00– 35.00

Source: Oil, Paint and Drug Reporter.

TABLE 7.—Prices quoted on talc, carlots, f.o.b. works, in 1960

(Per short ton)

Grade [1]	1960
Georgia: 98 percent minus 200-mesh:	
Gray, packed in paper bags	$10.50–$11.00
White, packed in paper bags	12.50– 15.00
New Jersey: Mineral pulp, ground, bags extra	10.50– 12.50
Vermont:	
100 percent through 200-mesh, extra white, bulk basis [2]	12.50
99½ percent through 200-mesh, medium white, bulk basis [2]	11.50– 12.50
Virginia:	
200-mesh	10.00– 12.00
325-mesh	12.00– 14.00
Crude	5.50

[1] Containers included unless otherwise specified.
[2] Packed in paper bags, $1.75 per ton extra.

Source: E&MJ Metal and Mineral Markets.

FOREIGN TRADE [3]

Imports.—Imports declined 5 percent in quantity and 1 percent in value in 1960. Italy supplied 74 percent of all imports, compared with 71 percent in 1959. The value of imports of manufactures, except toilet preparations, declined sharply from $52,509 in 1959 to $11,447 in 1960.

Exports.—Exports exclusive of talcums increased 1 percent in quantity and 11 percent in value. The Federal Government removed restrictions on exports of steatite, talc, and other minerals to Hong Kong and Macao.

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 8.—U.S. imports for consumption of talc, steatite or soapstone, and French chalk, by classes and countries

County	Crude and unground		Ground, washed, powdered, or pulverized, except toilet preparations		Cut and sawed		Total unmanufactured	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1951–55 (average)	150	$28,064	22,759	[1] $702,631	87	$29,670	22,996	[1] $760,365
1956	117	17,555	23,128	[1] 684,954	106	46,761	23,351	[1] 749,270
1957	277	42,265	20,032	[1] 622,472	86	36,616	20,395	[1] 701,353
1958	31	6,040	22,760	737,584	99	41,114	22,890	784,738
1959:								
Belgium-Luxembourg			40	344			40	344
Canada			1,588	24,404			1,588	24,404
France			4,817	100,101	2	555	4,819	100,656
India	54	5,020	420	12,037			474	17,057
Italy	331	13,058	17,593	663,273	8	2,551	17,932	678,882
Japan			10	448	64	31,166	74	31,614
Mexico	114	375	305	6,496			419	6,871
United Kingdom			5	713			5	713
Total	499	18,453	24,778	807,816	74	34,272	25,351	860,541
1960:								
Canada	60	1,583	1,514	25,532			1,574	27,115
France			3,476	75,890	2	580	3,478	76,470
India	14	1,793	741	17,452			755	19,245
Italy			17,713	693,211	6	1,966	17,719	695,177
Japan					43	21,870	43	21,870
Korea, Republic of			5	300			5	300
Mexico			401	8,669			401	8,669
Total	74	3,376	23,850	821,054	51	24,416	23,975	848,846

[1] Data known to be not comparable with other years.

Source: Bureau of the Census.

TABLE 9.—U.S. exports of talc, pyrophyllite, and talcum powders

Year	Talc, steatite, soapstone, and pyrophyllite				Powders—talcum (in packages), face and compact (value, thousands)
	Crude and ground		Manufactures, n.e.c.		
	Short tons	Value (thousands)	Short tons	Value (thousands)	
1951–55 (average)	25,502	$693	185	$102	$1,265
1956	42,333	1,009	69	74	1,371
1957	39,985	1,127	291	138	1,322
1958	58,647	1,358	212	93	1,341
1959	58,751	1,532	197	175	1,276
1960	59,457	1,801	158	92	1,378

Source: Bureau of the Census.

WORLD REVIEW

Japan, France, India, and Italy recorded substantial production increases as estimated world production reached a new peak in 1960.

Afghanistan.—A reportedly sizable and readily exploitable talc deposit in eastern Afghanistan was developed by the Shaker Ceramic Factory, a privately owned plant started with Japanese technical assistance.[4] Experimental products from the deposit indicated that the talc may be of ceramic grade suitabe for electronic applications.

Australia.—Western Mining Corp. acquired a half interest in the Three Springs talc mine about 190 miles north of Perth near the Perth-Geraldton railway.[5]

TABLE 10.—World production of talc, soapstone, and pyrophyllite by countries [1] [2]

(Short tons)

Country [1]	1951–55 (average)	1956	1957	1958	1959	1960
North America:						
Canada (shipments)	26,518	29,326	34,725	35,405	39,176	41,605
United States	643,521	739,039	684,453	718,165	791,558	734,473
Total	670,039	768,365	719,178	753,570	830,734	776,078
South America:						
Argentina	29,201	24,920	26,239	19,254	[3] 22,000	[3] 22,000
Brazil	21,310	30,684	23,023	31,442	23,369	[3] 24,250
Paraguay	[4] 68	[3] 110	[3] 110	[3] 110	[3] 110	[3] 110
Peru	826	4,031	2,689	2,073	1,694	2,194
Uruguay	1,041	1,580	1,566	1,990	2,335	3,296
Total	52,446	61,325	53,627	54,869	49,508	[3] 51,850
Europe:						
Austria	67,789	72,813	80,915	78,074	56,475	90,695
Finland	5,930	8,146	9,259	7,330	8,505	11,008
France	124,040	126,840	145,482	155,226	162,736	192,904
Germany, West (marketable)	35,467	39,463	32,854	[3] 33,000	[3] 33,000	[3] 35,000
Greece	1,651	2,205	2,205	1,962	[3] 2,200	[3] 2,200
Italy	93,887	105,005	110,591	120,704	120,436	135,198
Norway	78,430	82,154	117,965	107,828	93,783	99,208
Portugal	9	95			243	
Spain	22,805	30,808	35,091	33,360	30,661	27,395
Sweden	12,515	14,492	13,918	14,581	[3] 15,000	[3] 15,000
United Kingdom	4,039	4,270	4,256	4,645	[3] 4,400	[3] 4,400
Yugoslavia	[5] 2,922					
Total [1] [3]	470,000	510,000	575,000	580,000	550,000	635,000
Asia:						
Afghanistan	901	882	[3] 770	[3] 770	[3] 770	[3] 770
India	37,692	52,478	49,253	50,906	70,572	100,085
Japan	440,719	345,846	469,109	377,994	535,140	[3] 660,000
Korea, Republic of	15,659	15,686	12,434	17,581	19,272	24,889
Taiwan	3,996	6,758	5,938	3,677	7,101	11,637
Total [1] [3]	565,000	565,000	705,000	615,000	800,000	960,000
Africa:						
Kenya	183					
Swaziland			22	157	1,008	1,714
Union of South Africa	6,667	1,968	2,314	765	1,412	1,979
United Arab Republic (Egypt Region)	4,284	7,706	6,031	7,253	6,708	[3] 6,600
Total	11,134	9,674	8,367	8,175	9,128	[3] 10,293
Oceania: Australia	12,629	14,979	16,575	17,539	16,272	[3] 18,000
World total (estimate) [1] [2]	1,780,000	1,930,000	2,080,000	2,030,000	2,260,000	2,450,000

[1] Talc or pyrophyllite is reported in China, Rumania, and U.S.S.R., but data are not available; estimates for these countries are included in total.

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[3] Estimate.

[4] Average for 1953–55.

[5] Average for 1 year only, as 1955 was first year of production.

Compiled by Liela S. Price, Division of Foreign Activities.

[4] U.S. Embassy, Kabul, Afghanistan, State Department Dispatch 215: May 5, 1960, p. 2.

[5] Mining Magazine (London), Newsletter: Vol. 103, No. 5, November 1960, p. 294.

Pakistan.—The Government granted licenses to several firms to explore deposits containing soapstone and other minerals discovered by the U.S. Geological Survey in Azid Kashmir.[6]

TABLE 11.—Austria, France, and Italy: Exports of talc and soapstone by countries [1]

(Short tons)

Destination	Exporting countries					
	Austria		France		Italy	
	1959	1960	1958	1959	1959	1960
Algeria			3,468	3,844		1
Belgium-Luxembourg	3,046	4,022	3,993	4,554	(2)	(2)
Denmark	159	264				
France	1,379	1,515			(2)	(2)
Germany:						
East	313	455				
West	19,034	22,214	4,601	4,852	6,526	10,132
Hungary	1,575	2,382				
Italy	964	765				
Morocco: Southern zone			790	749		
Netherlands	1,068	1,438	705		(2)	(2)
Philippines	11	29			(2)	(2)
Poland	6,886	33,091				
Portugal		11		456	(2)	(2)
Sweden	66	55	526	716		
Switzerland	2,996	3,148	7,235	6,595	(2)	(2)
United Kingdom	560	416	6,052	5,314	8,707	11,799
United States			3,428	4,594	18,091	16,973
Yugoslavia	26	141				
Other countries			2,685	3,739	12,689	16,333
Total	38,083	69,946	33,483	35,413	46,013	55,238

[1] This table incorporates some revisions.
[2] Data not separately recorded.

Compiled from Customs Returns of Austria, France, and Italy by Corra A. Barry, Division of Foreign Activities.

TABLE 12.—Union of South Africa: Salient statistics of pyrophyllite (wonderstone)

	1959 [1]	1960 [2]
Production short tons	392	699
Exports do	286	562
Value	$27,633	$54,917
Local sales short tons	111	108
Value	$8,406	$9,413

[1] U.S. Embassy, Johannesburg, Union of South Africa, State Department Dispatch 7: Aug. 24, 1960, encl. 3, p. 2; encl. 4, p. 2; encl. 5, p. 2.
[2] U.S. Embassy, Johannesburg, Union of South Africa, State Department Dispatch 358: May 4, 1961, p. 3.

Union of South Africa.—The 1960 production and exports of massive pyrophyllite (wonderstone) were 78 and 97 percent higher, respectively, than in 1959.

[6] Mining World, What's Going On In Mining: Vol. 22, No. 4, April 1960, p. 62.

TECHNOLOGY

A new use for pyrophyllite in the synthesis of crystals such as diamonds was described.[7] An article was published describing the reduction of soapstone to micron sizes at a considerable reduction in power cost.[8] A process was developed to produce synthetic talc.[9] An apparatus was described whereby the pressure distribution in dry-pressed talc or clay wares can be determined by measuring pressure penetration in a cylindrical sample.[10] A study was made of the effect of reducing the extremely fine particle fraction of talcs on its pressing characteristics and ceramic properties.[11]

A patent was issued for using talc in a sealing composition for electrical cables.[12] An improved joint-sealing compound employing talc was developed for use between building brick or block.[13] The compound is permanently nonbrittle and requires no water when used. A process for removing silica from pyrophyllite and clays was patented.[14] A method of forming a flowable slurry of solid particles, such as talc, in a vaporizable liquid prior to processing was evolved.[15] A precision grinder for minerals like talc was patented that scavenged the abrasive gangue materials and at the same time removed softer mineral particles upon reduction to the desired size.[16] Slurry additives such as sodium hydroxide and sodium carbonate [17] or ammonia and carbon dioxide [18] prevent scale formation in equipment used in fluid-energy grinding of talc and other minerals.

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[7] Pough, Frederick H., The "Gem" Factory on Route 128: Jewelers' Circ. Keystone, vol. 130, No. 7, April 1960, pp. 78, 80, 92–94.

[8] Godfrey, Kneeland A., Jr., Soapstone Yields to Pneumatic Mill: Rock Products, vol. 60, No. 12, December 1960, pp. 96–98.

[9] Chemistry, Synthetic Talc Prepared in Bulk: Vol. 34, No. 1, September 1960, p. 35.

[10] Building Science Abstracts (London), Clay and Clayware: Vol. 33, No. 8, August 1960, p. 225.

[11] Felton, Ernest, and Watterlond, Robert, Aerodynamic Classified Talcs and Their Effect in a Ceramic Body: Am. Ceram. Soc. Bull., vol. 39, No. 12, December 1960, pp. 717–720.

[12] British Patent 834,182 (assigned to Compagnie Générale d'Électricité), Electric Cable in a Waterproof, Grooved Metal Sheathing, May 4, 1960.

[13] Fekler, J. L., Surface Covering Unit: U.S. Patent 2,916,908, Dec. 15, 1959.

[14] Schoenfelder, H., and Ginsberg, H. (assigned to Vereinigte Aluminum-Werke A. G.), Method for Reducing the Silica Content of Alumina-Containing Materials of the Clay Type: U.S. Patent 2,939,764, June 7, 1960.

[15] Stratford, W. M. (assigned to Texaco, Inc.), Treating Solid Materials: U.S. Patent 2,914,391, Nov. 24, 1959.

[16] Lykken, H. G., and Lykken, W. H. (assigned to Microcyclomat Co., Minneapolis, Minn.), Precision Grinder: U.S. Patent 2,941,731, June 21, 1960.

[17] Chapman, R. W. and Dille, R. M. (assigned to Texaco, Inc.), Preventing Scale Formation in Slurry Feeding Processes by Means of a Mixture of Alkali Hydroxide and Carbonate: U.S. Patent 2,924,515, Feb. 9, 1960.

[18] Guptill, F. E., Jr. (assigned to Texaco, Inc.), Preventing Scale Formation in Slurry Feeding Processes by Means of a Mixture of Ammonia and Carbon Dioxide: U.S. Patent 2,924,578, Feb. 9, 1960.

Thorium

By Don H. Baker, Jr.[1]

THORIUM application in high-temperature alloys and in atomic energy continued to hold the attention of many in 1960. Progress was shown in the research and devolpment of effective thermal breeder reactors as a part of the atomic energy program for the utilization of thorium.

Domestic production of thorium-containing minerals was negligible and requirements for the commodity were met by production from previous years and by imports. Magnesium-thorium alloys consumed more thorium than all other uses. Some form of the magnesium-thorium alloys was incorporated in all U.S. missiles and space vehicles, whether operational or in various stages of development. Thorium compounds recovered from the waste liquor of a uranium processing plant at Elliot Lake in the Blind River Area of Canada were the major source of thorium imports. The Van Rhynsdorp monazite lode mine in the Union of South Africa remained closed.

LEGISLATION AND GOVERNMENT PROGRAMS

The program for the utilization of thorium as a nuclear fuel was gaining impetus with the construction of reactors to test concepts and develop additional engineering data.

At the Oak Ridge National Laboratory pilot plant, thorium oxide powders were prepared in efforts to produce oxide having desirable slurry properties for use in the homogenous reactor program. After an oxide has been developed having the desired slurry properties for which specification can be set, the Atomic Energy Commission (AEC) planned to obtain thorium oxide from commercial sources. AEC announced that its thorium operations were limited to development of thorium uses in AEC programs. Indications were that there might be a continuing requirement for modest quantities of thorium metals which would exceed the current inventory. Should such a requirement develop, AEC planned to obtain the metal by procurement from commercial sources.[2]

The Office of Minerals Exploration (OME) continued to include thorium in the list of minerals eligible for financial assistance. No exploration contracts for thorium were made in 1960.

Thorium nitrate was eligible for procurement for the supplemental stockpile in exchange for surplus agricultural commodities, under the Department of Agriculture, Commodity Credit Corporation barter program.

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[1] Commodity specialist, Division of Minerals.
[2] U.S. Atomic Energy Commission, Annual Report to Congress, 1960: January 1961, p. 485.

DOMESTIC PRODUCTION

Mine Production.—Domestic mine production was negligible because the industry wanted to reduce stockpiles and inventories of thorium-bearing materials. There was continued activity, however, in exploration, development, and consolidation of thorium mining properties in Idaho, Florida, and Montana, by Agency Creek Thorium and Rare Metals Corporation of America, Porter Brothers Corp., Baumhoff-Marshall, Inc., Sawyer Petroleum Co. (Techmanix Corp.), and National Lead Co.

Early in the year Sawyer Petroleum Co. assigned its thorium holdings in the Lemhi Pass District of Beaverhead County, Mont., to Techmanix Corp., thus consolidating both natural resource supply and chemical processing technology in one corporation.[3]

The consolidation and development of thorium holdings in the Idaho-Montana area was highlighted by cooperative ventures of the several companies. Rare Metals Corporation of America contracted with Agency Creek Thorium and Rare Metals Corp. to explore, develop, and mine thorium and rare metals on the latter's property in the Lemhi County, Idaho-Beaverhead County, Mont. (Lemhi Pass) area.[4] Nuclear Fuels and Rare Metals Corp. acquired the properties of Salmon Uranium Co. and Idaho Thorium Co. in the Lemhi Pass area.[5]

The Wilcox mill at Salmon, Idaho, acquired by Nuclear Fuels and Rare Metals, was to be modified to process thorium-bearing materials.[6] Porter Brothers Corp. continued development and refinement of techniques for extracting and recovering thorium from euxenite. Techmanix Corporation's new pilot plant, using a reportedly new and simpler process to make better than 90 percent pure thorium hydrate, was nearly completed.[7]

The results of geological and metallurgical studies by the Idaho Bureau of Mines and Geology and the University of Idaho College of Mines on the two major Idaho thorite deposits were reported. Areas studied encompassed Hall Mountain in Boundary County and the Lemhi Pass area.[8] These two areas showed promise of being among the most important thorite areas in the United States.

Refinery Production.—Principal domestic refineries were Lindsay Chemical Division, American Potash and Chemical Corp., West Chicago, Ill.; W. R. Grace & Co., Davison Chemical Divsion, Baltimore, Md., Pompton Plains, N.J., and Erwin, Tenn.; and Vitro Chemical Co., Chattanooga, Tenn. Mallinckrodt Chemical Works, St. Louis, Mo., recovered some thorium from Idaho euxenite, by a residue process primarily for columbium and uranium. Some thorium was offered commercially by Davison Chemical, Erwin, Tenn.; Dominion Magnesium, Ltd., Toronto, Canada; Sylvania-Corning Nuclear Corp., Wayside, N.Y.; Westinghouse-Electric Corp., Lamp Division, Bloomfield, N.J.; National Research Corp., Cambridge, Mass.; Nuclear Materials and Equipment Corp., Apollo, Pa.; Vitro Corporation of

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[3] News to Stockholders of Sawyer Petroleum, Sept. 6, 1960.
[4] California Mining Journal, vol. 29. No. 6. February 1960, p. 3.
[5] California Mining Journal, vol. 29, No. 10, June 1960, p. 5.
[6] Mining Record, vol. 71, No. 9, Mar. 3, 1960, p. 6.
[7] Chemical and Engineering News, vol. 38, No. 16, Apr. 18, 1960, p. 35.
[8] Newton, Joseph, and others, Study of Two Idaho Thorite Deposits: Idaho Bureau of Mines and Geology, Moscow, Idaho, Pamphlet No. 122, September 1960, 57 pp.

America; and Cerium Metals and Alloys Division, Ronson Metals Corp., Newark, N.J. National Lead of Ohio processed thorium metal for the AEC. Reactor-grade high-purity thorium oxide was produced by Davison Chemical and by Lindsay Chemical. High-purity thorium oxide ceramic also was offered by National Beryllia Corp., Hackell, N.J.

CONSUMPTION AND USES

Nonenergy Uses.—Consumption of thorium by domestic industry increased about 30 percent over 1959. The thorium consumed in electronic products and in making gas mantles accounted for 93 percent of the increase. Utilization of thorium in thorium-magnesium alloys increased only 2 percent over 1959. The use of thorium in chemical reagents, refractories, and research remained at essentially 1959 levels.

TABLE 1.—Thorium consumption for nonenergy purposes

(Pounds of contained ThO_2)

Use	1959	1960
Magnesium alloys	136,000	139,000
Gas-mantle manufacture	45,000	96,000
Refractories and polishing compounds	5,000	5,000
Chemical and medical products	5,000	5,000
Electronic products	1,000	2,500
Total	191,000	247,500

The Dow Chemical Co. was the chief producer of magnesium-thorium alloys. The operating range of lightweight magnesium alloys can be increased to 800° F. by the addition of thorium.

Missile and satellite construction consumed a major portion of the magnesium-thorium alloys produced. The thorium used in magnesium alloys represented about 56 percent of the total thorium consumed. The Discoverer (Agena A) series of satellites, which achieved successful orbit in 7 out of 12 firings, each contained more than 600 pounds of magnesium-thorium alloy sheet, extrusions, forgings, and castings. The Talos, Titan, and Polaris missiles contained large quantities of magnesium-thorium alloys. The use of these alloys in structural and skin members enabled the missiles and satellites to resist aerodynamic heating, compressive buckling, and temperature reversals while in flight. The alloys most frequently reported used in satellite and missile components were those of the following ASTM designations: HK31A, HM21A, HM31A, and HM11XA. These alloys contain 3, 2, 3, and 1.2 percent thorium, respectively.

The principal supplier of thorium-magnesium master alloy for magnesium-thorium alloys was Dominion Magnesium, Ltd., Toronto, Canada; others included Magnesium Elektron, Ltd., Davison Chemical, Rio Tinto Dow, and Vitro Chemical Co.

Energy Uses.—The use of thorium as an energy source continued to be investigated. Studies included the use of thorium and thorium compounds as fuel in breeder reactors to develop engineering design data. The program in part was carried on in the Consolidated Edison Thorium Reactor, Sodium Reactor Experiment, and in the Thorium-

Uranium Physics Experimental Program. The Oak Ridge National Laboratory pilot plant prepared and tested thorium oxide powder slurries for use in the homogeneous reactor program.

The fuel elements for the Advanced Epithermal Thorium Reactor (AETR), under construction at Canoga Park, Calif., were being fabricated by the W. R. Grace & Co., Davison Chemical Division, at its Erwin, Tenn., plant. This fabrication was the first such operation ever undertaken on a significant scale by private industry. A total of about 25 kilograms of uranium–233 was to be utilized. The AETR facility was being built by the Atomics International Division of North American Aviation Corp. for Southwest Atomic Energy Associates, a group of privately owned electric companies in the southwestern United States.

The development of thorium-fueled power reactors received close scrutiny in foreign countries, particularly those countries which had thorium natural resources but were lacking in uranium.

PRICES

Monazite quotations listed in E&MJ Metal and Mineral Markets remained steady during 1960 as follows:

Type and grade, rare-earth oxide including thoria, percent:	*Price per pound, c.i.f. U.S. ports*
Massive; 55	$0.13
Sand; 55	.15
Sand; 66	.18
Sand; 68	.20

Prices for thorite-type minerals were on a negotiated basis between buyer and seller but probably ranged from $1.25 per pound of contained thoria for 10-percent concentrates to $2.25 for 20-percent concentrates.

Thorium compounds offered for sale in 1960 by a leading producer for 100-pound lots or more were as follows:

	ThO_2, percent	*Price per pound*
Thorium compound:		
Carbonate	80–85	[1] $6.25–8.00
Chloride	50	7.00
Fluoride	80	5.50
Nitrate (mantle grade)	46	3.00
Oxide	97–99	5.50–8.50
Other forms:		
Metal (nuclear grade) [2]	-----	19.55
Thorium hardner (for alloying)	20–40	12.50–15.00

[1] Variable, depending on rare-earth content.
[2] F.o.b. AEC, Feed Materials Production Center, Fernald, Ohio.

The following prices per pound for Nuclear-grade thorium metal remained in effect in 1960:

	Powder or pellets	*Thorium ingot*
Less than 10 lb	$50	$54
10 to 100 lb	41	45
100 to 500 lb	34	38
500 to 2,000 lb	26	30
Over 2,000 lb	20	24

FOREIGN TRADE

The United States imported some thorium-bearing compounds from Canada.

WORLD REVIEW

World requirements for thorium were met by production of monazite in Australia, Federation of Malaya, and India, and from stockpiled material in the Union of South Africa and the United States. Byproduct thorium from a Canadian uranium mill also supplied the world markets. India and Brazil retained embargoes on exports of thorium.

NORTH AMERICA

Canada.—The Quirke Lake mine and concentrator of the Rio Algom mine was scheduled to close at the end of 1960. The thorium plant at Quirke, which had extracted thorium from mill waste liquors since early 1959 and was Canada's first thorium producing plant, was to be placed on a standby basis. Rio Tinto Dow announced that a new facility at the Nordic plant of Rio Algom Mines would be in operation by March 1961 to insure continued production of thorium compounds with a minimum interruption of output. The new plant will have a capacity of 150 tons of thorium a year from uranium mill waste material.

SOUTH AMERICA

Brazil.—Early in 1960, the Comissao Nacional de Energia Nuclear (National Nuclear Energy Commission) was authorized to negotiate the purchase of mines, mineral rights, machinery, patents, laboratories, and other items required for the concentration and beneficiation of monazite sands from Sociedade Comercial de Minerios Limitade (SULBA), a subsidiary of Orquima Industries Quimicas Reunidas S.A.[9]

Export restrictions imposed in 1956 on atomic-energy resources continued in effect.

EUROPE

France.—The uranium and thorium minerals industries of France were described in detail.[10]

U.S.S.R.—Extensive research on thorium and its compounds was continued in the U.S.S.R. in 1960, with particular emphasis directed toward its use in the atomic-energy program. Production of thorium metal by molten salt electrolysis is receiving extensive metallurgical research by Soviet scientists.

ASIA

Ceylon.—The Government mineralogist of Ceylon reported that in 1959, 94 short tons of monazite concentrate containing 70 percent monazite was produced from sands averaging 6.6 percent monazite. The sand was collected from Polkutowa, immediately north of Beruwela.

India.—Discovery of very large placer deposits containing monazite was made over an extensive inland area of Bihar and West Bental. Average thickness of the deposits was just under 3 feet. Sands con-

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[9] Bureau of Mines, Mineral Trade Notes: Vol. 50, No. 6, June 1960, p. 33.

[10] Annales des Mines, L'Industrie Miniere De L'Uranium: Vol. 11, November 1960, pp. 677–694.

tained from 2 to 4 percent heavy minerals, approximately one fourth of which was monazite. Associated heavy minerals, were ilmenite, sillimanite, zircon, magnetite, rutile, columbite, tantalite, and apatite.

Malaya, Federation of.—Monazite produced as a byproduct of tin in Malaya supplied some of the thorium requirements in the free world.

AFRICA

Rhodesia and Nyasaland, Federation of.—Monazite deposits were explored on the west shore of Lake Nyasa. At least three deposits are large enough to be of commercial value. More extensive deposits containing monazite also occur on the east shore of the lake, but the thoria content of this monazite was not of acceptable commercial grade.

Union of South Africa.—The monazite mine of the Anglo-American Corporation of South Africa, Ltd., near Van Rhynsdorp, a major source of thorium in the free world, remained closed during 1960.

OCEANIA

Australia.—Monazite recovered from beach-sand deposits of heavy minerals was shipped to foreign countries.

TECHNOLOGY

Investigations comparing the use of two acidic phosphate esters and primary amines for extracting thorium from uranium-plant barren solutions were described in detail.[11] Some of the advantages and disadvantages of each was given. Extraction of thorium with acidic phosphate esters from solutions containing rare-earth elements could result in a thorium product contaminated with rare earths.

The production of high-purity thorium powder by calcium reduction of thorium oxide at 950°C. was reported.[12] Purity of the powder produced was in direct relation to the purity of the thorium oxide used when redistilled calcium metal was the reductant. A modification of the technique, resulting in better overall recoveries, permits recycling of the relatively impure metal fines that are not recovered as primary material in the leaching of previous reaction masses. Extension of the process to manufacture of larger quantities from 7-kilogram batches should be straight forward.

The Federal Bureau of Mines reported that conditions were established for preparing cold-ductile thorium metal by an inert-atmosphere crucible-reduction technique, using either high-purity commercial magnesium or high-purity commercial sodium as the reducing agent.[13] Consolidated metal prepared by this method is readily fabricated to thin sheets, which remain soft and ductile after annealing.

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[11] Audsley, A., Ryan, W., and Wells, R. A., Recovery of Thorium From Uranium-Plant Barren Solutions by Solvent Extraction: Inst. Min. Met. Bull. (London), vol. 69, No. 643, June 1960, pp. 505–524.

[12] Fuhrman, N., Holden, R. B., and Whitman, C. I., Production of Thorium Powder by Calcium Reduction of Thorium Oxide: Jour. Electrochem. Soc., vol 107, No. 2, February 1960, pp. 127–131.

[13] Good, P. C., and Block, F. E., Metallic Reduction of Thorium Tetrachloride: Bureau of Mines Rept. of Investigations 5702, 1960, 12 pp.

Detailed investigations of the production of thorium by electrolysis of thorium fluoride containing salt melts were described by the Russians.[14]

The ternary phase diagram for thorium-tungsten-boron was studied, providing information important in the design and conception of high-temperature cathodes and the interpretation of the emission mechanism.[15] An improved method for producing thoriamolybdenum cermets used to make cathodes for magnetron vacuum tubes was reported.[16] Both developments will lead to improvement in the utilization of thorium in this type of application.

More precise measurements than previously reported were developed for the thorium spectrum.[17] This improvement increased interest in the possibility of using the thorium spectrum as a secondary standard wavelength. An improved technique, involving the measurement of four thorium isotopes, for dating geochronology may make it possible to date through the entire Pleistocene epoch.[18]

Further refinement and development of the magnesium-thorium alloy HM11XA, an improved die-casting alloy, opened up new areas of application in missiles and satellites, as well as more standard commercial applications.[19]

AEC researchers reported[20] that the optimum particle size, high-wear resistance, heat-transfer, and fluid-flow characteristics of aqueous slurries of thorium oxide have been developed sufficiently to provide a basis of design for a homogenous reactor blanket or core system for power reactors.

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[14] Morachevskiy, A. G. [Review of Research Done in 1959 on the Electrochemistry of Fused Salts]: Zhurnal Prikladnoy Khimii (Leningrad), vol. 33, No. 6, June 1960, pp. 1434–1448.

[15] Pitman, Douglas T., and Das, Dilip K., A Study of the Thorium-Tungsten-Boron System: Jour. Electrochem. Soc., vol. 107, No. 9, September 1960, pp. 763–766.

[16] Ceramic Industry, Thorium Oxide: Vol. 74, No. 1, January 1960, p. 100.

[17] Chemical and Engineering News, vol. 38, No. 41, Oct. 10, 1960, p. 46.

[18] Chemical and Engineering News, vol. 38, No. 38, Sept. 19, 1960, p. 60.

[19] Winkler, J. V., Progress in Magnesium Alloys: Metal Progress, vol. 78, No. 4, October 1960, pp. 146–149.

[20] Thomas, D. G., Compere, E. L., and McBride, J. P., Thorium Oxide Suspensions: Nucleonics, vol. 18, No. 12, December 1960, pp. 104–110.

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Tin

By John E. Shelton [1] and John B. Umhau [2]

CONSUMPTION of tin in the United States increased 4 percent, with tinplate production at a record high. Imports of metallic tin, the lowest since 1951, fell 9 percent. Tinplate exports increased for the first time in 4 years. The average price of Straits tin in the United States was a fraction lower than in 1959.

World production of tin increased 11 percent but was exceeded by world consumption, which rose 12 percent to a new record. As a result of continued increased demand, export restrictions on participating tin-producing countries were removed under the International Tin Agreement. A new 5-year "Second International Tin Agreement" was signed by enough governments to bring it into force (July 1, 1961) upon ratification. Indonesian tin concentrate was diverted from the Netherlands to the Federation of Malaya and Singapore, and the United States. Tin mining and smelting in the Republic of the Congo were disrupted by unsettled conditions following its independence. West Germany ranked second as a world tin consumer, with the United Kingdom third for the first time in history. A light, thin tinplate was marketed to meet competition from other materials used to make cans.

TABLE 1.—Salient tin statistics

(Long tons)

	1951–55 (average)	1956	1957	1958	1959	1960
United States:						
Production:						
Mines	109.32				50	10
Smelter	[1] 28,391	17,631	1,564	(2)	(2)	(2)
Secondary	28,335	29,440	24,260	22,810	[3] 23,700	22,050
Imports for consumption:						
Metal	62,756	62,590	56,158	41,149	[3] 43,578	39,488
Ore (tin content)	26,867	16,688	94	5,440	10,773	14,026
Exports	805	890	1,531	1,341	1,371	857
Consumption:						
Primary	54,084	60,470	54,429	47,998	45,833	51,530
Secondary	31,036	29,854	28,078	24,587	31,540	29,030
Price: Straits tin New York, average cents per pound	106.21	101.26	96.17	95.09	102.01	101.40
World:						
Production:						
Mine	187,200	[3] 199,500	[3] 200,300	[3] 153,600	[3] 161,600	179,700
Smelter	189,600	199,100	195,100	[3] 158,400	[3] 156,300	193,500

[1] Includes tin content of alloys made directly from ores.
[2] Figures withheld to avoid disclosing individual company confidential data.
[3] Revised figure.

[1] Commodity specialist, Division of Minerals.
[2] Commodity-industry analyst, Division of Minerals.

LEGISLATION AND GOVERNMENT PROGRAMS

The Export Control Act of 1949, extended to June 30, 1962, governed the destination of tin shipments. Exports were under general license to the free world. On May 12, 1960, the Bureau of Foreign Commerce, U.S. Department of Commerce, included tin in a list of commodities which may be exported to the U.S.S.R. and its European satellites without applying for individual export licenses. Regulations administered by the Office of Export Supply, U.S. Department of Commerce, required a license for export of detinned tinplate and terneplate scrap and detinned cans. However, exports of tinplate and terneplate scrap and old tin cans were exempted from licensing.

The foreign assets control regulations of the U.S. Treasury Department prohibited the entry of Chinese tin. Tin of U.S.S.R. origin could enter the United States but required a license (none were issued) on the presumption that it might be of Chinese origin. Alloys that might include Chinese and/or U.S.S.R. tin also were prohibited.

The Office of Minerals Exploration (OME) offered financial assistance to the extent of 50 percent of total allowable costs for exploration of eligible domestic tin deposits.

Tin continued on the Department of Agriculture, Commodity Credit Corporation (CCC), list of materials eligible for acquisition for the Government supplemental stockpile through agricultural surplus barter transactions. At the end of 1960, 8,000 tons of tin was received or in transit from barter transactions.

The Lost River tin mine, Seward Peninsula, Alaska, was offered for sale (with bids opening August 8, 1960) by the General Services Administration (GSA) and awarded to Lenhart J. Grothe, Box 61, Red Devil, Alaska, on his high bid of $21,777.

On June 10 the U.S. Senate passed and sent to the House of Representatives a bill (S. 1957 and H.R. 7395) to promote domestic mine production of tin and authorize a Federal purchase program for tin. Purchases were to be limited to 10,000 long tons of tin-in-concentrate during a 10-year period, with base prices of $1.40 a pound for tin-in-concentrate from lode mines and $1.25 a pound for tin-in-concentrate from placer deposits. Purchase would include tin concentrate produced in the United States and possessions and the Commonwealth of Puerto Rico. The legislation was pending in the House Committee on Interior and Insular Affairs when the 86th Congress adjourned.

DOMESTIC PRODUCTION

MINE PRODUCTION

Domestic mines produced 10 long tons of tin, recovered as a byproduct of molybdenum in Colorado.

A map was published showing geographical locations of tin occurrences in Alaska.[3]

SMELTER PRODUCTION

Tin smelting continued on a small scale by Wah Chang Corp., Texas City, Tex. As in 1958 and 1959, the production-payment provisions of the contract of sale were administered by the Federal

[3] Cobb, E. H., Molybdenum, Tin, and Tungsten Occurrences in Alaska: Geol. Survey Miner. Investigations Res. Map MR-10.

Facilities Corp. (FFC). Under this program in fiscal 1960, FFC received $173,000 (mortgages repaid, $80,000; interest on mortgages, $43,000; and smelter production, $50,000).[4] On June 30, 1960, FFC held a note with a balance of $1,030,000 bearing interest at 4 percent a year, obtained from the sale of the tin smelter. Payment of $49,682 was made on 8,871 long tons of tin produced during the year ending April 22, 1960.

Wah Chang Corp. completed negotiations with the Indonesian Government for smelting approximately 8,500 tons of tin metal per year, at a reduced charge, during a 2-year period ending April 30, 1962. The modified sales contract between FFC and Wah Chang Corp. was further extended another year beginning April 23, 1960, so that the commitment to the Indonesian Government could be fulfilled. The audit division, GSA, verified that the tin smelter has been operating at a financial loss.[5]

SECONDARY TIN [6]

Secondary tin production decreased 7 percent to 22,000 long tons, the smallest quantity since 1938. Almost 85 percent was recovered from seven scrap items—drosses, composition or red brass, tinplate, bronze, railroad-car boxes, auto radiators, and solder. Tin from old scrap dropped for the fifth successive year to the lowest tonnage recorded. New scrap supplied 4 percent less than 1959. About half of the secondary tin was recovered in bronze and brass, which declined the most (1,675 tons). Next in rank was the tin reclaimed in solder which showed the largest gain (255 tons), after a 4-year downward trend. Tin in chemical compounds (mainly from tinplate scrap) rose 6 percent to the highest since 1941.

TABLE 2.—Secondary tin recovered from scrap processed at detinning plants in the United States

	1959	1960
Tinplate scrap treated [1] ..... long tons	702,875	684,247
Tin recovered in the form of:		
Metal ..... do	2,710	2,620
Compounds (tin content) ..... do	670	655
Total [2] ..... do	3,380	3,275
Weight of tin compounds produced ..... do	1,270	1,295
Average quantity of tin recovered per long ton of tinplate scrap used ..... pounds	10.77	10.72
Average delivered cost of tinplate scrap ..... per long ton	$33.12	$27.55

[1] Tinplate clippings and old tin-coated containers have been combined to avoid disclosing individual company confidential data.
[2] Recovery from tinplate scrap treated only. In addition, detinners recovered 281 long tons (296 tons in 1959) of tin as metal and in compounds from tin-base scrap and residues in 1960.

The quantity of tinplate scrap treated, reversing a 7-year upward trend, declined almost 3 percent to 684,250 tons. Lower recovery per ton of scrap (for the 14th consecutive year) continued to reflect treatment of a larger proportion of electrolytic tinplate carrying a thinner coating of tin.

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[4] Budget of the United States Government for the Fiscal Year Ending June 30, 1962, p. 283.
[5] U.S. General Accounting Office, Report to The Congress of the U.S. on Audit of Federal Facilities Corp., General Services Administration, Fiscal Year 1960, pp. 4–8.
[6] The assistance of Archie J. McDermid and Edith E. den Hartog is acknowledged.

TABLE 3.—Stocks, receipts, and consumption of new and old scrap and tin recovered in the United States in 1960

(Long tons)

Type of scrap and class of consumer	Gross weight of scrap: Stocks Jan. 1	Gross weight of scrap: Receipts	Gross weight of scrap: Consumption New	Gross weight of scrap: Consumption Old	Gross weight of scrap: Consumption Total	Gross weight of scrap: Stocks Dec. 31	Tin recovered: New	Tin recovered: Old	Tin recovered: Total
Copper-base scrap:									
Secondary smelters:									
Auto radiators (unsweated)	4,421	33,624	-------	35,702	35,702	2,343	------	1,535	1,535
Brass, composition or red	4,789	75,220	27,190	49,115	76,305	3,704	1,168	1,846	3,014
Brass, low (silicon bronze)	291	2,094	1,305	744	2,049	336	------	3	3
Brass, yellow	5,536	47,078	6,447	42,272	48,719	3,895	12	387	399
Bronze	2,001	25,596	5,871	19,530	25,401	2,196	454	1,551	2,005
Low-grade scrap and residues	4,572	23,353	17,500	7,003	24,503	3,422	20	------	20
Nickel silver	611	3,121	404	2,520	2,924	808	3	21	24
Railroad-car boxes	103	361	-------	327	327	137	------	15	15
Total	22,324	210,447	58,717	157,213	215,930	16,841	1,657	5,358	7,015
Brass mills: [1]									
Brass, low (silicon bronze)	2,888	17,999	17,999	-------	17,999	2,333	------	------	------
Brass, yellow	14,573	154,957	154,957	-------	154,957	14,081	5	------	5
Bronze	601	1,993	1,993	-------	1,993	381	96	------	96
Mixed alloy scrap	10,245	4,007	4,007	-------	4,007	7,628	7	------	7
Nickel silver	2,668	6,443	6,443	-------	6,443	2,307	------	------	------
Total	30,975	185,399	185,399	-------	185,399	26,730	108	------	108
Foundries and other plants: [2]									
Auto radiators (unsweated)	278	3,605	-------	3,683	3,683	200	------	165	165
Brass, composition or red	1,495	7,418	4,475	3,379	7,854	1,791	208	161	369
Brass, low (silicon bronze)	212	509	27	427	454	181	------	------	------
Brass, yellow	1,562	10,950	5,161	5,617	10,778	1,309	11	52	63
Bronze	1,251	2,124	960	1,370	2,330	957	76	107	183
Low-grade scrap and residues	1,610	6,103	1,584	5,582	7,166	583	------	------	------
Nickel silver	27	77	-------	80	80	33	------	1	1
Railroad-car boxes	2,255	42,602	-------	43,179	43,179	1,756	------	2,051	2,051
Total	8,690	73,388	12,207	63,317	75,524	6,810	295	2,537	2,832
Total tin from copper-base scrap	------	------	------	------	------	------	2,060	7,895	9,955
Lead-base scrap:									
Smelters, refiners, and others:									
Babbitt	1,109	13,072	-------	12,918	12,918	1,263	------	627	627
Battery lead plates	[3] 25,628	332,340	-------	341,756	341,756	16,212	------	358	358
Drosses and residues	15,065	73,333	71,987	-------	71,987	16,411	2,449	------	2,449
Solder and tinny lead	536	8,583	66	8,662	8,728	391	11	1,510	1,521
Type metals	964	22,212	-------	21,574	21,574	1,602	------	1,025	1,025
Total	[3] 43,302	449,540	72,053	384,910	456,963	35,879	2,460	3,520	5,980
Tin-base scrap:									
Smelters, refiners, and others:									
Babbitt	71	485	1	512	513	43	------	430	430
Block-tin pipe	16	387	1	380	381	22	1	377	378
Drosses and residues	496	3,238	3,161	-------	3,161	573	1,984	------	1,984
Pewter	28	54	-------	56	56	26	------	48	48
Total	611	4,164	3,163	948	4,111	664	1,985	855	2,840
Tinplate scrap:									
Detinning plants	------	------	684,247	------	684,247	------	3,275	------	3,275
Total tin recovered	------	------	------	------	------	------	9,780	12,270	22,050

[1] Lines in brass mills and total sections do not balance as stocks include home scrap and purchased scrap assumed to equal receipts.
[2] Omits "machine shop scrap."
[3] Revised figure.

TABLE 4.—Tin recovered from scrap processed in the United States, by form of recovery

(Long tons)

Form of recovery	1959 [1]	1960	Form of recovery	1959 [1]	1960
Tin metal:			Solder	4,260	4,515
At detinning plants	2,910	2,745	Type metal	1,630	1,610
At other plants	310	270	Babbitt	1,250	1,245
			Antimonial lead	350	325
Total	3,220	3,015	Chemical compounds	855	905
			Miscellaneous [2]	85	60
Bronze and brass:					
From copper-base scrap	11,550	10,045	Total	8,430	8,660
From lead and tin-base scrap	500	330	Grand total	23,700	22,050
			Value (thousands)	$54,156	$50,084
Total	12,050	10,375			

[1] Revised figures.
[2] Includes foil, cable lead, and terne metal.

CONSUMPTION

Total tin consumption in the United States increased 4 percent. Three items—tinplate, solder, and bronze and brass—consumed more than 80 percent of the tin in 1960. Consumption of tin in tinplate (the leading use of primary tin, which took 65 percent of the 1960 total) increased a record 7,960 long tons, despite sharply curtailed tin-mill operations during the closing months of 1960.

Of the total output of tinplate, electrolytic represented about 92 percent and hot-dipped 8 percent.

The United States required 47 percent (42 percent in 1959) of the world consumption of tin for tinplate. Nearly 90 percent of the tinplate was used for making cans, of which 61 percent was for the food pack and 39 percent for nonfood products. The tonnage of tinplate shipments to canmakers continued virtually unchanged; however, can shipments dropped 3 percent. Beer cans declined 4 percent

TABLE 5.—Consumption of primary and secondary tin in the United States

(Long tons)

	1951–55 (average)	1956	1957	1958	1959	1960
Stocks Jan. 1 [1]	24,715	27,757	28,446	32,030	30,003	35,521
Net receipts during year:						
Primary	54,428	62,099	59,215	46,553	51,269	50,661
Secondary	2,547	2,185	2,868	2,524	2,471	2,217
Terne	409					
Scrap	30,102	28,999	26,758	23,680	30,814	27,448
Total	87,486	93,283	88,841	72,757	84,554	80,326
Available	112,201	121,040	117,287	104,787	114,557	115,847
Stocks Dec. 31 [1]	23,895	28,446	32,030	30,003	35,521	33,459
Total processed during year	88,306	92,594	85,257	74,784	79,036	82,388
Intercompany transactions in scrap	2,386	2,270	2,750	2,199	1,663	1,828
Tin consumed in manufactured products	[2] 85,920	90,324	82,507	72,585	77,373	80,560
Primary	54,084	60,470	54,429	47,998	45,833	51,530
Secondary	31,036	29,854	28,078	24,587	31,540	29,030

[1] Stocks shown exclude tin in transit or in other warehouses on Jan. 1, as follows: 1951–55 (average), 886 tons; 1956, 2,005 tons; 1957, 1,815 tons; 1958, 1,310 tons; 1959, 1,940 tons; 1960, 1,900; 1961, 2,570 tons.
[2] Includes tin losses in manufacturing.

reversing an 8-year upward trend, but this quantity represented the second largest tonnage recorded for this item. Cans for fish and seafood, soft drinks, and pet foods reached new peaks in 1960.

TABLE 6.—Tin content of tinplate produced in the United States

Year	Tinplate (hot-dipped)			Tinplate (electrolytic)			Tinplate waste-waste, strips, cobbles, etc.	Total tinplate (all forms)		
	Gross weight (short tons)	Tin content (long tons)	Tin per short ton of plate (pounds)	Gross weight (short tons)	Tin content (long tons)	Tin per short ton of plate (pounds)	Gross weight (short tons)	Gross weight (short tons)	Tin content (long tons) [1]	Tin per short ton of plate (pounds)
1951-55 (average)	1,328,649	15,382	26.0	3,281,028	14,698	9.9	[3] 259,824	4,869,501	[2] 31,148	14.3
1956	1,006,196	13,041	29.0	4,305,774	21,720	11.3	377,091	5,689,061	34,761	13.7
1957	686,616	8,370	27.3	4,593,587	23,676	11.6	435,181	5,715,384	32,046	12.6
1958	476,697	5,793	27.2	4,489,275	23,343	11.7	401,126	5,367,098	29,136	12.2
1959	396,739	4,685	26.5	3,997,171	20,590	11.5	374,130	4,768,040	25,275	11.9
1960	454,808	5,443	26.8	5,300,277	27,795	11.8	495,536	6,250,621	33,238	11.9

[1] Includes small tonnage of secondary pig tin and tin acquired in chemicals.
[2] Includes 1,068 long tons in tinplate waste-waste, strips, and cobbles through June 1954, thereafter not separately reported.
[3] Not reported during January-June 1954.

TABLE 7.—Consumer receipts of primary tin, by brands

(Long tons)

Year	Banka	English	Katanga	Longhorn	Straits	Others	Total
1951-55 (average)	3,316	4,017	4,171	7,234	32,937	2,753	54,428
1956	7,190	3,373	6,341	----------	43,468	1,727	62,099
1957	6,897	3,726	3,154	----------	41,460	3,978	59,215
1958	8,785	4,779	2,143	----------	25,999	4,847	46,553
1959	8,369	10,537	595	----------	24,496	7,272	51,269
1960	10,065	1,635	1,546	----------	31,355	6,060	50,661

TABLE 8.—Consumption of tin in the United States, by finished products

(Long tons of contained tin)

Product	1959			1960		
	Primary	Secondary[1]	Total	Primary	Secondary[1]	Total
Alloys (miscellaneous)	309	138	447	260	141	401
Babbitt	2,157	1,981	4,138	1,841	1,780	3,621
Bar tin	1,174	243	1,417	894	216	1,110
Bronze and brass	3,868	13,241	17,109	3,350	11,986	15,336
Chemicals including tin oxide	790	1,043	1,833	648	1,284	1,932
Collapsible tubes and foil	930	113	1,043	788	127	915
Pipe and tubing	79	40	119	35	43	78
Solder	7,046	12,986	20,032	6,660	11,618	18,278
Terne metal	58	242	300	132	337	469
Tinning	2,057	74	2,131	1,996	39	2,035
Tinplate[2]	25,275		25,275	33,238		33,238
Type metal	129	1,263	1,392	98	1,333	1,431
White metal	1,764	142	1,906	1,452	90	1,542
Other	197	34	231	138	36	174
Total	45,833	31,540	77,373	51,530	29,030	80,560

[1] Includes 3,045 long tons of tin contained in imported 94/6 tin-base alloys in 1959 and 3,090 in 1960; also tin content of alloys imported under the category of "Babbitt metal and solder."
[2] Includes small tonnage of secondary pig tin and tin acquired in chemicals.

STOCKS

Tinplate mills, holding nearly 65 percent of plant stocks of pig tin in the United States, decreased inventories 3,400 long tons. At the end of the year, pig-tin stocks at other industrial plants were 1,440 tons greater.

On December 31, 1960, GSA held 6,107 long tons of tin in the supplemental stockpile, obtained largely through the CCC barter program. The additional tonnage in the national stockpile may not be disclosed. GSA sold the 537 long tons of Copan which had been held in the Government's inventory of defense material.

TABLE 9.—U.S. industry tin stocks

(Long tons)

	1951–55 (average)	1956	1957	1958	1959	1960
Plant raw materials:						
Pig tin:						
Virgin	12,782	16,290	20,126	18,173	22,830	20,881
Secondary	299	304	327	281	270	257
In process[1]	10,814	11,852	11,577	11,549	12,421	12,321
Total	23,895	28,446	32,030	30,003	35,521	33,459
Additional pig tin:						
In transit in United States	1,016	1,815	1,310	1,940	1,900	2,570
Jobbers-importers	467	620	660	1,050	1,945	1,090
Afloat to United States	3,887	5,500	1,735	1,660	1,855	2,990
Total	5,370	7,935	3,705	4,650	5,700	6,650
Grand total	29,265	36,381	35,735	34,653	41,221	40,109

[1] Tin content, including scrap.

PRICES

The tin market in 1960 remained comparatively steady, mainly reflecting activity of the International Tin Council and operations of the buffer-stock manager. The price range was the smallest since 1904 (except for Government price stabilization during World War II).

On the London market the cash price averaged £796.7 per long ton against £785.4 in 1959. After the high of £799 on November 10, 1959, the price receded to the low of £780.8 on May 30. From this point an upward trend developed until July 21, when the price reached £823.3, the high for 1960. This was followed by a slight downturn and subsequent market efforts to gain increased strength. Cash tin was at a modest premium over 3-month tin, reflecting scarcity of nearby metal available for trading on the market.

On the Singapore market the price of Straits tin ex-works was £775.1 (£781.6 for 1959). The lowest quotation was £755.1 on May 3 and the highest £808.8, on August 2, 3, and 4.

TABLE 10.—Monthly prices of Straits tin for prompt delivery in New York

(Cents per pound)

Month	1959			1960		
	High	Low	Average	High	Low	Average
January	100.625	98.000	99.351	100.500	99.250	99.850
February	104.875	100.875	102.708	101.875	100.375	100.974
March	104.375	101.875	103.030	100.750	99.625	100.092
April	102.875	102.125	102.500	99.625	98.875	99.244
May	104.000	102.500	103.044	100.125	98.875	99.542
June	104.750	103.250	104.153	102.000	100.123	101.307
July	103.000	101.625	102.310	104.750	102.250	103.494
August	103.000	101.500	102.327	104.625	101.000	102.853
September	102.875	101.875	102.429	102.625	101.750	102.232
October	103.375	101.500	102.202	103.750	102.875	103.275
November	101.625	100.000	100.958	103.375	102.000	102.822
December	99.750	98.500	99.131	102.000	100.250	101.143
Total	104.875	98.000	102.012	104.750	98.875	101.402

Source: American Metal Market.

FOREIGN TRADE [7]

The principal tin items in the foreign trade of the United States in 1960 were imports of metallic tin, high-tin alloys, and tin concentrates and exports of tinplate and tin cans. Of less importance was the trade in tin scrap, including tin-alloy scrap, tinplate scrap, and tinplate circles, cobbles, strip, and scroll. Significant quantities of tin ingot, miscellaneous tin manufactures, and tin compounds was exported. Tin contained in babbitt, solder, type metal, and bronze imported and exported is shown in the Lead and Copper chapters. Ferrous scrap exports include tinplate and terneplate scrap not separately classified.

[7] Figures on U.S. imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 11.—U.S. imports for consumption of tin concentrate (tin content), by countries

Country	1959		1960	
	Long tons	Value	Long tons	Value
Argentina	(1)	$137	(1)	$152
Bolivia	106	145,871	117	151,366
Indonesia	7,946	17,994,804	12,509	28,003,464
Malaya, Federation of	6	11,839		
Mexico	100	164,908	64	134,901
Thailand	2,615	4,964,847	1,336	2,813,899
Total	10,773	23,282,406	14,026	31,103,782

[1] Less than 1 ton.

Source: Bureau of the Census.

TABLE 12.—U.S. imports for consumption of tin,[1] by countries

Country	1959		1960	
	Long tons	Value (thousands)	Long tons	Value (thousands)
Belgium-Luxembourg	705	$1,571	1,601	$3,572
Bolivia	325	711	939	2,015
Canada	(2)	(3)	(2)	2
Congo, Republic of,[4] and Ruanda-Urundi	850	1,684	336	752
Germany, West	40	87	10	22
Indonesia	200	438	550	1,253
Malaya, Federation of and Singapore	22,404	50,181	29,521	64,728
Netherlands	2,820	6,198	432	962
Portugal	[5] 541	[5] 1,156	225	502
United Kingdom	15,693	34,829	5,874	12,413
Total	[5] 43,578	[5] 96,855	39,488	86,221

[1] Bars, blocks, pigs, grain, or granulated.
[2] Less than 1 ton.
[3] Less than $1,000.
[4] Effective July 1, 1960; formerly Belgian Congo.
[5] Revised figure.

Source: Bureau of the Census.

TABLE 13.—U.S. exports of tin; imports for consumption and exports of tinplate, and terneplate in various forms

Year	Ingots, pigs, and bars				Tinplate and terneplate		Tinplate circles, strips, and cobbles	Tinplate scrap
	Exports		Reexports		Imports	Exports	Exports	Imports
	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Long tons	Long tons	Long tons
1951–55 (average)	244	$522	561	$1,441	643	[1] 575,412	23,394	37,949
1956	439	821	451	1,018	586	648,517	21,858	29,137
1957	1,112	1,526	419	919	40	625,666	19,531	31,431
1958	917	1,336	424	899	51	331,813	15,728	32,824
1959	943	1,890	428	970	59,811	328,888	15,082	37,151
1960	608	1,294	249	549	17,612	504,942	20,491	36,402

[1] Owing to changes in classifications, data for 1951 not strictly comparable to other years.

Source: Bureau of the Census.

TABLE 14.—U.S. imports for consumption and exports of miscellaneous tin, tin manufactures, and tin compounds

Year	Miscellaneous tin and manufactures						Tin compounds	
	Imports			Exports				
	Tinfoil, tin powder, flitters, metallics, tin and manufactures, n.s.p.f. (value) (thousands)	Dross, skimmings, scrap, residues, and tin alloys, n.s.p.f.		Tin cans, finished or unfinished		Tin scrap and other tin-bearing material, except tinplate scrap (value) (thousands)	Imports (long tons)	Exports (long tons)
		Long tons	Value (thousands)	Long tons	Value (thousands)			
1951-55 (average)	[1] $553	5,688	[2] $10,198	31,001	$13,269	[3] $2,538	11	93
1956	[1] 605	5,073	[2] 9.430	30,502	13,245	2,324	10	167
1957	[1] 561	5,077	9,485	30,166	14,309	3,911	10	218
1958	610	3,208	5,771	35,849	18,322	992	11	(4)
1959	1,008	[5] 3,350	[5] 6,469	36,320	19,027	1,231	6	(4)
1960	839	809	1,642	32,875	17,362	1,355	3	(4)

[1] Data known to be not comparable with other years.
[2] Data for 1955-56 known to be not comparable to other years.
[3] Owing to changes in classifications, data for 1951 not strictly comparable to later years.
[4] Beginning Jan. 1, 1958, not separately classified.
[5] Revised figure.

Source: Bureau of the Census.

WORLD REVIEW

INTERNATIONAL TIN AGREEMENT

The International Tin Agreement entered its fifth and last year. The buffer-stock manager's special authority to operate on the market in the middle range at £780–£830 (97.50–103.75 cents a pound) was withdrawn effective July 1, 1960. Export restrictions first imposed December 15, 1957, were removed beginning October 1, 1960. The annual tonnage limit on U.S.S.R. tin exports was suspended after September 30. A United Nations Tin Conference approved the text of a new 5-year "Second International Tin Agreement". By December 31, 1960, enough governments had signed to bring it into force on July 1, 1961, upon ratification.

The established permissible buffer stock of 25,000 long tons of tin metal or equivalent in cash included 10,050 long tons of tin metal on December 31, 1959, and 10,030 long tons on March 30, June 30, September 30, and December 31, 1960. The entire United Kingdom strategic stockpile of tin had been liquidated by March 31, 1960. In March the Government of Italy notified the Council that it intended to gradually dispose of 2,500 tons of noncommercial tin stocks, held by the Government of Italy, within the domestic Italian market. Disposal began in September. None of the 3,000 tons of Canadian noncommercial tin stocks was turned over to the buffer-stock manager for sale in 1960.

TABLE 15.—International Tin Agreement export control

Producing country	Vote			Percent allotted		Export amount (by control periods) (long tons) Jan. 1, 1960–Sept. 30, 1960		
	(1)	(2)	(3)	(4)	(2)	Ninth [5]	Tenth [6]	Eleventh [2]
Congo, Republic of the	93	94	82	9.05	9.17	3,258	3,394	3,004
Ruandi-Urundi			16					435
Bolivia	193	184	183	19.40	18.43	6,984	7,275	6,911
Indonesia	188	189	188	18.90	19.00	6,804	7,087	7,125
Malaya, Federation of	371	376	374	37.75	38.20	13,590	14,156	14,325
Nigeria	64	65	65	6.10	6.20	2,196	2,288	2,325
Thailand	91	92	92	8.80	9.00	3,168	3,300	3,375
Total	1,000	1,000	1,000	100.00	100.00	36,000	37,500	37,500

[1] International Tin Council, 1959 Statistical Yearbook, p. 9, for July 1959–June 1960.
[2] Percentages and votes for July 1960–June 1961; and export amount, July 1–Sept. 30, 1960, fixed at 22d meeting, May 2–3, 1960. Council's estimate of likely actual exports given at 36,300 tons. At 24th meeting, Aug. 25, 1960, separate percentages established at 8.01 for Republic of the Congo and 1.16 for Ruanda-Urundi.
[3] Reallocated at 24th meeting, Aug. 25, 1960, for July 1960–June 1961.
[4] Fixed at 18th meeting, May 26–29, 1959, for July 1959–June 1960.
[5] Jan. 1–Mar. 31, 1960. Fixed at 20th meeting, Dec. 1–4, 1959.
[6] Apr. 1–June 30, 1960. Fixed at 21st meeting, Mar. 8–9, 1960. Council's estimate of actual exports given as 35,300 tons.

TABLE 16.—International Tin Agreement exports in control periods [1]

(Long tons)

Producing country	1959				1960		
	Fifth	Sixth	Seventh	Eighth	Ninth	Tenth	Eleventh
Congo, Republic of the } Ruanda-Urundi	1,789	2,059	2,267	2,676	3,249	3,088	3,373
							551
Bolivia	4,165	4,527	4,783	5,184	3,848	5,345	4,818
Indonesia	3,853	4,496	4,666	5,706	6,814	7,115	7,084
Malaya, Federation of	7,458	8,535	9,449	11,421	13,249	14,534	14,188
Nigeria	1,182	1,359	1,524	1,828	2,205	2,066	2,175
Thailand	1,626	1,919	2,235	2,452	3,213	2,957	3,252
Total exports	20,073	22,895	24,924	29,267	32,578	35,105	35,441
Total permitted	20,000	23,000	25,000	30,000	36,000	37,500	37,500

[1] Figures represent exports reported in accordance with definitions as to point of export in the International Tin Agreement and are therefore different from standard trade statistics.

TABLE 17.—International Tin Agreement voting power of consuming countries

Country	At 18th meeting,[1] 1959–60	At 22d meeting,[2] 1960–61	Country	At 18th meeting,[1] 1959–60	At 22d meeting,[2] 1960–61
Australia	32	40	Israel	7	7
Austria	13	14	Italy	58	64
Belgium	40	41	Korea, Republic of	6	6
Canada	60	65	Netherlands	51	38
Denmark	73	88	Spain	11	11
France	174	189	Turkey	13	15
India	61	70	United Kingdom	401	352
			Total	1,000	1,000

[1] May 26–29, 1959.
[2] May 2–3, 1960.

The International Tin Council met five times in 1960. At a meeting in March, total permissible exports were set at 37,500 tons for the control period April 1 to June 30, the fifth successive increase. The Council extended to the end of June its authority to the buffer-stock manager to operate within the middle range between £780 to £830 per ton.

At a meeting, May 2–3, the total permissible exports for the control period July 1 to September 30 were again fixed at 37,500 tons. New percentages and votes of participating countries were approved for the year beginning July 1, 1960. Authority granted the buffer-stock manager on previous occasions to operate within the £780 to £830 range was not renewed.

At a New York meeting on June 23, recommendation was made to member governments that at the end of the present agreement a new agreement should be entered into in the form considered and approved at the United Nations Tin Conference in New York during May and June.

At meetings on August 25, and on December 5–7, the Council decided not to fix total permissible export quantities for the quarterly periods beginning October 1, 1960, and January 1, 1961. The December meeting gave approval to an interim committee established to facilitate the coming into force of the second agreement.

The United Nations Tin Conference, May 23 to June 24, 1960, approved the text of a new agreement to supersede the one expiring June 30, 1961. The new agreement was open for signature in London from September 1 to December 31, 1960, subject to ratification under constitutional procedures of the signatory governments on or before June 30, 1961. Before entering into force (July 1, 1961) the agreement needed to be ratified by at least nine tin-consuming countries with 500 votes and by six tin-producing countries with 950 votes. Representation at the Tin Conference included delegates from 23 countries; 12 other nations, including the United States, participated as observers.

By December 31, 1960, the second agreement had been signed by governments of 7 producing countries with a total of 1,000 votes and by 14 consuming countries with more than 833 votes. These signatures were enough to bring the agreement into force upon ratification. The producing countries signing were: Bolivia, Republic of the Congo, Indonesia, Federation of Malaya, Nigeria, Ruanda-Urandi, and Thailand. The consuming countries signing included: Australia, Austria, Belgium, Canada, Denmark, France, India, Italy, Japan, Mexico, Netherlands, Spain, Turkey, and United Kingdom.

Of the 10,000 tons of tin programed for acquisition by CCC barter transactions up to December 31, 1960, a total of 7,700 tons exempt from export restrictions had been moved from the Republic of the Congo and Ruanda-Urundi (700 tons), Bolivia (5,000 tons), and Thailand (2,000 tons). The Council had approved barter arrangements through 1960 for 9,234 long tons of tin as follows: Bolivia, 6,000; Thailand, 2,250; Republic of the Congo and Ruanda-Urundi, 984 tons.

TABLE 18.—World mine production of tin (content of ore), by countries [1]

(Long tons)

Country	1951-55 (average)	1956	1957	1958	1959	1960
North America:						
Canada	181	338	317	355	334	230
Mexico	442	500	473	544	377	365
United States	109	----------	----------	----------	50	10
Total	732	838	790	899	761	605
South America:						
Argentina	167	85	182	205	225	[2] 225
Bolivia (exports)	31,332	26,843	27,794	17,731	23,811	19,406
Brazil	190	175	293	409	462	[2] 500
Peru	----------	3	14	30	42	[2] 40
Total	31,689	27,106	28,283	18,375	24,540	20,171
Europe:						
Czechoslovakia [3]	200	200	200	200	200	200
France	369	433	445	----------	----------	----------
Germany, East	511	[2] 660	[2] 670	[2] 720	[2] 720	[2] 720
Portugal	1,354	1,169	1,127	1,249	1,129	663
Spain	959	550	491	467	326	190
U.S.S.R. [4 5]	9,400	11,800	13,000	13,500	15,000	16,500
United Kingdom	964	1,044	1,028	1,087	1,252	1,199
Total [2 5]	13,800	15,900	17,000	17,200	18,600	19,500
Asia:						
Burma	1,204	1,300	1,100	1,300	1,300	[2] 1,100
China [4]	10,300	20,000	23,000	23,000	26,000	28,000
Indonesia	33,808	30,053	27,723	23,201	21,616	22,607
Japan	682	926	949	1,108	998	854
Laos	175	254	274	301	294	[2] 360
Malaya	58,439	62,295	59,293	38,458	37,525	51,979
Thailand	9,981	12,481	13,528	7,720	9,526	12,080
Total [2 5]	114,600	127,300	125,900	95,100	97,300	117,000
Africa:						
Congo, Republic of the (formerly Belgian) and Ruanda Urundi	14,574	14,764	14,253	11,214	10,319	[2] 10,109
Cameroun, Republic of	82	85	71	75	65	69
Congo, Republic of	----------	----------	----------	26	32	[2] 40
Morocco: Southern zone	11	5	8	6	9	10
Niger, Republic of	79	56	50	61	57	[2] 60
Nigeria	8,232	9,067	9,534	6,200	5,541	7,675
Rhodesia and Nyasaland, Federation of	69	354	283	534	665	705
South-West Africa	232	475	636	161	5	255
Swaziland	33	29	25	15	5	6
Tanganyika (exports)	46	15	14	19	65	138
Uganda	94	33	40	41	36	32
Union of South Africa	1,131	1,442	1,463	1,416	1,272	1,276
Total	24,583	26,300	26,377	19,768	18,071	20,375
Oceania: Australia	1,763	2,078	1,952	2,237	2,350	[2] 2,000
World total (estimate)	187,200	199,500	200,300	153,600	161,600	179,700

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] Estimated by authors of the chapter and in a few instances from the Statistical Bulletin of the International Tin Council, London, England.
[3] Estimate, according to the 47th annual issue of Metal Statistics (Metallgesellschaft) through 1959.
[4] Estimated smelter production.
[5] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.

Compiled by Augusta W. Jann, Division of Foreign Activities.

TABLE 19.—World smelter production of tin, by countries [1]

(Long tons)

Country	1951-55 (average)	1956	1957	1958	1959	1960
North America:						
Mexico	259	218	207	460	[2] 240	[2] 240
United States	28,391	17,631	1,564	[3] 5,440	[3] 10,773	[3] 14,026
Total	28,650	17,849	1,771	5,900	11,013	14,266
South America:						
Argentina	136	61	39			
Bolivia (exports)	155	421	266	705	955	1,468
Brazil	767	1,544	1,401	629	2,953	[2] 3,000
Peru	23		3	10	15	
Total	1,081	2,026	1,709	1,344	3,923	4,468
Europe:						
Belgium	9,959	9,716	9,869	8,723	5,945	7,947
Germany:						
East	513	[2] 600	[2] 600	[2] 600	[2] 600	[2] 600
West	463	683	955	646	1,010	[2] 742
Netherlands	26,170	28,197	29,259	17,098	9,592	6,393
Portugal	561	1,127	1,072	1,259	1,167	598
Spain	749	576	783	449	323	299
U.S.S.R. [2] [4]	9,400	11,800	13,000	13,500	15,000	16,500
United Kingdom	28,149	26,434	34,174	32,551	27,229	27,404
Total [2] [4]	76,000	79,100	89,700	74,800	60,900	60,500
Asia:						
China [2]	10,300	20,000	23,000	23,000	26,000	28,000
Indonesia	802	300	322	[2] 600	[2] 600	[5] 1,800
Japan	772	1,105	1,260	1,307	1,308	1,261
Malaya	66,590	73,263	71,289	45,336	45,729	76,130
Total [2] [4]	78,500	94,700	95,900	70,200	73,600	107,200
Africa:						
Congo, Republic of the (formerly Belgian)	2,797	2,772	3,105	2,642	3,291	[2] 3,513
Morocco: Southern zone	6	[2] 12	[2] 12	[2] 12	[2] 12	[2] 12
Rhodesia and Nyasaland, Federation of	34	12	253	503	631	671
Union of South Africa	830	756	825	901	726	622
Total	3,667	3,552	4,195	4,058	4,660	4,818
Oceania: Australia	1,734	1,850	1,806	2,121	2,226	[2] 2,213
World total (estimate)	189,600	199,100	195,100	158,400	156,300	193,500

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] Estimated by authors of the chapter and in a few instances from the Statistical Bulletin of the International Tin Council, London, England.
[3] Imports into the United States of tin concentrates (tin content).
[4] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.
[5] Estimated exports.

Compiled by Augusta W. Jann, Division of Foreign Activities.

REVIEW BY COUNTRIES

Australia.—Tableland Tin Dredging, N.L., North Queensland, the leading tin producer, suspended operations in November because of unprecedented drought conditions. Tin consumption in Australia was 3,810 long tons, against 3,540 tons in 1959; tinplate required 1,495 tons in 1960 and 1,200 tons in 1959. The Port Kembla mill, in its third year of operation, produced 101,620 tons of tinplate (80,230 in 1959), and the output of 9,020 tons in November equaled mill capacity. The company planned to increase the annual capacity of the mill to 272,000 tons. In addition, an electrolytic tinning line, which is to begin production in 1962, was being built.

Tinplate production supplied 60 percent of domestic requirements in 1960. Most of the remainder was acquired from the United Kingdom and the United States. Receipts of tinplate from the United States increased to 19,100 long tons, the highest since 1956.

Bolivia.—Exports of tin-in-concentrate and ore totaled 19,406 tons valued at $42.8 million, a decrease of 19 percent in value and tonnage compared with 1959. Except for 1958, the quantity was the smallest since 1933. Tin represented 72 percent of the gross value of Bolivian minerals exported in 1960. Tin production in nationalized mines dropped for the 7th consecutive year.

TABLE 20.—Bolivia: Tin production by nationalized mines

(Long tons of contained tin)

Mine	1959	1960	Mine	1959	1960
Caracoles	580	713	Oploca-Santa Ana	9	25
Catavi	5,194	4,666	San Jose	813	831
Chorolque	466	585	Santa Fe	628	653
Colavi	96	108	Tasna	312	410
Colquechaca	7	46	Unificada	882	906
Colquiri	3,509	2,811	Viloco	186	268
Huanuni	2,563	2,627	Others	12	23
Japo	90	82			
Morococala	209	236	Total	15,556	14,990

Source: U.S. Embassy, La Paz, Bolivia, from data furnished by Corporation Minera de Bolivia.

TABLE 21.—Bolivia: Exports of tin by groups

(Long tons of contained tin)

Group	1953–57 (average)	1958	1959	1960
Corporation Minera de Bolivia [1]	24,562	13,852	17,590	12,677
Banco Minero:				
Medium mines	4,428	3,173	5,410	2,393
Small mines				2,868
Smelter (tin metal)	251	705	811	1,468
Total	29,241	17,730	23,811	19,406

[1] Decree of October 31, 1952, nationalized the major producers of tin, namely, Patino Mines & Enterprises Inc., Compagnie Aramayo de Mines en Bolivie, and Maurico Hocschild, S.A.M.I., included in this group.

Source: Departmento de Estadistica—Direccion General de Minas, Ministeno de Mines y Petroleo.

TABLE 22.—Bolivia: Exports of tin by countries

(Long tons of contained tin)

Destination	1959	1960	Destination	1959	1960
Argentina	414	3	Peru	9	---------
Brazil	162	954	Switzerland	35	---------
Chile	---------	9	United Kingdom	15,804	16,088
Germany, West	1,126	924	United States	6,021	1,373
Japan	4	---------			
Mexico	186	36	Total	23,811	19,406
Netherlands	50	19			

Source: Departmento de Estadistica—Direccion General de Minas, Ministeno de Mines y Petroleo.

Congo, Republic of the.—Operations were suspended in September at the properties of Compagnie Geologique et Miniera des Ingénieurs et Industriels Belges (Geomines) at Manono, swept by tribal revolt and armed clashes. Communication was irregular during the latter part of 1960, and firm information was lacking on tonnages produced and exported. However, in the Kivu-Maniema district, where the main tin deposits occur, Symetain-Societe Congolaise (the largest tin producer), Compagnie Belge d'Enterprises Minieries (Cobelmin), and others maintained operations. Tin-ore stocks accumulated as shipments were disrupted.

Indonesia.—Tin output rose 5 percent but, except for 1959, was the lowest since 1947. The islands of Banka, Billiton, and Singkep furnished 60, 31, and 9 percent, respectively, of the total.

Tin exports totaled 26,830 tons in 1960. Exported tin-in-concentrate was 25,065 tons; 12,165 went to the United States. The movement of 9,895 tons to Malaya-Singapore began in May, and 3,005 tons was shipped, "London option", until March. Shipments to the Netherlands were stopped. The remaining 1,765 tons as metal was exported to Belgium, Japan, United Kingdom, and United States.

Malaya, Federation of.—Of the total mine production of 51,980 long tons, 64 percent came from European mines (mostly dredges) and 36 percent from Asian mines (mostly by gravel pumps), including 2 percent from dulang washing. European mines produced 33,505 long tons (22,645 in 1959), and Asian mines 18,475 (14,880 in 1959). Gains in output over 1959 were made by all methods of mining, with the largest by dredging (9,150 tons) and by gravel pumps (3,930 tons). The use of the hydrocyclonic jig improved recovery by gravel pump mines. Export duties on tin were M$55.2 million, compared with M$35.5 million in 1959. In December the Government announced an increase in the export duty on tin effective January 1, 1961. The duty was on a sliding scale when tin prices exceed M$388.5 per picul. The new increase was equal to a 5-percent addition when prices are at M$400 per picul (the maximum on the scale). The state of emergency (antiguerrilla activities), in force since July 1948, was declared ended on July 31, 1960.

Active mines totaled 483 at the beginning of 1960, compared with 591 at the end of the year. Dredges increased from 45 to 69, and gravel-pump units rose from 392 to 470. The labor force was 29,242 on December 31, 1960, against 23,778 on December 31, 1959.

Permitted exports of tin under the International Tin Agreement were 42,071 tons from January 1 to September 31, 1960. During this period, tin exports as defined by the agreement totaled 41,971 tons. Tin-in-concentrate delivered to smelters was 57,470 tons (36,863 in 1959).

The principal world source of tin continued to be the large plants of the Eastern Smelting Co., Ltd., on the island of Penang and the Straits Trading Co., Ltd., at Pulau Brani, Singapore, and Butterworth, Province Wellesley. Concentrate treated was derived mostly from the Federation of Malaya, Thailand, and Indonesia. Total tin-in-concentrate available for the Federation smelters was 72,440 tons (45,530 in 1959, revised). Smelter production was the highest since 1941. Bulk smelting of Indonesian concentrate, discontinued in 1934, resumed in 1960 with receipt of nearly 10,000 tons diverted from the Netherlands. Exports of tin metal, the highest since 1950, were almost entirely from Penang.

Stocks of tin metal decreased from 3,288 tons at the beginning of 1960 to 2,967 tons at yearend. Tin-in-concentrate (including mine stocks) declined from 11,851 tons at the beginning to 9,697 at the end of the year.

TABLE 23.—Malaya: Exports of tin-in-metal, by countries

(Long tons)

Destination	1959	1960	Destination	1959	1960
Argentina	899	1, 830	Japan	8, 566	10, 796
Australia-New Zealand	1, 530	2, 049	Netherlands	231	806
Belgium		5, 280	United Kingdom	102	2, 815
Canada	1, 020	2, 040	United States	22, 845	29, 616
Denmark		500	Yugoslavia		575
France	382	2, 961	Others	2, 743	3, 380
Germany, West	110	6, 831			
India	3, 617	3, 263	Total	44, 673	76, 367
Italy	2, 628	3, 625			

Source: Federation of Malaya, Department of Statistics, Monthly Statistical Bulletin: March 1961.

TABLE 24.—Malaya: Imports of tin-in-concentrate, by countries

(Long tons)

Country	1959	1960	Country	1959	1960
Burma	1, 365	1, 394	Other countries	167	119
Indonesia		9, 695			
Laos	386	445	Total	8, 532	21, 512
Thailand	6, 614	9, 859			

Nigeria.—Nigeria produced 10,370 long tons of tin concentrate (7,488 in 1959) averaging 74 percent tin. The entire tin-in-concentrate exports, totaling 8,500 tons (5,583 in 1959), went to the United Kingdom. Stocks of tin-in-concentrate at mines dropped from 1,076 tons at the beginning of 1960 to about 500 tons at yearend. Columbium was produced as a byproduct or coproduct of tin mining in Nigeria.

In the year ending March 31, 1960, Nigeria's largest tin producer—Amalgamated Tin Mines of Nigeria, Ltd.—reported treating over 9 million cubic yards, compared with 7.6 million in the preceding year. The value of the ground worked dropped from 0.775 pound to 0.75 pound of cassiterite per cubic yard.

The output (in long tons) was obtained by the following methods:

Method:	*Cassiterite*	*Columbite*
Jig plants	683	214
Dragline washing plants	667	24
Gravel pumps and elevators	964	68
Contractors	706	82
Mill tailing treatment	81	29
	3, 101	417

Plans were made to build tin smelting plants on the Jos Plateau in northern Nigeria by Nigerian Embel Tin Smelting Co., Ltd. (Portuguese) and Makeri Smelting Co. (formed in Nigeria by Conslidated Tin Smelters, Ltd.).

On October 1, 1960, Nigeria became independent of British rule and was recognized as a member of the British Commonwealth of Nations.

Thailand.—Tin was the most important mineral resource of Thailand and ranked third as a major export, being exceeded in value only by rice and rubber. The new bucket dredge (the largest in Thailand) of the Tongah Harbor Tin Dredging Co. began offshore operations in February 1960. Shipments to the United States included 93 tons (1,858 tons in 1959) under CCC barter transactions in exchange for tobacco. West Germany was the destination of 30 long tons of tin-lead alloy in 1960.

TABLE 25.—Thailand: Exports of tin-in-concentrate, by countries

(Long tons)

Destination	1959	1960	Destination	1959	1960
Brazil	1,062	752	Netherlands	10	446
Germany, West	9	----------	Portugal	----------	52
Japan	43	41	United States	1,947	542
Malaya, Federation of	6,809	7,058			
Mexico	14	20	Total	9,894	8,911

U.S.S.R.—The annual tonnage limit on U.S.S.R. tin exports, reached by an understanding between U.S.S.R. and the International Tin Council, was suspended after September 30,1960. U.S.S.R. imports from China were 20,500 long tons in 1959 and 20,000 (estimated) in 1960.

TABLE 26.—Sino-Soviet Bloc: Shipments of tin metal

(Long tons)

Source and destination	1959	1960	Source and destination	1959	1960
From USSR to:			From China to—Continued		
Austria	----------	225	Japan	----------	[1] 118
Burma	20	----------	Netherlands	786	909
Denmark	----------	13	Sweden	321	----------
Finland	409	----------	Switzerland	144	58
France	158	135	United Arab Republic	226	----------
Germany, West	3,222	3,584	United Kingdom	21	300
Iceland	7	----------	Yugoslavia	197	200
India	443	596			
Italy	----------	322	Total	3,597	4,602
Japan	315	766			
Netherlands	6,321	492	From Poland to:		
Sweden	20	----------	Austria	10	----------
Switzerland	51	17	Germany, West	100	162
United Arab Republic	362	----------	Netherlands	329	----------
Uruguay	2	----------	Sweden	50	----------
United Kingdom	450	896	United Kingdom	94	----------
Yugoslavia	579	466			
			Total	583	162
Total	12,359	7,512			
			From Hungary to:		
From China to:			Netherlands	49	----------
Canada	54	----------	Austria	20	----------
Finland	45	----------			
France	100	----------	Total	69	----------
Germany, West	1,413	2,932			
Hong Kong	90	85	Grand total	16,608	12,276
India	200	----------			

[1] From North Viet-Nam.

Source: Statistical Bulletin of the International Tin Council.

United Kingdom.—Mine production of 1,200 long tons of tin was derived principally from 660 tons of black tin (65 percent) produced in Cornwall, England, by Geevor Tin Mines, Ltd., and 860 tons (70 percent) by South Crofty, Ltd.

The United Kingdom ranked second as a free world smelter of tin ore, third as a consumer of pig tin, and second as a producer of tinplate. Most of the tin concentrate treated was from Bolivia and Nigeria, with receipts dropping to the lowest tonnage since 1947. A pronounced increase in tin consumption caused West Germany to become the world's second largest consumer, outranking the United Kingdom, in third place, for the first time. Primary tin consumption by the United Kingdom was 22,550 long tons (21,000 in 1959), of which half was for making tinplate. Tinplate production gained for the eighth consecutive year and totaled 1.19 million long tons, 12 percent more than 1959 (1,068,600) and the largest on record. Of the 1960 output, 64 percent was electrolytic and 36 percent hot-dipped. About 41 percent of the tinplate, 448,500 long tons, was exported in 1960. Sharp decreases in shipments to India and the United States were more than offset by gains in exports to South America, South Africa, Europe and unspecified destinations. The United States took 11,540 long tons in 1960, compared with 26,260 in 1959. Shipments to Sweden increased for the fifth successive year.

Imports of tin metal, mainly from Malaya and U.S.S.R., increased to 2,905 long tons (730 in 1959). Tin metal exports dropped to 8,470 long tons (32,700 in 1959), about 60 percent going to the United States in 1960.

Pig-tin stocks, the bulk under control of the buffer-stock manager, totaled 11,780 long tons at the end (11,530 at the beginning) of 1960. Stocks of tin-in-concentrate were 2,940 tons at the beginning, compared with 1,960 tons at the end of 1960. Yearend stocks of tin-in-concentrate afloat were 1,725 tons (1,465 at the beginning of 1960). All of the British strategic stockpile of tin was liquidated.

TECHNOLOGY

Exploration of the Maranboy tinfield Northern Territory, Australia indicated a considerable tonnage of marginal-grade ore that could be a strategic reserve in an emergency.[8]

Developments in tin-ore beneficiation trended toward modernization of gravity concentration procedures utilizing high-capacity hydrocyclones.[9]

The inclusions in cassiterite were found to indicate that most pegmatitic tin deposits have been formed from siliceous melts, whereas other types were formed from water solutions.[10]

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[8] Shepard, J., Exploration of Maranboy Tinfield: Min. Chem. Eng. Rev. (Melbourne), vol. 52, No. 12, Sept. 15, 1960, pp. 58–61.

[9] Dalton-Brown, H., Recovery of Cassiterite at the Sungei Besi Mines, Selangor, Malaya: Inst. of Min. Met. Bull. (London), vol. 70, No. 648, November 1960, pp. 33–48.

Williams, F. A., Recovery of Fine Alluvial Cassiterite: Correlation of Bore Valuations with Plant-Scale Recovery: Inst. Min. and Met. Bull. (London), vol. 70, No. 648, November 1960, pp. 49–69.

Chaston, I. R. M., Developments in the Treatment of Malayan Tin Ores: Paper 29, The 1960 International Mineral Processing Congress, London, April 1960.

[10] Little, W. M., Inclusions in Cassiterite and Associated Minerals: Econ. Geol., vol. 55, No. 3, May 1960, pp. 485–509.

A report [11] described the purification of tin by vacuum distillation. Volatile metals such as cadmium, lead and magnesium were removed. Other studies showed that heating in vacuum and repeated zone recrystallization would result in a product containing 99.99998 tin.[12]

Small additions of some base metals retarded grain growth of zone-refined tin.[13]

Examination of tin oxidation by electron-microscope and electron-diffraction techniques showed that oxidation starts with growth of oxide platelets, slows as cavities develop between oxide and metal, and speeds up if the oxide film is ruptured.[14]

A book describing the physical and chemical properties and uses of tin and tin alloys was published.[15] The authors presented technical data and discussed its application.

Studies indicated, that the iron-tin alloy, $FeSn_2$, forms below and above the melting point of tin by a diffusion mechanism.[16]

A light, thin tinplate was introduced. The new tinplate, called "Ferrolite", available in weights of 40 through 60 pounds per base box, in addition to the 75 to 100 pounds per base box weight now used by most can producers, was expected to meet competition from other materials in packaging such diverse items as frozen fruit-juice concentrate and motor oil.[17]

A method for tin plating a traveling steel strip was patented.[18] The steel strip is tinned in a reducing atmosphere by passing a solid solution of molten tin over a roller surface. The thickness of the tin plate can be varied by changing the speed of the roller.

Organic coatings can be removed from tin plate by dipping the metal in an aqueous solution of aniline and ammonia.[19]

Research by the Tin Research Institute in 1960 included studies on aluminum-tin bearings, tin alloys and coatings, an organotin as a wood preservative, preparation of tags and wires for soldering, and rust and corrosion resistance of tinplate.[20]

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[11] Caldwell, H. S., Jr., Spendlove, M. J., and St. Clair, H. W., Removing Volatile Metals From Lead and Tin by Vacuum Distillation: Bureau of Mines Rept. of Investigations 5703, 1960, 12 pp.

[12] Aleksandrov, B. N. [Production of Pure Tin by Prolonged Heating in Vacuum and Repeated Zone Recrystallization]: Fizika Metallov i Metallovedeniye (U.S.S.R.), vol. 9, No. 1, 1960, pp. 53–56.

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[14] Boggs, W. E., Kachik, R. H., and Pellissier, G. E., The Oxidation of Tin, I. Kinetics of Oxidations of Pure Tin and the Effects of Temperature and Oxygen Pressure; Boggs, W. E., Trozzo, P. S., and Pellissier, G. E., The Oxidation of Tin, II. Morphology and Mode of Growth of Oxide Films on Pure Tin; Boggs, W. E., The Oxidation of Tin, III. Mechanisms of Oxidation of Pure Tin: Jour. Electrochem. Soc., vol. 107, No. 8, August 1960, p. 179c.

[15] Hedges, E. S., and others, Tin and Its Alloys: Edward Arnold Ltd., London, England, 1960, 424 pp.

[16] Frankenthal, Robert P., and Loginow, Alexei W., Kinetics of the Formation of the Iron-Tin Alloy $FeSn_2$: Jour. Electrochem. Soc., vol. 107, No. 11, November 1960, pp. 920–923.

[17] American Metal Market, U.S. Steel Announces Thin Tinplate: April 28, 1960, p. 1.

[18] Toye, Trevor Cyril (assigned to The British Iron and Steel Research Association, London), Method of Tinning Steel Strip: U.S. Patent 2,937,108, May 17, 1960.

[19] Coleman, Charles H. (assigned to United States of America as represented by the Secretary of the Army), Rapid Removal of Organic Coatings from Tin Plate: U.S. Patent 2,955,965, Oct. 11, 1960.

[20] International Tin Research Council, Annual Report 1960: Tin Res. Inst., Greenford, England, 44 pp.

Titanium

By John W. Stamper[1]

PRODUCTION of 786,000 tons of ilmenite concentrate in 1960 was a record. Output of titanium dioxide pigments, which uses 95 percent of the ilmenite consumed, decreased 11 percent, but shipments declined only 3 percent. Rutile production was 8,800 tons, down 7 percent from 1959, but shipments increased 9 percent. A decline in the use of rutile in welding rods was more than offset by an increase in its consumption for making titanium metal, and overall consumption rose 2 percent.

Activity in all phases of the titanium metal industry increased significantly over 1959. Increased demand for titanium metal was attributed to greater use in missiles and space vehicles coupled with rising utilization of the metal's resistance to corrosion in the chemical-process industries.

Production of rutile increased in all producing countries except the United States and the Egypt Region of the United Arab Republic, and world output of rutile rose 8 percent. World output of 2.2 million tons of ilmenite was a record.

Free world productive capacity for titanium dioxide expanded from a reported 220,000 tons in 1940 to over 1 million tons in 1960. Additional expansion to meet rising domestic and foreign demand for titanium pigments was announced by several firms.

LEGISLATION AND GOVERNMENT PROGRAMS

On February 16, 1960, rutile was transferred from Group II to Group I of the List of Strategic and Critical Materials for Stockpiling. The rutile on hand and on order was sufficient to complete stockpile objectives at the end of 1960.

The Government continued to barter surplus agricultural products for titanium sponge metal from Japan. Government cash commitments under DPA contracts for delivery of rutile and other materials which would be surplus to maximum stockpile objectives were reduced by converting the contracts to barter, and the Government acquired rutile from Australia in this program.

The barter program was administered by the U.S. Department of Agriculture, Commodity Credit Corporation (CCC).

DOMESTIC PRODUCTION

Concentrates.—Production of 786,000 tons of ilmenite was 24 percent above the 1959 output. Mine production of rutile declined 7 percent, but shipments increased 9 percent.

Output of ilmenite was reported by the following companies: American Cyanamid Co., Piney River, Va.; E. I. du Pont de Nemours

[1] Commodity specialist, Division of Minerals.

TABLE 1.—Salient titanium statistics

	1951–55 (average)	1956	1957	1958	1959	1960
United States:						
Ilmenite concentrate: [1]						
Mine shipments ______ short tons__	530,124	735,388	782,975	565,164	637,263	789,283
Value ______ thousands__	$8,116	$14,199	$21,802	$11,155	$12,106	$14,655
Imports [2] ______ short tons__	257,618	359,281	460,353	348,144	371,687	265,645
Consumption [2] ______ do____	784,314	1,027,645	957,184	849,005	1,061,076	988,572
Rutile concentrate:						
Mine shipments ______ do____	8,151	12,065	10,644	1,863	8,648	9,433
Value ______ thousands__	$791	$1,749	$1,544	$210	$877	$879
Imports ______ short tons__	[3] 16,310	48,906	84,837	36,563	23,228	29,235
Consumption ______ do____	21,028	46,853	53,393	21,677	[4] 23,741	24,229
Sponge metal:						
Production ______ do____	3,316	14,595	17,249	4,585	3,898	5,311
Imports for consumption ___ do____	[5] 199	2,048	3,532	2,073	1,563	2,231
Consumption ______ do____	[6] 3,240	10,936	8,221	4,147	3,953	5,487
Price: Grade A-1, Dec. 31 per pound__	$4.59	$2.75	$2.25	$1.82	$1.60	$1.60
World:						
Ilmenite concentrate: Production short tons__	1,161,100	1,792,000	1,972,200	1,718,000	1,937,200	2,225,800
Rutile concentrate: Production short tons__	56,000	122,200	156,200	103,200	106,400	115,000
Sponge metal: Production short tons__	[6] 9,100	19,100	22,300	7,700	7,900	9,100

[1] Includes a mixed product containing rutile, leucoxene, and altered ilmenite.
[2] Includes titanium slag.
[3] Includes 109 tons rutile content of zirconium ore as reported to the Bureau of Mines by importers.
[4] Revised figure.
[5] 1952–55 only.
[6] 1954 and 1955 only. Data for previous years not available.

& Co., Inc., Starke and Lawtey, Fla.; Metal & Thermit Corp., Beaver Dam, Va.; National Lead Co., Tahawus, N.Y.; Titanium Alloy Manufacturing Division, National Lead Co., Skinner, Fla., and The Florida Minerals Co., Vero, Fla. The J. R. Simplot Co. shipped 2,000 tons of ilmenite valued at $30,000 from a stockpile at Boise, Idaho.

Rutile producers were as follows: Metal & Thermit Corp., Beaver Dam, Va.; Titanium Alloy Manufacturing Division, National Lead Co., Skinner, Fla.; and The Florida Minerals Co., Vero, Fla.

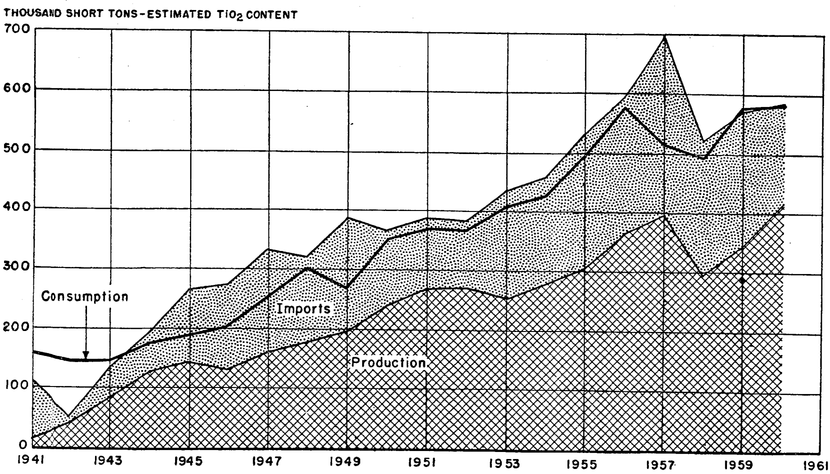

FIGURE 1.—Domestic production, imports, and consumption of ilmenite (includes titanium slag and a mixed product), 1941–60.

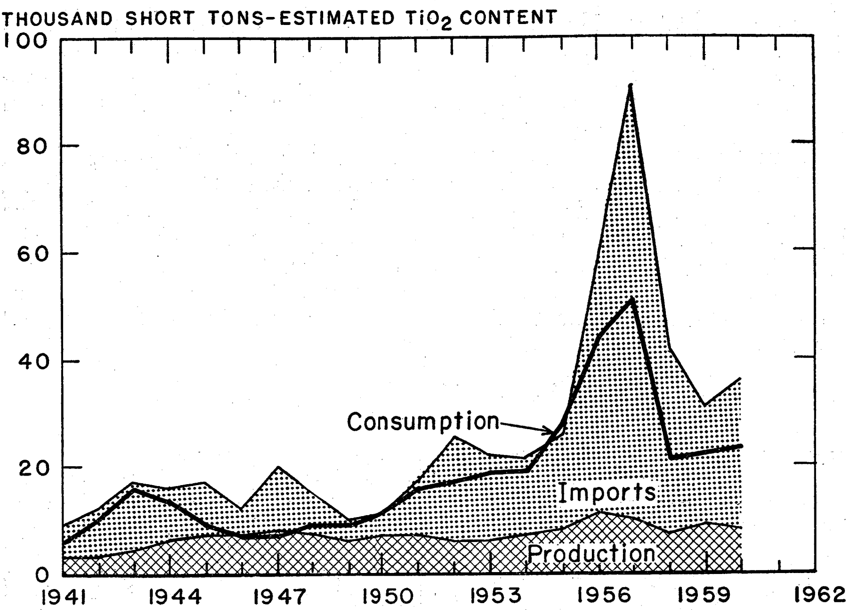

FIGURE 2.—Domestic production, imports, and consumption of rutile, 1941–60.

The Glidden Co. began construction of mining and processing facilities at its Lakehurst, N.J., ilmenite deposit. The company scheduled completion of the facilities for 1962. The deposit was acquired in 1959.[2]

Metal & Thermit Corp. expanded operations at its rutile and ilmenite mine at Hanover, Va., to include facilities to recover aplite used in

TABLE 2.—Production and mine shipments of titanium concentrates from domestic ores in the United States

(Short tons)

	Production (gross weight)	Shipments		
		Gross weight	TiO_2 content	Value
Ilmenite:[1]				
1951–55 (average)	541,775	530,124	270,862	$ 8,115,531
1956	684,956	735,388	386,498	14,198,947
1957	757,180	782,975	407,167	21,801,548
1958	563,338	565,164	297,021	11,154,854
1959	634,886	637,263	342,746	12,105,827
1960	786,372	789,283	417,202	14,655,228
Rutile:				
1951–55 (average)	7,413	8,151	7,613	790,992
1956	11,997	12,065	11,348	1,748,883
1957	10,702	10,644	10,025	1,543,540
1958	7,406	1,863	1,804	209,872
1959	9,466	8,648	8,148	876,988
1960	8,808	9,433	9,065	879,435

[1] Includes a mixed product containing rutile, leucoxene, and altered ilmenite.

[2] The Glidden Co., Ann. Rept., 1960, p. 2.

the glass industry. Commercial mica and sphene (a calcium titanium silicate) were reported to occur on the company's property.[3]

Metal.—Production of titanium sponge metal was 5,300 tons compared with 3,900 tons in 1959. Activity in other phases of the titanium metal industry increased 20 to 58 percent.

Commercial producers of titanium sponge were as follows: Union Carbide Metals Co., Division of Union Carbide Corp., Ashtabula, Ohio; E. I. du Pont de Nemours & Co., Inc., Newport, Del.; Reactive Metals, Inc. (formerly Mallory Sharon Metals Corp.), Ashtabula, Ohio; and Titanium Metals Corp. of America (TMCA), Henderson, Nev. Du Pont and TMCA used magnesium to reduce titanium tetrachloride to titanium metal; Reactive Metals and Union Carbide used sodium.

TABLE 3.—Titanium-metal data

(Short tons)

	1956	1957	1958	1959	1960
Sponge metal:					
Production	14,595	17,249	4,585	3,898	5,311
Imports for consumption	2,048	3,532	2,073	1,563	2,231
Industry stocks	3,000	2,800	1,000	1,100	1,100
Government stocks (DPA inventories)	9,316	19,821	22,463	22,474	22,474
Consumption	10,936	8,221	4,147	3,953	5,487
Scrap-metal consumption	2,033	1,743	1,336	1,690	2,027
Ingot:[1]					
Production	11,688	10,009	5,408	6,017	8,297
Consumption	10,860	10,428	4,971	5,964	7,978
Mill shape production	5,166	5,658	2,594	3,211	5,080

[1] Includes alloy constituents.

Titanium melters were: Harvey Aluminum, Inc., Torrance, Calif.; Reactive Metals, Inc., Niles, Ohio; Oregon Metallurgical Corp., Albany, Oreg.; Crucible Steel Co. of America, Midland, Pa.; Republic Steel Corp., Masillon and Canton, Ohio; and TMCA, Henderson, Nev.

Oregon Metallurgical Corp. produced ingots and castings. The other companies produced and processed ingots into mill products such as sheet, strip, plate, forging billets, and bars. Harvey Aluminum, Inc., produced titanium castings in addition to other mill products. Ladish Co., Cudahy, Wis., processed ingots into forged products.

Pigments.—On a gross-weight basis, production of titanium dioxide pigments decreased 11 percent and shipments decreased 3 percent below the record levels of 1959. Data on domestic production and shipments in table 4 are based on TiO_2 content. Data in table 10 show capacity of titanium dioxide plants in the United States and foreign countries.

Titanium pigments were produced by the following companies: American Cyanamid Co., Piney River, Va., and Savannah, Ga.; The Glidden Co., Baltimore, Md.; E. I. du Pont de Nemours & Co., Inc., Edge Moor, Del., Baltimore, Md., and New Johnsonville, Tenn.; National Lead Co., St. Louis, Mo., and Sayreville, N.J.; and The New Jersey Zinc Co., Gloucester City, N.J.

[3] Rocks and Minerals, M & T Expands Mineral Mining Operations: Whole No. 275, March–April 1960, p. 113.

TABLE 4.—Titanium dioxide data

Year	Production (short tons)	Shipments [1]	
		Quantity (short tons)	Value, f.o.b. plant (thousands)
1950	298,618	299,036	$128,943
1951	319,139	302,770	139,905
1952	314,442	276,820	124,609
1953	333,570	329,256	149,491
1954	361,006	363,010	175,661
1955	408,836	422,950	203,559
1956	477,601	454,405	234,935
1957	456,610	399,476	213,761
1958	403,867	425,765	231,888
1959	506,334	481,930	259,944
1960	454,986	(2)	(2)

1 Includes interplant transfers. 2 Not available.

Source: Facts for Industry and Current Industrial Reports series, M19A and M28A, Inorganic Chemicals, published jointly by the Bureau of the Census and the Business and Defense Services Administration, U.S. Department of Commerce.

Construction of a 25,000-ton-a-year titanium dioxide plant at an undisclosed location on the west coast was announced. The plant is 85-percent owned by the American Potash & Chemical Corp., and 15 percent by Laporte Titanium, Ltd., a subsidiary of Laporte Industries, Ltd., of England. The plant will be the first titanium dioxide plant west of the Mississippi River.[4]

Welding-Rod Coatings.—A total of 222,000 tons of welding rods containing titaniferous materials in their coatings was produced. Of the total output, 40 percent contained rutile; 19 percent, ilmenite; 13 percent, a mixture of rutile and manufactured titanium dioxide; 12 percent, manufactured titanium dioxide; 15 percent, slag; and 1 percent, other.

CONSUMPTION AND USES

Concentrates.—Consumption of ilmenite, which is used principally for making titanium dioxide pigments, decreased 5 percent to 868,000 tons. Titanium slag consumption, also used chiefly for pigment production, declined 16 percent below 1959. Increased consumption of rutile for making titanium tetrachloride for metal production more than offset a decrease in its use in welding rod coatings; thus, overall consumption increased.

Metal.—Titanium sponge metal consumption increased 39 percent over 1959 to 5,500 tons. About 500 pounds of titanium scrap was used in producing a ton of titanium ingot. Consumption of titanium mill products, using shipments as a gage, was 5,100 tons, 58 percent higher than in 1959. High-speed aircraft (military and civilian), missiles, and space vehicles were the major end-use items for titanium metal.

One titanium producer estimated that requirements for titanium metal in missile and space applications were double those of 1959. Broadening of the missile base contributed to the increase to some

4 American Potash & Chemical Corporation, AP&CC, Laporte Industries to Manufacture Titanium Dioxide: The Brine Line, vol. 8, No. 5, December 1960, pp. 1–2.

TABLE 5.—Consumption of titanium concentrates in the United States, by products

(Short tons)

Year and product	Ilmenite [1]		Titanium slag		Rutile	
	Gross weight	Estimated TiO_2 content	Gross weight	Estimated TiO_2 content	Gross weight	Estimated TiO_2 content
1951–55 (average)	700,928	366,670	[2] 83,386	[2] 58,720	21,028	19,805
1956	865,211	464,009	162,434	115,148	46,853	44,453
1957	840,719	434,077	116,465	82,545	53,393	50,870
1958	731,424	379,765	117,581	82,937	21,677	20,579
1959:						
Pigments (mfg. TiO_2) [3]	913,017	473,471	142,048	100,186		
Titanium metal	(4)	(4)	(5)	(5)	6,001	5,721
Welding-rod coatings	794	470	860	614	14,687	13,819
Alloys and carbide	3,906	2,700	(5)	(5)	[6] 760	[6] 733
Ceramics	27	17			421	394
Fiberglass					992	968
Miscellaneous [7]	3	2	421	306	880	827
Total	917,747	476,660	143,329	101,106	[6] 23,741	[6] 22,462
1960:						
Pigments (mfg. TiO_2) [3]	864,794	462,623	119,308	84,257		
Titanium metal	(4)	(4)			8,073	7,685
Welding-rod coatings	658	390	968	680	13,406	12,668
Alloys and carbide	2,584	1,574	(5)	(5)	377	360
Ceramics	27	17			374	350
Fiberglass					704	686
Miscellaneous [7]	17	10	216	158	1,295	1,193
Total	868,080	464,614	120,492	85,095	24,229	22,942

[1] Includes a mixed product containing rutile, leucoxene, and altered ilmenite used to make pigments and metal.
[2] 1952–55 only.
[3] "Pigments" include all manufactured dioxide.
[4] Included in "Pigments" to prevent disclosing individual company confidential data.
[5] Included in "Miscellaneous" to prevent disclosing individual company confidential data.
[6] Revised figure.
[7] Includes consumption for chemicals and experimental purposes and losses in grinding.

extent; in certain missile applications, however, titanium was reported to be cheaper than other suitable materials, and part of the increase in these uses was attributed to substitution of titanium for other metals.

A double shell of titanium reportedly was used in the midsection of the space capsule used in Project Mercury, America's man-in-space program.[5] The shells were supported by titanium rings and stringers. Other significant applications for titanium in space vehicles and missiles included cryogenic pressure vessels for liquid-fueled missiles, rocket motor cases for solid-fueled vehicles, rocket nozzle exit cones, control mechanisms and housings, and skin.

The use of titanium in the honeycomb-core construction for jet inlet guide ramps of the Navy's Mach 2 attack aircraft, the A3J Vigilante, was described. Titanium's immunity to salt-water corrosion reportedly was so effective in replacing aluminum cover sheets and channels that the A3J aircraft already built were to be fitted with the new design.[6]

Use of high-strength titanium alloy in the barrel of the new U.S. Army recoilless infantry gun, the Davy Crockett, announced early in

[5] Crucible Steel Co. of America, Titanium Review: Vol. 9, No. 1, March 1961, pp. 1–3.
[6] Aviation Week and Space Technology, Corrosion-Fighting Titanium Sheet Paves Way for Honeycomb in Navy A3J: Vol. 72, No. 11, Mar. 14, 1960, pp. 104–105.

1960, represented the first major nonaircraft ordnance application for titanium. One company estimated that 2 million pounds of titanium would be needed for this application from 1960 to 1965.[7]

Increased commercial utilization of corrosion-resistant titanium pumps and heat exchangers was reported. A 250-gallon titanium cooking kettle was reportedly unaffected after 4,000 hours of cooking exposure to several foods which seriously corrode and pit nickel-alloy and stainless steel vessels.[8]

Cast titanium parts, such as pumps, impellers, and pump shafts, for use in hot nitric acid, hypochlorites, chlorine, and chloride environments were reported to be cheaper than similar parts of stainless steel and nickel alloys when downtime and maintenance costs were considered.[9]

Welded-titanium-tube heat exchangers used in a hot solution of metal sulfates in sulfuric acid, such as encountered in titanium dioxide plants, were reportedly more efficient than heat exchangers made from lead-covered copper tubing. Forty-five of the coil type heat exchangers, each consisting of 120 linear feet of 2-inch outside diameter welded titanium tubing, were being constructed for use in titantium pigment plants of the National Lead Co.[10]

Pigments.—Consumption of titanium pigments, based on gross weight and using shipments as a gage, decreased 3 percent below 1959. Consumption of pigments not separately classified in table 6 included use in ceramics, roofing, siding, gems, titanium chemicals, and plastics.

STOCKS

Rutile stocks increased slightly and represented over 3 years' supply at the 1960 rate of consumption. Ilmenite stocks also increased, but stocks of titanium slag decreased. Yearend stocks of titanium sponge held by producers, melters, and semifabricators totaled 1,000 tons, the same as stocks at the end of 1959, and represented a 2 months' supply at the 1960 consumption rate. An additional 22,474 tons was held in Defense Production Act inventories.

Titanium sponge metal scrap held by melters and semifabricators increased from 3,400 tons at the beginning of 1960 to 3,600 tons at yearend.

PRICES

Concentrates.—The price quoted for ilmenite in E&MJ Metal and Mineral Markets remained unchanged in 1960 at \$23 to \$26 per long ton (59.5 percent TiO_2, f.o.b. Atlantic seaboard).

Rutile prices continued to decline. The price of rutile (94 percent TiO_2, f.o.b. Atlantic seaboard) quoted by E&MJ Metal and Mineral

[7] Daily Metal Reporter, 2 Million Lbs. Titanium Needed for New Weapon: Vol. 60, No. 85, May 4, 1960, pp. 1, 4.

[8] Steel, Success of Corrosion Test Widens Field for Titanium: Vol. 146, No. 6, Feb. 8, 1960, p. 88.

[9] Aschoff, W. A., Why to Use Titanium and Zirconium Castings: Materials in Design Eng., vol. 51, No. 1, January 1960, pp. 102–104.

[10] Chemical Engineering, Big Equipment Sale Shows Titanium May Be Outgrowing Gimmick Phase: Vol. 67, No. 26, Dec. 26, 1960, p. 31.
Chemical Week Titanium Equipment Costs Tumble: Vol. 87, No. 25, Dec. 17, 1960, pp. 29–30.

TABLE 6.—Distribution of titanium-pigment shipments, by industries[1]

(Percent)

Industry	1951-55 (average)	1956	1957	1958	1959	1960
Distribution by gross weight:						
Paints, varnishes, and lacquers	68.2	65.3	64.9	65.8	64.8	65.1
Paper	8.6	10.3	10.9	11.5	11.7	11.3
Floor coverings (linoleum and felt base)	4.7	4.2	4.1	5.0	4.9	4.8
Rubber	3.0	3.4	3.6	3.9	4.2	4.0
Coated fabrics and textiles (oilcloth, shade cloth, artificial leather, etc.)	2.1	2.8	3.2	2.9	3.1	2.8
Printing ink	1.2	1.3	1.4	1.5	1.7	1.3
Other	12.2	12.7	11.9	9.4	9.6	10.7
Total	100.0	100.0	100.0	100.0	100.0	100.0
Distribution by titanium dioxide content:						
Paints, varnishes, and lacquers	60.1	58.3	57.7	59.1	58.2	58.5
Paper	12.2	13.6	14.2	15.2	15.1	14.6
Floor coverings (linoleum and felt base)	5.4	4.9	5.0	6.4	6.3	6.2
Rubber	4.0	4.4	4.6	5.1	5.4	4.9
Coated fabrics and textiles (oilcloth, shade cloth, artificial leather, etc.)	2.8	3.6	4.1	3.7	3.9	3.5
Printing ink	1.7	1.8	1.9	1.9	2.2	1.7
Other	13.8	13.4	12.5	8.6	8.9	10.6
Total	100.0	100.0	100.0	100.0	100.0	100.0

[1] Data based on figures supplied to the Bureau of Mines by producers and include interplant transfers.

Markets was $85 per short ton at the beginning of 1960. A nominal price of $80 per short ton was quoted at the end of the year.

Manufactured Titanium Dioxide.—The prices of rutile and anatase grades of manufactured titanium dioxide pigment and calcium-rutile base titanium pigments were unchanged. The following prices were quoted in the Oil, Paint and Drug Reporter at the end of 1960:

	Price
Anatase, chalk-resistant, regular and ceramic, carlots, delivered, per pound	$0.25½
Less than carlots, delivered, per pound	.26½
Rutile, nonchalking, bags, carlots, delivered East, per pound	.27½
Less than carlots, delivered East, per pound	.28½
Titanium pigment, calcium-rutile base, 30 percent TiO_2, bags, carlots, delivered, per pound	.09⅜
Less than carlots, delivered, per pound	.09⅞

Metal.—Prices per pound quoted for titanium sponge metal were constant during 1960 at $1.60 for Grade A-1 and $1.50 for Grade A-2.

Prices for titanium sheet and strip declined in 1960, and prices per pound of mill shapes (f.o.b. mill, commercially pure grades, in lots of 10,000 pounds) were quoted as follows:

	Price
Sheet:	
Jan. 1 to Sept. 1	$7.75 to $8.00
Sept. 1 to Dec. 31	7.25 to 8.00
Strip:	
Jan. 1 to Sept. 1	7.25 to 8.00
Sept. 1 to Dec. 31	6.75 to 7.50
Plate: Jan. 1 to Dec. 31	5.25 to 6.00
Wire: Jan. 1 to Dec. 31	5.55 to 6.05
Forging billets: Jan. 1 to Dec. 31	3.20 to 3.70
Hot rolled bars: Jan. 1 to Dec. 31	4.00 to 4.50

TABLE 7.—Stocks of titanium concentrates in the United States, December 31

(Short tons)

Year and stock	Ilmenite		Titanium slag		Rutile	
	Gross weight	TiO_2 content, estimated	Gross weight	TiO_2 content, estimated	Gross weight	TiO_2 content, estimated
1959:						
Mine	33,561	15,560			6,444	6,047
Distributor	114	68			3,524	3,367
Consumer	679,527	[1] 355,365	155,011	109,507	66,422	63,081
Total	713,202	[1] 370,993	155,011	109,507	76,390	72,495
1960:						
Mine	30,650	14,249			5,819	5,314
Distributor	3,632	1,988			5,417	5,177
Consumer	745,202	387,679	132,621	93,706	66,545	62,946
Total	779,484	403,916	132,621	93,706	77,781	73,437

[1] Revised figure.

Ferrotitanium.—All gades of ferrotitanium quoted in E&MJ Metal and Mineral Markets remained unchanged in price. Nominal prices quoted were as follows:

	Price
Low-carbon:[1]	
Titanium, 40 percent; carbon, 0.10 percent maximum	$1.35
Titanium, 25 percent; carbon, 0.10 percent maximum	1.50
Medium-carbon:[2]	
Titanium, 17 to 21 percent; carbon, 3 to 5 percent	$290–295
High-carbon:[2]	
Titanium, 15 to 19 percent; carbon, 6 to 8 percent	240–245

[1] Price per pound in 1-ton lots or more, lump (½ inch, plus), packed; f.o.b. destination Northeastern United States.
[2] Price per net ton, carload lots, lump, packed; f.o.b. destination Northeastern United States.

FOREIGN TRADE[11]

Imports.—U.S. imports of ilmenite and titanium slag dropped 29 percent to 266,000 short tons, the lowest reported since 1952. Imports of slag containing 70 percent titanium dioxide were from Canada.

Rutile imports increased 26 percent to 29,000 short tons and included material brought in from Australia under CCC barter agreements. Australia, as in past years, was the chief source, but significant rutile came from the Union of South Africa.

Imports of titanium sponge metal were 2,231 short tons, the second highest in history, being exceeded only by the 1957 figure of 3,500 tons. Titanium metal imports included 1,550 tons of metal imported from Japan under the CCC barter agreements. About 40 tons of metal was imported from Canada and classified free under certain public laws (scrap). About 77 tons also was imported from the United Kingdom under this category. The remainder was from Japan and was dutiable.

[11] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 8.—U.S. imports for consumption of titanium concentrates,[1] by countries

Country	1951–55 (average)	1956	1957	1958	1959	1960
Ilmenite:						
Australia .... short tons..	31	197	----------	22,736	47,317	33,089
Canada[2] .... do....	91,128	196,660	217,762	112,874	157,296	104,243
India .... do....	166,448	133,520	240,279	212,479	167,074	128,313
Malaya, Federation of.... do....	11	28,864	2,279	----------	----------	----------
Other countries .... do....	([3])	40	33	55	----------	----------
Total .... do....	257,618	359,281	460,353	348,144	371,687	265,645
Value	[4]$4,257,901	[4]$9,197,835	[4]$10,316,853	$6,766,391	$7,991,208	$5,066,502
Rutile:						
Australia .... short tons..	[5]16,310	48,845	84,743	36,507	22,954	27,847
Union of South Africa.... do....	----------	----------	----------	----------	274	1,358
Other countries .... do....	----------	61	94	56	----------	30
Total .... do....	[5]16,310	48,906	84,837	36,563	23,228	29,235
Value	$1,463,859	$7,147,827	$11,843,295	$4,512,937	$2,943,258	$3,610,616

[1] Classified as "ore" by Bureau of the Census.
[2] Chiefly titanium slag averaging about 70 percent TiO_2.
[3] Less than 1 ton.
[4] Data known to be not comparable with other years.
[5] Includes 109 tons rutile content of zirconium ore as reported to Bureau of Mines by importers.

Source: Bureau of the Census.

Imports classified by the Bureau of the Census as "Titanium Potassium Oxylate and All Compounds and Mixtures Containing Titanium," which are virtually all titanium dioxide pigments, were 6,184 short tons in 1960, compared with 2,817 tons in 1959. In recent years, most of the material under this classification has come from the United Kingdom, Japan, and Italy.

Exports.—Titanium dioxide and pigment exports declined for the fourth straight year. Canada, as in past years, was the destination of most of the pigments, accounting for 17,132 tons. Other countries that received 1,000 tons or more were as follows: Mexico 2,700; Belgium-Luxembourg, 2,500; Netherlands, 2,300; Philippines, 1,900; and Italy, 1,800.

Exports of 1,260 tons of titanium ores and concentrates included 900 tons to Canada, 88 tons to Mexico, 85 tons to Colombia, and about 71 tons each to Chile and Hong Kong. Small quantities were sent to Trinidad and Tobago, Uruguay, Argentina, Netherlands, and the United Kingdom.

For the fifth successive year exports of titanium sponge and scrap increased significantly over the previous year. Of the 879 tons exported, 620 was sent to the United Kingdom; 125 to West Germany; 55 to France; and the remainder to Sweden, Canada, Netherlands, Austria, Italy, Japan, and Australia. Exports of titanium metal products declined 15 percent to 426 tons. Most of the titanium products went to Canada, which received 411 tons. West Germany received 9 tons, and most of the remainder went to France, Italy, and the Netherlands. Of the 245 tons of ferroalloys exported, Canada received 195 tons; Colombia, 22; and Sweden and France, each 6 tons. Most of the remainder went to Chile and Belgium-Luxembourg.

TABLE 9.—U.S. exports of titanium products, by classes

Year	Ores and concentrates		Metal and alloys in crude form and scrap [1]		Primary forms n.e.c. [2]		Ferroalloys		Dioxide and pigments	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1951-55 (average)	938	$112,663	(3)	(3)	(4)	(4)	220	$70,016	46,563	$15,459,135
1956	1,838	312,285	14	$59,992	559	$8,304,835	364	148,459	64,806	25,158,181
1957	2,019	276,472	71	77,629	779	9,404,232	367	130,046	52,960	19,687,188
1958	1,246	172,481	97	172,285	336	5,227,932	323	138,431	37,016	11,346,651
1959	4,656	289,507	496	543,104	499	5,161,074	321	[5] 145,621	36,282	10,558,287
1960	1,260	166,685	879	868,846	426	3,237,949	245	157,419	33,655	10,000,884

[1] Beginning Jan. 1, 1955, classified as sponge and scrap.
[2] Beginning Jan. 1, 1955, classified as intermediate mill shapes and mill products, n.e.c.
[3] Not separately classified before 1952. 1952, 762 tons ($31,134); 1953, 2 tons ($11,858); 1954, 48 tons ($1,107,582); 1955, 10 tons ($36,353).
[4] Not separately classified before 1952. 1952, 3 tons ($38,979); 1953, 31 tons ($798,077); 1954, 171 tons ($3,587,401); 1955, 35 tons ($1,211,311).
[5] Revised figure.

Source: Bureau of the Census.

WORLD REVIEW

The strong upward trend of recent years in titanium dioxide productive capacity continued in 1960. Plans for new or expanded capacity were announced or construction was started on titanium dioxide facilities in Canada, Portugal, India, Africa, Australia, and the United States. Data in table 10 on free world capacity were estimated by the Federal Bureau of Mines from various sources. At the end of 1960, world TiO_2 capacity was 1.1 million short tons. Capacity for an additional 387,000 tons was planned. In a 1958 article, world TiO_2 capacity was reported at 220,000 tons in 1940 and at 882,000 tons in 1957.[12] Another article, published in 1959, estimated capacity at 725,000 tons in February 1957 and 1,059,000 tons in January 1960.[13]

A study of world titanium dioxide capacity and the use of sulfuric acid by that industry was published. A brief description of production processes was given, and the TiO_2 productive capacity in the United States and other free world countries was discussed.[14] It was estimated in the article that 2.5 to 2.6 million tons of 66°-Baumé sulfuric acid was used in 1960 in making titanium dioxide. About half was used in the United States.

The United States continued to be the free world's principle source and consumer of ilmenite and the chief market for rutile. Ilmenite output in India declined 17 percent, partly owing to the closing of two Hopkins and Williams, Ltd., titanium mines, one in 1959 and a second in 1960. Output of 1,100 and 3,700 tons of rutile in India and Union of South Africa, respectively, were the highest recorded for those countries.

[12] L'Echo des Mines et de la Metallurgie, Paris: No. 3520, September 1958, p. 558.
[13] Oil, Paint and Drug Reporter, Titanium Dioxide Horse-Pond? World Capacity Seen Galloping to 960,000 Metric Tons By '60: Vol. 176, No. 8, Aug. 24, 1959, pp. 5, 38.
[14] Sulphur, TiO_2, A Major Sulphur Growth Industry: British Sulphur Corp. (London), Quart. Bull. 28, May 1960, pp. 2–14.

TABLE 10.—Free world titanium dioxide pigment capacity [1]

(Short tons TiO_2)

	Location of plant	Annual capacity, 1960	Planned additional capacity [2]
North America:			
Canada:			
Canadian Titanium Pigments	Varennes, Quebec	18,000	7,000
British Titan Products (Canada) Ltd.	Sorel, Quebec		20,000 (1962)
Continental Titanium Corp	Baie St. Paul, Quebec		2,000
Total		18,000	29,000
Mexico: Pigmentos y Productos Quimicos S.A. de C.V.	Tampico, Tamaulipos	8,000	
United States:			
E. I. du Pont de Nemours & Co., Inc.	Edgemoor, Del	90,000	
	Baltimore, Md	40,000	
	New Johnsonville, Tenn	50,000	27,000 (1962)
National Lead Co	Sayreville, N.J	157,000	
	St. Louis, Mo	136,000	
The Glidden Co	Baltimore, Md	56,000	
American Cyanamid Co	Piney River, Va	18,000	
	Savannah, Ga	72,000	
New Jersey Zinc Co	Gloucester City, N.J	24,000	24,000 (1961)
American Potash & Chemical Corp	Pacific Coast		25,000 (1962)
Total		643,000	76,000
Total North America		669,000	105,000
South America:			
Brazil: Cia. Quimica Industrial S.A	Sao Paulo, Sao Paulo	4,600	
Total South America		4,600	
Europe:			
Belgium: Soc. Chimique des Derives du Titane.	Langerbrugge	11,000	18,000
Finland: Vuorikemia Oy	Otanmäki		17,600 (1961)
France:			
Fabriques de Produits Chimiques de Thann et de Mulhouse.	Strasbourg	13,200	23,100
Le Products du Titane, S.A	Le Havre	16,500	1,700
Total		29,700	24,800
Germany, West:			
Titangesellschaft mbH	Leverkusen	77,000	11,000 (1961)
Farbenfabriken Bayer, A.G	Uerdingen	45,000	26,000
Pigment Chemie G.m.b.H	Homberg		20,000 (1962)
Total		122,000	57,000
Italy: Soc. Montecatini	Bovisa (Milan)	9,900	
	Spinetta Morengo	19,800	24,000
Total		29,700	24,000
Netherlands: N.V. Titaandioxydefabriek	Botlek, Rotterdam area		11,000 (1962)
Portugal: La Pigmentos de Titanium, Lda	Sines, Estremadura Prov	1,000	15,000 (1963)
Spain: Union Quimica del Norte de Espana, S. A	Axpe-Erandio, Biscay	8,300	8,300
Chromogenia y Quimica S. A	Barcelona	2,800	2,800
Total		11,100	11,100
United Kingdom:			
British Titan Products Co	Grimsby	80,000	16,500 (1962)
	Billingham	22,000	
Laporte Titanium, Ltd	Stallingborough	34,000	22,000
Total		136,000	38,500
Total Europe		340,500	217,000

See footnotes at end of table.

TABLE 10.—Free world titanium dioxide pigment capacity [1]—Continued

	Location of plant	Annual capacity, 1960	Planned additional capacity [2]
Asia:			
India:			
Travancore Titanium Products, Ltd	Trivandrum, Kerala	3,200	770
M/S Botamium, Ltd	Bombay, Maharashtra		4,900
Total		3,200	5,670
Japan:			
Titanium Industry Co., Ltd	Ube, Yamaguchi Pref	7,900	
Teikoku Kako Company, Ltd	Saidaiji, Okayama Pref	7,900	5,300 (1962)
Furukawa Mining Co., Ltd	Osaka, Osaka Pref	7,900	5,300 (1962)
Sakai Chemical Industry Co., Ltd	Sakai, Osaka Pref	3,000	6,600 (1962)
Mitsui Metal Mining Co., Ltd	Tamano, Okayama Pref	300	
Ishihara Sangyo Kaisha, Ltd	Yokkaichi, Mie Pref	30,000	5,000 (1961)
Fuji Titanium Industry Co., Ltd	Hiratsuka, Kanagawa Pref	2,400	2,400 (1962)
	Kobe, Hyogo Pref	4,600	
Total		64,000	24,600
Total Asia		67,200	30,270
Africa:			
Union of South Africa: African Explosives & Chemical Industries, Ltd, and British Titan Products Co. Ltd	Umbogintiwini		11,000 (1962)
Total Africa			11,000
Oceania:			
Australia:			
Australian Titan Products Co., Ltd	Burnie, Tasmania	11,000	13,600 (1964)
Laporte Titanium, Ltd	Bunbury, Western Australia		10,000 (1962)
Total Oceania		11,000	23,600
World total		1,092,300	386,870

[1] Data based on information from various sources including periodicals (English and foreign languages), Foreign Service Despatches, published announcements of individual companies (annual reports), and Bureau of Mines publications.
[2] Figures in parenthesis indicate scheduled year of completion if known.

NORTH AMERICA

Canada.—The Quebec Iron & Titanium Corp. (QIT) ilmenite-smelting plant at Sorel, Quebec, operated at capacity in 1960, producing 386,600 short tons of titanium slag. Kennecott Copper Corp., two-thirds owner of QIT, announced further expansion of the facilities to permit treatment of 1.1 million tons of ore per year.[15]

Several sources reported that the Continental Titanium Corp., formerly Continental Iron & Titanium Mining, Ltd., planed a $2 million titanium dioxide plant 60 miles east of Quebec City in the Baie St. Paul area. The plant reportedly will use a continuous process to treat

[15] Kennecott Copper Corp., Forty-Sixth Annual Rept., 1960, pp. 11–13.

TABLE 11.—World production of titanium concentrates (ilmenite and rutile) by countries [1] [2]

(Short tons)

Country [1]	1951-55 (average)	1956	1957	1958	1959	1960
Ilmenite:						
Australia (sales) [3]	516	4,787	79,694	78,342	93,864	[4] 137,800
Canada [5]	100,664	220,885	269,690	161,312	270,477	388,339
Ceylon	----------	----------	----------	----------	----------	6,720
Finland	[6] 50,965	113,444	116,568	117,384	94,966	92,219
Gambia	[7] 608	----------	15,297	31,851	14,553	----------
India	258,838	375,861	331,768	346,260	334,000	275,575
Japan [8]	[9] 2,899	9,634	8,998	3,932	3,445	1,444
Malagasy Republic (Madagascar)	----------	----------	----------	1,150	659	[4] 660
Malaya (exports)	42,645	136,837	102,742	83,806	81,593	132,432
Mexico	[10] 12	----------	----------	166	----------	----------
Mozambique	----------	----------	----------	[11] 7,751	11,400	3,781
Norway	145,232	209,990	231,693	233,585	249,274	258,283
Portugal	568	679	388	506	2,113	[4] 1,600
Senegal	11,045	22,156	39,573	36,927	32,941	24,159
Spain	2,509	5,962	9,796	18,161	8,113	[4] 8,300
Thailand	----------	386	2,039	922	550	[4] 550
Union of South Africa	[6] 643	1,855	3,118	29,611	87,232	90,431
United Arab Republic (Egypt Region)	2,188	4,547	[4] 3,700	[4] 3,000	17,100	[4] 17,100
United States [12]	541,775	684,956	757,180	563,338	634,886	786,372
World total ilmenite (estimate) [1] [2]	1,161,100	1,792,000	1,972,200	1,718,000	1,937,200	2,225,800
Rutile:						
Australia	48,275	108,434	144,372	93,327	91,734	[4] 100,300
Brazil	63	338	270	269	220	----------
Cameroun, Republic of	122	168	44	----------	----------	----------
India	123	606	530	503	429	1,082
Norway	17	26	22	----------	----------	----------
Senegal	7	650	243	1,157	----------	----------
Union of South Africa	----------	----------	32	552	3,381	3,695
United Arab Republic (Egypt Region)	----------	----------	----------	----------	1,157	[4] 1,100
United States	7,413	11,997	10,702	7,406	9,466	8,808
World total rutile (estimate) [1] [2]	56,000	122,200	156,200	103,200	106,400	115,000

[1] In addition to the countries listed, titanium concentrates are produced in U.S.S.R., and Brazil produces ilmenite, but no reliable information is available; no estimates are included in the total.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Represents sales.
[4] Estimate.
[5] Beginning 1951, represents titanium slag containing approximately 70 percent TiO_2 and small quantities of "titanium ore".
[6] Average for 1953–55.
[7] Average for 1954–55.
[8] Represents titanium slag.
[9] Average for 1952–55.
[10] Average for 1 year only, as 1955 was the first year of production reported.
[11] Exports.
[12] Includes a mixed product containing ilmenite, leucoxene, and rutile.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

one from its nearby titanium deposit. About 10 tons of TiO_2 reportedly will be extracted daily at a cost 30 percent below that for conventional batch processes.[16]

British Titan Products (Canada), Ltd., began construction of its $16 million titanium pigment plant at Tracy, Quebec.[17] Planned capacity of this plant, which was to utilize titanium slag from QIT, reportedly was about 20,000 tons of TiO_2 a year.

[16] Chemical Engineering, Can High-Quality Titanium Dioxide Be Made via a Continuous Process? Vol. 67, No. 22, Oct. 31, 1960, p. 41.
Precambrian, Mining in Canada (Winnipeg), Continental Iron and Titanium Report Limited Demand: Vol. 33, No. 7, July 1960, p. 30.
Precambrian, Mining in Canada, Reports From the Industry: Vol. 33, No. 8, August 1960, p. 45.
[17] Chemical Week, Titanium Dioxide: Vol. 87, No. 14, Oct. 1, 1960, p. 26.

TABLE 12.—Quebec Iron & Titanium Corp. smelting operations

(Short tons)

	1951-55 (average)	1956	1957	1958	1959	1960
Ore smelted	216,840	[1] 520,651	627,255	[1] 420,932	626,310	967,373
Titanium slag produced	97,820	218,575	258,920	161,312	243,700	386,639
Estimated TiO_2 content	69,560	157,374	186,422	116,150	175,464	278,380
Value of slag produced	$3,043,451	$6,688,416	$9,740,570	$6,575,077	[1] $8,509,149	$14,257,292
Titanium slag shipped	93,804	213,742	262,879	105,622	(2)	(2)
Desulfurized iron produced	73,119	159,874	187,529	117,878	163,509	248,578

[1] Revised figure.
[2] Data not available.

EUROPE

Netherlands.—The Glidden Co. announced that through Glidden International, an unconsolidated subsidiary, a technological assistance and licensing agreement was entered into with N. V. Titaandioxydefabriek for construction of a TiO_2 plant in the Botlek area in the Netherlands.[18]

Norway.—Mining at the Titania A/S new ilmenite mine at Tellnes, Rogaland County, started in 1960.[19] About 260,000 tons of ilmenite was produced at the new mine and at the Titan Co. A/S mine at Sokndal. Both these companies were owned by National Lead Co. (U.S.A.). Mining at Sokndal was expected to decline as the new mine is developed. Output of ilmenite concentrate at both mines was expected to be 250,000 to 300,000 tons a year. Estimates of reserves at Hauge i Dalane range from 200 to 350 million tons containing about 17 percent TiO_2 and 20 percent iron.[20] The company was investigating pilot plant methods to produce a concentrate containing 70 to 80 percent TiO_2.

Portugal.—A new company, La Pigmentos de Titanium, Lda., formed by Sociedade Mineira de Sante Fe of Lisbon with Fabriques de Produits Chimique de Thann et de Mulhouse and Compagnie de Saint-Gobain, planned an $8.2 million titanium dioxide plant at Sines on the Atlantic Coast, 100 miles south of Lisbon.[21] Anticipated capacity of the plant was not disclosed, but it will reportedly use 33,000 short tons of Portuguese ilmenite in the sulfuric acid process.

ASIA

Ceylon.—The Ceylon Mineral Sands Corp. reportedly began producing ilmenite at Pulmoddai.[22]

India.—It was reported that the (Kerala) Government's refusal of a request for a downward revision of royalty rates caused Hopkins and Williams, Ltd., to close its ilmenite processing plant at Chavara.[23] At

[18] The Glidden Co., Annual Rept., 1960, p. 2.
[19] Bureau of Mines, Mineral Trade Notes: Vol. 52, No. 2, February 1961, p. 30.
[20] Chemical Age (London), Norwegian Ilmenite Plant Due on Stream in October: Vol. 84, No. 2143, Aug. 6, 1960, p. 204.
[21] Bureau of Mines, Mineral Trade Notes: Vol. 51, No. 5, November 1960, p. 53.
Chemical Age (London), Titanium Pigment Plant for Portugal: Vol. 84, No. 2160, Dec. 3, 1960, p. 951.
Sulphur Institute News, Titanium Dioxide: Vol. 1, No. 4, May 1961, p. 3.
[22] Mining Journal (London): Vol. 255, No. 6535, Nov. 18, 1960, p. 568.
[23] Bureau of Mines, Mineral Trade Notes: Vol. 52, No. 3, March 1961, p. 33.

Chavara the company formerly produced about 200,000 tons of ilmenite concentrate a year, about half of the Indian output. In 1959, the company closed a small ilmenite processing plant at Manavalakurichi, Madras. The closings resulted in reduction of 1960 Indian output by about 17 percent.

Laporte Industries, Ltd., a British firm, and Bombay Dyeing & Manufacturing Co. were reportedly planning a titanium dioxide plant near Bombay, with Laporte holding the minority interest.[24]

The following analysis of the beach sands of Chavara was reported by the Indian Bureau of Mines: Ilmenite, 65 to 75 percent; rutile, 3 to 8 percent; zircon, 5 to 10 percent; sillimanite, 5 to 10 percent; quartz, 5 to 10 percent; and monazite, 1 to 2 percent.[25]

Japan.—Titanium slag production decreased 58 percent to 1,444 tons. Hokuetsu Electric Chemical Industries Co. was the principal producer and accounted for over half the total. Nisso Steel Manufacturing Co., Ltd., and Morioka Electric Chemical Co. produced the remainder.

Output of titanium sponge metal dropped 7 percent to 2,543 tons. Osaka Titanium Co. Ltd., and Toho Titanium Industry Co., Ltd., produced 1,516 and 1,012 tons, respectively. A small quantity was made by Nippon Soda Co., Ltd. Part of the output by Osaka and Toho was exported to the United States under CCC barter agreements.

Titanium dioxide production was 54,000 tons, the highest ever recorded. Nearly half of the output was exported.

TABLE 13.—Japan: Titanium metal and titanium dioxide data

(Short tons)

	1956	1957	1958	1959	1960
Titanium metal:					
Production	2,768	3,393	1,812	2,730	2,543
Exports	2,783	2,734	1,962	1,982	2,130
Stocks, end of year	186	940	677	1,148	1,100
Titanium dioxide:					
Production	25,269	36,811	33,285	39,192	54,446
Exports	10,208	16,590	15,223	15,587	21,160
Stocks, end of year	1,174	2,490	2,754	1,077	2,295

AFRICA

Union of South Africa.—South African Titan Products (Pty.), Ltd., reportedly began constructing an $8.8 million titanium dioxide plant at Umbogintwini. The plant was expected to be completed in 1962 and to have an annual capacity of 10,000 tons of titanium dioxide. South African Titan Products was formed by British Titan Products Co., Ltd., and African Explosives & Chemical Industries, Ltd.[26]

United Arab Republic (Egypt Region).—Soviet mining equipment for use in developing the General Ilmenite Co. ilmenite mine at Abu Ghalaga was reported to have arrived in Egypt. Equipment included

[24] Chemical Age (London), Laporte-Indian Joint Venture for Titanium Oxide: Vol. 85, vol. 52, No. 7, Apr. 16, 1960, pp. 50–58.

[25] Mining Journal (London), India's Heavy Mineral Sands: Vol. 253, No. 6479, Oct. 23, 1959, p. 392.

[26] Chemistry and Industry (London), Titanium Oxide Plant for South Africa: July 23, 1960, No. 30, p. 974.

seven 10-ton trucks, sea water conversion condensers, and air compressors. The ore was to be trucked 20 miles to Abu Ghusan where a jetty capable of handling 4,500- to 5,000-ton ships was nearing completion.[27]

OCEANIA

Australia.—Australian Titan Products Pty., Ltd., a subsidiary of British Titan Products Co., Ltd., planned to double production at its Burnie, Tasmania, titanium dioxide plant to 24,000 tons a year. Cost of the expansion was to be about $9 million.[28]

It was reported that Laporte Titanium, Ltd., planned to build a 10,000-ton-a-year titanium dioxide plant at Bunbury, south of Perth, Western Australia. The cost of the plant, scheduled to start by 1962, was to be approximately $8.5 million.[29]

Technological developments in mining Autralian titanium sand deposits [30] reflected a continuing effort by producers to improve methods and cut costs.

TABLE 14.—Australia: Exports of ilmenite concentrate by countries [1]

(Short tons)

Destination	1955-56	1956-57	1957-58	1958-59	1959-60
Belgium-Luxembourg		1,335	3,228		
France		621	223	10,037	3,810
Japan	(2)	16,373	16,668	10,862	21,596
Netherlands		134	3,360		
United Kingdom			20,447	7,285	2,031
United States			22,736	23,490	45,565
Other countries	426			93	838
Total	426	18,463	66,662	51,767	73,840

[1] Years ending June 30.
[2] Data not available.

Compiled from Customs Returns of Australia by Corra A. Barry, Division of Foreign Activities.

TECHNOLOGY

The Federal Bureau of Mines published reports on several phases of its titanium research program.

Results of laboratory tests on drill samples from an Oklahoma placer deposit indicated that nearly 8 million tons of titanium concentrate containing 45 percent TiO_2 could be recovered from the deposit.[31] The titanium content compared favorably with commercial grades; however, the concentrate obtained in the laboratory was high in chromium.

[27] U.S. Consulate General, Cairo, Egypt, State Department Dispatch 339: Dec. 2, 1959.
[28] South African Mining and Engineering Journal (Johannesburg), Titanium in Australia: Vol. 71, No. 3520, July 22, 1960, p. 187.
[29] Financial Standard (Melbourne), British Firm Wants More Titanium From W.A.: Vol. 115, No. 2910, Aug. 25, 1960, p. 33.
Chemical Age (London), Laporte to Establish Titanium Oxide Plant in W. Australia: Vol. 84, No. 2162, Dec. 17, 1960, p. 1029.
[30] Woodcock, J. T., Ore Dressing Developments in Australia 1959: Chem. Eng. Min. Rev., vol. 52, No. 7, Apr. 16, 1960, pp. 54–58.
[31] Hahn, A. D., and Fine, M. M., Examination of Ilmenite-Bearing Sands in Otter Creek Valley, Kiowa and Tillman Counties, Okla.: Bureau of Mines Rept. of Investigations 5577, 1960, 77 pp.

TABLE 15.—Australia: Exports of rutile concentrates by countries[1]

(Short tons)

Destination	1956	1957	1958	1959	1960[2]
Belgium	4,797	4,114	2,532	1,390	(3)
France	4,599	4,620	5,459	7,482	(3)
Germany, West	4,042	5,964	4,114	10,037	(3)
Italy	3,433	3,644	3,293	3,519	(3)
Japan	2,335	4,232	2,920	7,967	(3)
Netherlands	9,968	11,056	10,579	12,243	5,190
Sweden	3,591	3,938	3,687	2,824	(3)
United Kingdom	13,993	12,345	13,026	9,690	6,292
United States	51,754	79,086	29,365	25,241	13,589
Other countries	2,161	4,339	9,714	10,258	24,829
Total	100,673	133,338	84,689	90,651	[2] 49,900

[1] This table incorporates some revisions.
[2] January through June, inclusive.
[3] Data not separately recorded.

Compiled from Customs Returns of Australia by Corra A. Barry, Division of Foreign Activities.

Results of surface sampling and laboratory tests to determine the feasibility of recovering iron and titanium minerals from a titaniferous iron deposit in Colorado were reported.[32] Three NX-size holes were diamond drilled in the area to ascertain the mineralization at depth. Results of the examination indicated the presence of over 100 million tons of material containing 6.5 percent TiO_2.

Under a cooperative research agreement with Wah Chang Corp., methods were developed in a Bureau laboratory whereby titanium sponge metal with a hardness consistently less than 110 Brinell was made by the Kroll process.[33] The study showed that removal of residual atmospheric and other dissolved gases from the titanic chloride, careful regulation of the rate of feeding the titanium tetrachloride to the reaction, and preliminary dehydration of crude titanium sponge were important factors in lowering the Brinell hardness of the resulting sponge.

A theory on the reaction between sodium metal and titanium tetrachloride was developed.[34] Theoretical and experimental evidence indicated that the reduction reactions take place in a two-phase system consisting of sodium dissolved in sodium chloride and titanium chlorides dissolved in sodium chloride, the final reduction being electrochemical in nature.

Operating variables in consumable arc melting and casting of titanium metal and the methods developed for preparation and use of various mold materials were discussed in a report.[35] Design and operation of the casting furnace, safety considerations, and description of alloying methods were given. Development of laminated machined graphite and rammed graphite mold materials for casting reactive metals such as titanium was discussed. A method for cen-

[32] Rose, Charles K., and Shannon, Spencer S., Jr., Cebolla Creek Titaniferous Iron Deposits, Gunnison County, Col.: Bureau of Mines Rept. of Investigations 5679, 1960, 30 pp.

[33] Mark, W. M., Yih, S., Lo, C. L., and Baker, D. H., Jr., Methods for Improving Quality of Titanium Sponge Produced by the Kroll Process: Bureau of Mines Rept. of Investigations 5665, 1960, 29 pp.

[34] Henrie, T. A., and Baker, D. H., Jr., Mechanism of Sodium Reduction of Titanium Chlorides in Fused Salts: Bureau of Mines Rept. of Investigations 5661, 1960, 33 pp.

[35] Ausmus, S. W., Wood, F. W., and Beall, R. A., Casting Technology for Titanium, Zirconium, and Hafnium: Bureau of Mines Rept. of Investigations 5686, 1960, 31 pp.

trifugally casting a tubular titanium billet that was extruded to a tube of 2 1/16-inch outside diameter, 1 5/8-inch inside diameter by 17 feet long also was described.

Investigative work on chemical, optical emission, spectrochemical, and X-ray spectrographic methods for analyzing titanium metal for tin was described.[36]

The effect of additions of zirconium and cobalt on the microstructure and physical properties of titanium-vanadium alloys was determined.[37] Generally, zirconium strengthens solutions treated and aged titanium alloys containing 5 to 10 atomic percent (A/O) vanadium, but alloys containing over 30 A/O zirconium and vanadium combined were hot short and oxidized easily. None of the alloys containing up to 16 percent vanadium and up to 4 percent cobalt which were studied was stable with respect to complete retention of the beta phase. These alloys, solution treated and aged 4 hours at 500° C., were characterized by moderate strength and elongation.

The effect of major impurities such as oxygen, nitrogen, carbon, and iron on mechanical properties of electrolytic titanium was investigated.[38] Strength of electrolytic titanium was found to be a linear function of impurity content. Nitrogen was the most effective strengthener, followed by oxygen, then carbon. In the composition range where carbides are present, above 0.10 weight-percent carbon, strength of titanium-carbon alloys increased only slightly. Iron is a more effective strengthener of titanium than carbon, but its effects are attributed to the presence of transformed beta in the structure.

The microstructure and tensile properties of titanium-antimony alloys containing up to 5 percent antimony were studied.[39] Antimony strengthened the titanium by solid-solution hardening. The general relationship of hardness, strength, and elongation of these alloys is similar to that found in several grades of high purity and commerical titanium.

Industrial progress in titanium technology was indicated in several reports.

Operation of a pilot-plant chlorinator designed to produce 5 tons of $TiCl_4$ a day from ilmenite or titanium slag was described.[40] The plant, developed by the New Jersey Zinc Co., reportedly could be operated continuously with a briquetted charge of titanium slag, coal, and a binder. Iron and aluminum chlorides in the product gases were collected in a multistage condenser and removed from the condenser walls by a scraper.

A process was described for recovering sulfuric acid and an iron oxide suitable for blast furnace feed from the byproduct liquor ob-

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[36] Sullivan, T. A., Lewis, R. W., Carpenter, L., and Boyle, B. J., Methods for Analyzing Titanium Metal for Tin: Bureau of Mines Rept. of Investigations 5639, 1960, 14 pp.

[37] Ramsdell, J. D., and Hull, E. D., Properties of Titanium-Vanadium-Cobalt Alloys: Bureau of Mines Rept. of Investigations 5591, 1960, 13 pp.

Ramsdell, J. D., and Hull, E. D., Properties of Titanium-Vanadium-Zirconium Alloys: Bureau of Mines Rept. of Investigations 5604, 1960, 12 pp.

[38] Ramsdell, J. D., and Mathews, D. R., Effect of Impurities on Mechanical Properties of Electrolytic Titanium: Bureau of Mines Rept. of Investigations 5701, 1960, 12 pp.

[39] Ramsdell, J. D., and Lenz, W. H., Effect of Antimony on Tensile Properties of Titanium: Bureau of Mines Rept. of Investigations 5586, 1960, 11 pp.

[40] Chemical Engineering Progress, Chlorination of Titanium Ores in a Vertical Reactor: Vol. 56, No. 5, May 1960, pp. 68–72.

tained during the production of titanium dioxide from ilmenite.[41] Copperas ($FeSO_4 \cdot 7H_2O$), formed during production of titanium dioxide, was converted to the monohydrate and roasted in a multiple-bed fluidized roaster. The technique reportedly was used at the Pyewipe Works of British Titan Products, Ltd., to recover 70 tons of acid per day.

A skull melting furnace for melting up to 1,000-pound ingots from bulk titanium scrap was described in a report.[42]

A modified shell molding technique utilized graphite bonded with phenolic resin as mold material for casting titanium and other reactive metals.[43] Success of the technique was attributed to use of a slurry of alcohol and the powdered graphite and binder which was coated in a thin layer on a preheated pattern. A standard dry shell molding mixture was used to back up the thin coating. Sound titanium castings with surface quality as good as that produced with machined graphite molds reportedly were produced in these molds.

In a report on the technology of the fused salt electrolysis of titanium, W. J. Kroll discussed the status and perspective of various techniques which have been investigated.[44] Use of fused salts in general and the technical problems and potentials involved in their use were discussed in another report.[45] These reports emphasized the increasing technological importance of ionic liquids such as fused salts and the need for fundamental knowledge of their electronic properties such as that which is available on aqueous electrolytic solutions.

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[41] Chemical Age (London), Dorr-Oliver Process Recovers Sulfuric Acid and Iron from Effluents: Vol. 84, No. 2164, Dec. 31, 1960, p. 1075.

[42] Iron Age, New Furnace Permits Recovery of Reactive Metal Scrap: Vol. 185, No. 25, June 23, 1960, pp. 108–109.

[43] Westwood, A. R. C., New Breakthrough on Casting Titanium: Modern Castings, vol. 37, No. 3, March 1960, pp. 36–39.

[44] Kroll, W. J., The Fusion Electrolysis of Titanium: Chem. and Ind., No. 43, Oct. 22, 1960, pp. 1314–1322.

[45] Ellis, Richard B., Fused Salts: Chem. and Eng. News, vol. 38, No. 41, Oct. 10, 1960, pp. 96–106.

Tungsten

By Andrew S. Prokopovitsh[1] and Mary J. Burke[2]

DOMESTIC production of tungsten concentrate during 1960 was greater than in either of the 2 preceding years, principally because of the demand for tungsten metal. Foreign production also was larger, owing to increased world demand for tungsten in modern technology and despite a continuing decline in U.S. tungsten imports, which were the smallest in 15 years.

LEGISLATION AND GOVERNMENT PROGRAMS

In July, the U.S. Department of Agriculture announced that offers were being requested under the barter program to exchange surplus agricultural commodities in the Commodity Credit Corporation (CCC) inventory for all or part of 1.1 million pounds of tungsten carbide powder. Under terms of this barter, the tungsten concentrates would have to originate in friendly foreign countries and processing into tungsten carbide powder would have to be done in the United States. Delivery of the powder to the CCC had to be made within 22 months. The material delivered under this proposed transaction was to be transferred to the Supplemental Stockpile as authorized by the Agricultural Trade Development and Assistance Act of 1954 (P.L. 480).

TABLE 1.—Salient tungsten statistics

(Thousand pounds of contained tungsten)

	1951-55 (average)	1956	1957	1958	1959	1960
United States:						
Mine production	10,281	14,761	8,032	(1)	(1)	6,669
Mine shipments	10,199	14,027	5,254	3,605	3,473	6,972
Imports, general	19,498	21,857	14,186	6,873	6,248	5,178
Imports for consumption	19,348	20,860	14,018	6,542	5,435	3,525
Consumption	8,156	9,061	8,544	5,320	9,835	11,605
Stocks:						
Producer	338	1,477	4,326	(1)	(1)	2,402
Consumer and dealer	3,721	2,980	4,103	4,670	3,196	3,143
World: Production	70,618	78,898	[2] 65,193	[2] 53,963	[2] 55,961	66,240

[1] Figure withheld to avoid disclosing individual company confidential data.
[2] Revised figure.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

DOMESTIC PRODUCTION

U.S. mine production of tungsten increased substantially in 1960. As in the past, most of the tungsten produced domestically was a coproduct with molybdenum and was obtained principally from ores mined in western States.

The Pine Creek mine of Union Carbide Nuclear Co. near Bishop, Calif., and the Climax mine of American Metal Climax Inc. near Leadville, Colo., operated throughout the year. These two mines had accounted for virtually all domestic production in 1959 and 1958. Early in 1960 two additional mines, the Hamme mine of Tungsten Mining Corp., in Vance County, N.C., and the Calvert mine of Minerals Engineering Co. in Beaverhead County, Mont., resumed operation.

Several smaller mining and milling operations were reported in Colorado, Idaho, Nevada, and Washington.

CONSUMPTION AND USES

Consumption of tungsten concentrate exceeded by 18 percent the record peacetime consumption of 1959, and only during the high demand years of World War II was consumption greater than in 1960.

The continuing demand for tungsten metal and carbides resulted in new construction and expansion of existing processing facilities. General Electric Co. began constructing a tungsten carbide manufacturing plant at Houston, Tex., and a new metals plant at Cleveland, Ohio. Sylvania Electric Products, Inc., announced that a planned addition to its refractory-metals processing plant at Towanda, Pa., would double its tungsten production capacity. Metals and Residues, Inc., Springfield, N.J., installed additional reduction facilities which resulted in a large increase in productive capacity. Wah Chang Corp. moved its tungsten fabricating facilities from Union City, N.J., to a new plant at Fair Lawn, N.J.

Consumption increased in two of the major use categories. Compared with 1959, consumption of tungsten in pure metal uses increased 18 percent, and in carbides it increased 3 percent. Consumption of tungsten in high-speed and other alloy steels decreased 25 percent, in high-temperature and other nonferrous alloys 15 percent.

Carbides accounted for 41 percent of total consumption, cemented carbides for 31 percent, and cast carbides for 10 percent.

Data in table 5 include consumption of imported ferrotungsten, other imported products, and scrap. The nonferrous alloys include cutting and wear-resistant alloys, high-temperature and other superalloys, alloy welding rods, and electrical contact and resistance alloys. The pure metal uses include wire, rod, and sheet, as well as various shaped parts produced by powder metallurgy techniques.

TABLE 2.—Tungsten concentrate shipped from mines in the United States

Year	Quantity			Reported value, f.o.b. mines [1]		
	Short tons, 60 percent WO_3 basis	Short-ton units WO_3 [2]	Tungsten content (thousand pounds)	Total (thousands)	Average per unit of WO_3	Average per pound of tungsten
1951-55 (average)	10,716	642,963	10,199	$40,033	$62.26	$3.93
1956	14,737	884,323	14,027	51,201	57.90	3.65
1957	5,520	331,208	5,254	[3] 8,186	24.72	1.56
1958	3,788	227,255	3,605	3,991	17.56	1.11
1959	3,649	218,927	3,473	4,502	20.56	1.30
1960	7,325	439,530	6,972	9,815	22.33	1.40

[1] Values apply to finished concentrate and are in some instances f.o.b. custom mill.
[2] A short-ton unit equals 20 pounds of tungsten trioxide (WO_3) and contains 15.862 pounds of tungsten (W).
[3] Estimate.

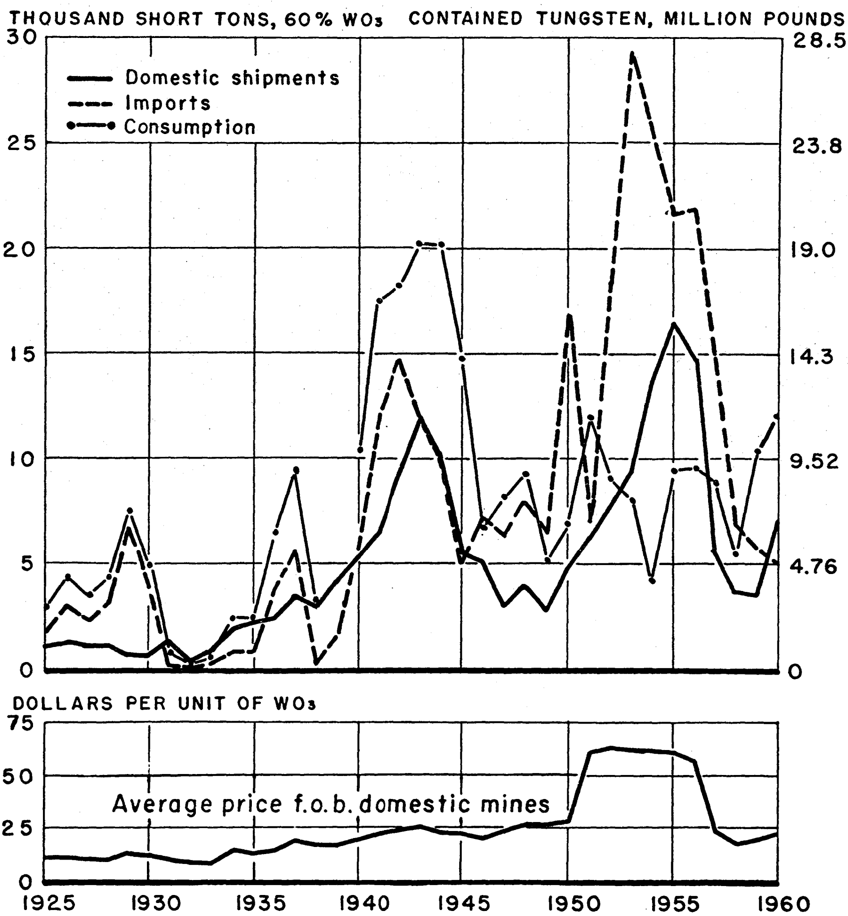

FIGURE 1.—Domestic shipments, imports, consumption, and average price of tungsten ore and concentrate, 1925–60.

TABLE 3.—Distribution of tungsten concentrate consumed

	Tungsten content (thousand pounds)		Short tons (60 percent WO_3)		Percent of total	
	1959	1960	1959	1960	1959	1960
Manufacturers of steel ingots and ferrotungsten	2,993	2,121	3,145	2,228	30	18
Manufacturers of hydrogen-reduced metal powder	4,810	5,691	5,054	5,980	49	49
Manufacturers of carbon-reduced metal powder and tungsten chemicals and consumption by firms making several products	2,032	3,793	2,135	3,986	21	33
Total	9,835	11,605	10,334	12,194	100	100

TABLE 4.—Production, shipments, and stocks of tungsten products in the United States in 1960

(Thousand pounds of contained tungsten)

	Product			
	Hydrogen- and carbon-reduced metal powder	Tungsten carbide powder (made from metal powder)	Chemicals	Other [1]
Received from other producers	2,181		1,168	750
Gross production during year	6,009	2,653	6,717	2,229
Used to make other products listed here	3,246		4,661	304
Net production	2,763	2,653	2,056	1,925
Shipments [2]	4,291	2,711	2,888	2,622
Producer stocks, Dec. 31	1,904	252	1,173	738

[1] Includes ferrotungsten, tungsten carbide powder (crystalline), scheelite (produced from scrap), nickel-tungsten, self-reducing oxide, crushed cast carbide powder, pellets, and scrap.
[2] Includes quantities consumed by producing firms for manufacture of products not listed here.

TABLE 5.—Consumption of tungsten products by end uses, in 1960

(Thousand pounds of contained tungsten)

End use	Ferrotungsten melting base, self-reducing tungsten, tungsten sponge mix, etc.	Carbon-reduced tungsten powder [1]	Hydrogen-reduced tungsten powder [1]	Tungsten carbide powder: Made from metal powder	Tungsten carbide powder: Crystalline and crushed cast	Chemicals	Scheelite (natural or synthetic)	Scrap	Other	Total
Steel:										
High speed	529	28	--------	--------	--------	--------	1,041	75	------	1,673
Hot work and other tool	225	12	--------	--------	--------	--------	96	72	------	405
Alloy (other than tool) [2]	121	10	2	--------	--------	--------	102	27	------	262
High-temperature nonferrous alloys [4]	51	14	117	--------	--------	4	117	213	4	520
Other nonferrous alloys [5]	13	8	155	19	36	338	1	45	2	617
Tungsten metal:										
Wire, rod, and sheet	--------	--------	1,243	--------	--------	--------	--------	------	------	1,243
Other	--------	--------	512	--------	1	--------	--------	------	3	516
Carbides:										
Cemented or sintered	--------	13	1	2,427	366	--------	--------	26	------	2,833
Other (including cast or fused)	--------	199	41	--------	572	--------	--------	103	------	915
Chemicals [6]	--------	--------	--------	--------	--------	112	--------	------	------	112
Total	939	284	2,071	2,446	975	454	1,357	561	9	9,096
Stocks at consumer plants Dec. 31	178	28	179	81	4	66	--------	250	2	788

[1] Includes tungsten metal pellets that may be hydrogen or carbon reduced or scrap.
[2] Does not include quantities consumed in making tungsten carbide powder.
[3] Includes steel mill rolls and stainless and other alloy steels.
[4] Includes cutting and wear-resistant alloys.
[5] Includes diamond-drill-bit matrices, electrical contact points, and welding rods.
[6] Includes fluorescent powders and organic and inorganic pigments.

STOCKS

Tungsten concentrate contained in the National Stockpile exceeded minimum and long-term objectives. Stocks of concentrate held by consumers and dealers at yearend decreased 2 percent. Producer stocks of tungsten products increased 60 percent.

PRICES AND SPECIFICATIONS

Steady or only slightly fluctuating prices of ore and concentrate, metal powder, and ferrotungsten characterized the domestic tungsten market.

Prices of domestic concentrate ranged from $22 to $25 per short-ton unit of tungsten trioxide (WO_3) f.o.b. mine or mill, and at yearend quoted prices were $22 to $24, slightly less than the duty-paid price of foreign ore.

Tungsten metal powder (98.8 percent in 1,000-pound lots) was quoted at $2.75–$2.90 throughout the year in E&MJ Metal and Mineral Markets.

The price of hydrogen-reduced tungsten-metal powder (99.99 percent) was $3.35–$4.25 from January 7 until September 1, and $3.90–$4.20 from September 1 until September 22. Thereafter, prices were quoted at $3.10–$3.90.

Ferrotungsten prices did not differ from the previous year's quotation of $2.15 per pound of contained tungsten (in lots of 5,000 pounds or more, ¼-inch lump, packed; f.o.b. destination, continental United States, 70–80 percent W).

TABLE 6.—Prices of tungsten concentrate in 1960

	Foreign ore per short-ton unit of WO_3, 65-percent basis c.i.f. U.S. ports, duty extra		London market, per long-ton unit of WO_3
	Wolfram	Scheelite	
Jan. 7	$18.25-$19	$18.25-$19	156s., 6d.
Feb. 4	19.50- 20	19.50- 20	157s., 6d.
Mar. 3	19.50- 20	19.50- 20	157s., 6d.
Apr. 7	19 - 19.50	19 - 19.50	147s., 6d.
May 5	18.75- 19.25	18.75- 19.25	145s.
June 2	19 - 19.25	19 - 19.25	157s., 6d.
July 7	20 - 20.25	20 - 20.25	157s.-162s.
Aug. 4	20 - 20.25	20 - 20.25	156s.-162s.
Sept. 1	20 - 20.25	20 - 20.25	155s.-161s.
Oct. 6	20 - 20.25	20 - 20.25	155s.-161s.
Nov. 3	18.50- 19	18.50- 19	148s.-153s.
Dec. 1	18.50- 19	18.50- 19	148s.-153s.
Average price	19.46	19.46	
Duty	7.93	7.93	
Average price duty paid	27.39	27.39	

Source: E&MJ Metal and Mineral Markets.

FOREIGN TRADE[3]

General imports of tungsten concentrate declined 17 percent compared with 1959. The decline was attributed to the availability, at competitive prices, of ammonium paratungstate produced from domestic ores.

About 83 percent of the total imports in 1960 came from Brazil, Australia, Portugal, and Bolivia, in order of importance. The remaining 17 percent came from 10 other countries. Imports of tungsten metal, tungsten carbide, and combinations containing tungsten or tungsten carbide in lumps, grains, or powder contained 159,759 pounds of tungsten valued at $369,711. Imports of ferrochromium tungsten, chromium tungsten, chromium cobalt tungsten, and other alloys not specifically provided for contained 36,666 pounds of tungsten valued at $61,758.

Imports of tungstic acid and other tungsten compounds contained tungsten valued at $264. Imports of tungsten or tungsten carbide scrap were 184,210 pounds, gross weight, valued at $227,429.

Exports and reexports of tungsten concentrate were 1,266,432 and 458,221 pounds, gross weight, respectively, valued at $1,250,565 and $343,049. There were no exports or reexports of ferrotungsten.

Exports of tungsten powder totaled 165,952 pounds valued at $973,689; reexports were 1,897 pounds valued at $2,201. Exports of tungsten metal and alloys in crude form and scrap were 773,360

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

pounds, gross weight, valued at $268,681; reexports were 10,106 pounds valued at $14,254.

Exports of semifabricated forms were 31,691 pounds gross weight valued at $796,645. Reexports were 72 pounds valued at $3,005.

TABLE 7.—U.S. imports for consumption of tungsten ore and concentrate, by countries

(Thousand pounds and thousand dollars)

Country	1959			1960		
	Gross weight	Tungsten content	Value	Gross weight	Tungsten content	Value
North America: Mexico	52	28	$49	2	1	$1
South America:						
Argentina				276	142	158
Bolivia	1,337	735	442	801	451	314
Brazil	1,957	1,144	1,136	936	560	618
Peru	555	311	210	115	66	82
Uruguay	8	3	5			
Total	3,857	2,193	1,793	2,128	1,219	1,172
Europe:						
Germany, West	87	46	23			
Netherlands	115	66	76	48	28	30
Portugal	1,409	780	647	1,713	1,017	1,146
Spain	102	53	32	13	8	5
Sweden	98	54	30			
United Kingdom				22	13	15
Total	1,811	999	808	1,796	1,066	1,196
Asia:						
Burma	357	195	132	228	128	123
Hong Kong	22	13	7	101	57	52
Korea, Republic of	1,431	798	428	396	225	116
Malaya	186	105	113			
Thailand	189	105	134			
Total	2,185	1,216	814	725	410	291
Africa: Congo,[1] Republic of the, and Ruanda-Urundi	559	314	219	201	113	88
Oceania: Australia	1,223	685	552	1,245	716	730
Grand total	9,687	5,435	4,235	6,097	3,525	3,478

[1] Effective July 1, 1960; formerly Belgian Congo.

Source: Bureau of the Census.

TABLE 8.—U.S. imports for consumption of ferrotungsten, by countries

(Thousand pounds and thousand dollars)

Country	1959			1960		
	Gross weight	Tungsten content	Value	Gross weight	Tungsten content	Value
Austria	190	150	$148	163	120	$150
France	27	22	29			
Germany, West	48	38	37	11	7	8
Netherlands	12	10	9			
Portugal	62	50	49			
Sweden	160	136	117	39	31	39
United Kingdom	159	127	137	11	9	10
Total	658	533	526	224	167	207

Source: Bureau of the Census.

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TABLE 9.—U.S. imports for consumption of tungsten or tungsten carbide forms

Year	Ingots, shot, bars, or scrap		Wire, sheets, or other forms, n.s.p.f.		Total	
	Gross weight (pounds)	Value	Gross weight (pounds)	Value	Gross weight (pounds)	Value
1951-55 (average)	227,976	$514,448	20,682	[1] $69,648	248,658	[1] $584,096
1956	485,583	840,271	168,103	578,328	653,686	1,418,599
1957	66,717	[1] 130,139	190,413	[1] 483,195	257,130	[1] 613,334
1958	53,299	57,543	196,190	348,179	249,489	405,722
1959	258,051	199,464	193,061	367,324	451,112	566,788
1960	184,945	233,425	174,877	528,035	359,822	761,460

[1] Data known to be not comparable with other years.

Source: Bureau of the Census.

WORLD REVIEW

NORTH AMERICA

Canada.—Canada Tungsten Mining Corporation, Ltd. expected to begin mining at its Northwest Territory tungsten discovery late in 1962. Tentative plans were to operate at a rate of 300 tons per day with the possibility of providing mill capacity for up to 500 tons daily. The tungsten occurrences consist of skarn-type replacement ore deposits with scheelite mineralization. The deposits are at elevations of 4,500 to 5,500 feet, and the main ore body has 1.32 million tons of tungsten ore, grading better than 2.5 units WO_3 per ton.

Mexico.—Tungsten output increased 43 percent compared with 1959 production.

Nicaragua.—In December, a Nicaraguan newspaper reported discovery of several tungsten-quartz veins containing wolframite and scheelite.

SOUTH AMERICA

Argentina.—The Government agency, Comité de Comercialización de Minerales (Cocomine), continued to purchase concentrate above market price. Of 840 tons produced, about 350 tons was exported. At yearend, some concentrate sold for more than U.S.$30 per ton unit during an auction staged in Buenos Aires by the Secretary of Industry.

Bolivia.—Messrs. Barton and Grillo took an option on the Chicote Grande wolframite deposit, reported to be the largest in Bolivia, and they planned to begin operating in the near future. The deposit contains 83 wolframite veins assaying between 1 and 7 percent WO_3. Part of the Taminani Llamperas deposit was being mined by Cesar Grillo for export.

Peru.—Pasto Bueno, owned by Fermín Málaga Santolalla e Hijos, continued to operate at reduced capacity, producing 34,345 short-ton units of WO_3. The output, however, was an increase of 6 percent over that of 1959. Almost all concentrate produced was exported. Canada, Japan, and the United States were the major recipients. Minor quantities were shipped to West Germany and Holland.

TABLE 10.—World production of tungsten ore and concentrate by countries [1]

(Short tons, 60 percent WO_3 basis)

Country	1951-55 (average)	1956	1957	1958	1959	1960
North America:						
Canada	1,343	1,893	1,602	575	----	----
Mexico	565	628	294	8	138	198
United States (shipments)	10,716	14,737	5,520	3,788	3,649	7,325
Total	12,624	17,258	7,416	4,371	3,787	7,523
South America:						
Argentina	771	1,293	1,441	1,127	827	[2] 840
Bolivia (exports)	4,427	5,255	4,809	2,457	2,671	2,370
Brazil (exports)	1,721	2,017	2,304	2,596	1,609	2,205
Peru	780	1,242	1,215	992	542	573
Total	7,699	9,807	9,769	7,172	5,649	5,988
Europe:						
Austria	----	----	140	146	152	243
Finland	74	74	----	163	42	----
France	1,208	1,348	1,091	1,108	973	825
Italy	22	30	20	10	6	9
Portugal	5,455	5,506	4,756	2,109	2,478	3,203
Spain	2,596	1,354	1,319	1.301	854	830
Sweden	459	504	557	660	375	391
U.S.S.R. [2]	8,300	8,300	8,800	9,400	9,900	10,500
United Kingdom	74	68	55	2	----	----
Yugoslavia	[3] 118	83	90	99	86	[2] 110
Total [2]	18,300	17,300	16,800	15,000	14,900	16,100
Asia:						
Burma [4]	2,138	2,982	2,873	1,667	2,122	1,755
China [2]	19,600	19,800	16,500	16,500	19,800	22,000
Hong Kong	73	30	42	46	47	39
India	9	2	2	----	1	3
Japan	674	1,200	1,144	881	1,446	1,091
Korea:						
North [2]	1,650	2,190	2,665	3,300	4,400	5,500
Republic of	4,643	4,472	4,567	3,597	3,492	5,870
Malaya	115	117	63	57	24	46
Thailand	1,574	1,411	1,080	725	553	486
Total [2]	30,500	32,200	28,950	26,800	31,900	36,800
Africa:						
Algeria	22	----	----	----	----	----
Congo, Republic of the (formerly Belgian) and Ruanda Urundi [4]	1,332	2,142	1,914	1,479	1,209	1,138
Morocco: Southern zone	18	3	----	----	----	----
Nigeria	15	4	----	----	----	----
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	333	287	180	103	36	11
South-West Africa [4]	188	388	278	64	2	154
Tanganyika (exports)	12	7	----	----	----	----
Uganda (exports)	184	193	224	31	14	84
Union of South Africa	461	330	290	61	42	37
United Arab Republic (Egypt Region)	14	----	----	----	----	----
Total	2,579	3,354	2,886	1,738	1,303	1,424
Oceania:						
Australia	2,491	2,954	2,629	1,587	1,218	[2] 1,760
New Zealand	44	33	36	3	11	[2] 11
Total	2,535	2,987	2,665	1,590	1,229	[2] 1,770
World total (estimate)	74,200	82,900	68,500	56,700	58,800	69,600

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] Estimate.
[3] Average for 1953-55.
[4] Including WO_3 in tin-tungsten concentrates.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

EUROPE

Portugal.—Wolframite concentrate production increased 23 percent over 1959; scheelite concentrate production increased 28 percent. A number of mines were inoperative.

U.S.S.R.—Shipments of tungsten concentrate to the European market were reported. Export of concentrate to West Germany was scheduled at 2,300 tons in 1961, compared with 1,650 tons in 1960 and 1,320 tons in 1959. Shipments of tungsten ores and concentrates to the United Kingdom amounted to 712 tons values at $900,000 in 1960, compared with 188 tons valued at $160,000 in 1959.

United Kingdom.—The United Kingdom imported tungsten concentrate from at least 15 countries in 1960. Bolivia, Brazil, Czechoslovakia, Republic of Korea, the U.S.S.R., Spain, and the United States supplied most of the imports.

Yugoslavia.—Tungsten output of the Yugoslav gold-tungsten combine in Blagojev Kamen was increased by opening new workings. Further plans included a new plant, to be completed early in 1962, to process domestic and imported ores at an annual production rate of 400 tons of ferrotungsten and tungstic oxide.

ASIA

China.—China was the foremost tungsten producer. Reportedly, Chinese tungsten technology was greatly improved; mines had been modernized, mills had been enlarged, and more advanced techniques had been adopted.

India.—India Hard Metals Ltd. of Calcutta, in collaboration with Wickman Ltd. of England, was establishing a factory to produce tungsten carbide powder, tips, and tools.

Korea, Republic of.—As a result of the tapering off of the export market, the output of tungsten declined in the fourth quarter of 1960. However, production for the year exceeded that of 1959.

Thailand.—Tungsten concentrate output in Thailand decreased 12 percent in 1960 compared with 1959. Exports of tungsten concentrate totaled 740 tons, compared with 460 tons in 1959. Of the 1960 total, 360 tons was exported to Japan, 145 tons to the Netherlands, and the remainder to Canada, France, West Germany, and the United Kingdom. Stocks of tungsten concentrate on hand January 1960 totaled 1,310 tons.

AFRICA

Congo, Republic of the, and Ruanda-Urundi.—Production of tungsten was concentrated in several firms operating in the Kivu and in Ruanda-Urundi, notably Kinorétain and Synétain. The principal producers in the Kivu were believed to have maintained their production rates.

Uganda.—Production of wolfram increased substantially. Exports of wolfram rose from 12 tons in 1959 to 143 tons in 1960.

OCEANIA

Australia.—King Island Scheelite, Ltd. resumed limited mining operations in early 1960; by November the firm reportedly concluded a

2-year agreement for the sale of its scheelite and began operating on a 5-day, three-shift-per-week basis.

TECHNOLOGY

Research on tungsten centered mainly on techniques to improve its purity, ductility, fabrication, and high-temperature oxidation resistance.[4]

Application research, especially alloy, flame spraying, and sheet rolling, resulted in an upsurge in consumption of the pure metal.

The Federal Bureau of Mines tungsten research program included studies on preparing and evaluating pure tungsten metal, its alloys, and compounds. Thermodynamic studies of tungsten oxides resulted in new low-temperature heat-capacity data.[5]

Tungsten deposits in Arizona and resources in Montana were investigated and described in Bureau publications. The Bureau also published reports describing milling, mining methods, and costs.[6]

Other Government-sponsored research programs to develop tungsten-base alloys and sheets having specific properties were in progress, and a technical description of the status of tungsten sheet-rolling was given.[7]

A major tungsten sheet-rolling program was initiated by the U.S. Navy, Bureau of Naval Weapons, with the assistance of the Materials Advisory Board of the National Academy of Sciences. Emphasis was placed on thin-gage sheet with exceptional surface quality and gage control. An advisory panel was formed, composed of members representing producers, users, research organizations, and Government agencies. The panel established tungsten sheet requirements for immediate (3 to 5 years) and more distant periods, technical requirements, coatings, quality specifications, test methods, and chemical analysis.

Several firms expanded their producing and fabricating plants throughout the year. New tungsten processing facilities, completely sealed from the atmosphere and filled with argon gas, were constructed for forging and rolling tungsten metal at high temperatures without oxidation and atmospheric contamination.[8]

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[4] Goetzel, C. G., Venkatesan, P. S., and Bunshah, R. F., Development of Protective Coatings for Refractory Metals: Wright Air Development Division Technological Report 59–405, February 1960, 50 pp.

[5] King, E. G., Weller, W. W., and Christensen, A. U., Thermodynamics of Some Oxides of Molybdenum and Tungsten: Bureau of Mines Rept. of Investigations 5664, 1960, 29 pp.

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[7] Jaffee, R. I., Harris, W. J., and Promisel, N. E., Development of Refractory Metal Sheet in the United States: Jour. Less-Common Metals, vol. 2, April/August 1960, pp. 95–193.

[8] American Metal Market, vol. 67, No. 113, June 14, 1960, p. 10.

Operations were remotely controlled from the outside, but observers clad in protective clothing could remain within for observation and corrective action. Inert fabrication facilities such as these may greatly advance the technology and use of tungsten.

Vapor-deposited pure tungsten was found to be one of the most satisfactory materials for high-temperature nozzle liners in solid-propellent atmosphere and space uses.[9]

The Bureau of Mines was active in developing and adapting the tungsten hexafluoride coating process for such applications. Another important coating process was flame-spraying tungsten carbide on base materials. A comprehensive and up-to-date description of the production, chemical properties, and applications of cemented tungsten carbides was published.[10]

Single homogeneous crystals of pure tungsten produced as cylinders a quarter of an inch in diameter and over 1 foot long were reported made in a similar manner to the Verneuil flame-fusion process.[11]

Spherical metal powders with uniform particles ranging in size from 20 to 150 microns were produced for use in parts requiring controlled porosity. Also made were tungsten alloy powders capable of yielding true solid-solution alloy products.

Tungsten metalworking processes based on explosives or the sudden release of electrical energy received considerable attention and were described in several publications.[12]

Porous tungsten permeable to water at atmospheric pressure was reported produced by a sintering process that had promise as a transpiration-cooled composite when infiltrated with metals such as copper or aluminum.[13]

Intensive reviews and bibliographies with over 3,000 references concerning tungsten and its properties, alloys, and compounds were published.[14]

The fabricable range for tungsten-rhenium alloys was determined, and data on bend ductility and tensile properties were published.[15]

Progress was made in extruding tungsten at high temperatures from billets prepared by powder metallurgy methods.

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[9] Perkins, R. A., Refractory Materials Research and Development; Aerojet-General Corp., pres. at Working Group on Refractory Materials, Sacramento, Calif., July 1960.

[10] Schwarzkopf, P., and Kieffer, R., Cemented Carbides: MacMillan Company, New York, N.Y., 1960, 349 pp.

[11] Science Service Inc., Chemistry, vol. 34, No. 4, December 1960, p. 13.

[12] Wagner, H. J., and Boulger, F. W., High Velocity Metalworking Processes Based on the Sudden Release of Electrical Energy: Battelle Memorial Inst. DMIC Rept. 70, Oct. 27, 1960, 15 pp.

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[13] Missiles and Rockets, vol. 7, No. 12, Sept. 19, 1960, p. 82.

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[15] Klopp, W. D., Holden, F. C., and Jaffee, R. I., Further Studies on Rhenium Alloying Effects in Tungsten: Battelle Memorial Inst., July 12, 1960, 32 pp.

Welding and brazing of tungsten metal were subjects of continuing study by several organizations, and a number of techniques were described.[16]

Metallic tungsten crystal fibers of microscopic size having high tensile strength were reported capable of imparting unusual strength to metals, ceramics, and composites.[17]

Listed among the patents granted were several regarding recovery, refining, and processing.[18]

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Gibbs, E. F., and Others, Frontiers of Welding Progress: Metal Progress, vol. 78, No. 1, July 1960, pp. 84–115.

[17] McDanels, D. L., Jech, R. W., and Weeton, J. W., Metals Reinforced With Fibers: Metal Progress, vol. 78, No. 6, December 1960, pp. 69, 118–121.

[18] Pilloton, R. L., Crayton, P. H. (assigned to Union Carbide Corp., New York), Process for Recovering Tungsten Values From Tungsten-Bearing Ore; U.S. Patent 2,963,342, Dec. 6, 1960.
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Uranium

By Don H. Baker, Jr.[1]

DOMESTIC uranium-ore production in 1960 was the highest in history, with over 1,000 mines producing nearly 8 million short tons of ore valued at $152 million. The ore was processed by 25 mills yielding 17,646 tons of concentrate valued at about $330 million. Free world uranium production totaled over 42,290 tons of U_3O_8 (uranium oxide), compared with about 43,000 tons in 1959 and 36,000 in 1958. Reorientation of uranium mine and mill production because of a stretchout of procurement policies was evident in the free world.

TABLE 1.—Salient uranium statistics

(Short tons)

	1956	1957	1958	1959	1960
United States:					
Production:					
Mine (ore shipments)	[1] 3,500,000	3,695,478	5,178,315	6,934,927	7,970,211
Mill (U_3O_8 content)	6,000	8,640	12,560	16,390	17,646
Imports:					
Ore and concentrate (U_3O_8 content)	7,500	11,826	16,500	18,120	15,770
World:					
Production (U_3O_8 content)	14,470	23,470	36,450	36,250	41,140

[1] Estimate.

Although peaceful uses of the commodity were being investigated and developed, uranium's chief use was for military applications. A total of 163 nuclear reactors of different types were in operation, in the United States by the end of 1960. The authorized nuclear naval fleet of the United States comprised some 49 vessels. The cooperation of the United States in sharing data about peaceful uses of atomic energy with foreign countries was broadened through agreements with the European Atomic Energy Community (Euratom), the International Atomic Energy Agency (IAEA), the Inter-American Nuclear Energy Commission, and the Organization for European Economic Cooperation (OEEC).

LEGISLATION AND GOVERNMENT REGULATIONS

On July 1, 1960, the Atomic Energy Commission (AEC) established the Atomic Energy Commission Procurement Regulations (AECPR), to be incorporated into the Federal Procurement Regulations System (FPR).

[1] Commodity specialist, Division of Minerals.

The FPR is intended to eliminate inconsistencies between procurement policies and procedures of individual Federal Government agencies, and to make the agencies' procurement regulations more readily available.

The AECPR will be published in the Federal Register and in loose-leaf form.

The AEC revised its regulations for the protection of employees in atomic energy industries and the general public against hazards arising from the possession or use of AEC-licensed radioactive materials. The revisions are embodied in amendments to Title 10, Chapter 1, Part 20, of the Code of Federal Regulations entitled "Standards for Protection Against Radiation." The amendments became effective on January 1, 1961.

On July 2, 1960, a proposed amendment to permit the use of tritium on timepieces was published in the Federal Register. Tritium is a radioactive material that emits no penetrating gamma radiation. Its use in place of radium as the activating agents for phosphorus on the hands and dials of luminous timepieces would reduce the amount of exposure to radiation of users. The amendment has been made to Part 30, Title 10, of the Code of Federal Regulations.

DOMESTIC PRODUCTION

Mine Production.—Uranium-ore production in the United States reached a new high in 1960, totaling 8 million dry tons valued at nearly $152 million, a 15-percent increase over the 6.9 million tons valued at $141 million in 1959. The United States was the largest free world producer. Producing States in order of value of mine production were New Mexico, Wyoming, Colorado, Utah, Arizona, Washington, Texas, South Dakota, Nevada, Idaho, Montana, Oregon, Alaska, California, and New Jersey.

TABLE 2.—Uranium mine production in 1960

State	Ore shipped		U_3O_8 content	
	Short tons	Value (thousands)	Percent	Pounds
Arizona	283,684	$6,219	0.27	1,531,880
Colorado	1,149,583	23,462	.25	5,747,900
Montana	1,726	29	.21	7,240
New Mexico	3,793,494	61,827	.21	15,932,660
South Dakota	41,104	586	.19	156,180
Utah	1,089,757	27,843	.30	6,538,540
Washington	171,255	3,223	.23	787,760
Wyoming	1,357,225	27,387	.25	6,786,120
Other [1]	82,383	1,612	.24	395,400
Total	7,970,211	152,188	----------	37,883,680

[1] Includes Alaska, California, Idaho, Nevada, New Jersey, Oregon, and Texas.

The AEC's program of bonus payments for initial production from new domestic sources of uranium ores expired on March 31. During the life of this program, March 1, 1951, to March 31, 1960, bonuses of $17.7 million were paid for production of 5.4 million pounds of U_3O_8.

Mill Production.—Domestic uranium concentrate production in 1960 totaled 17,646 tons of U_3O_8 valued at about $330 million, compared with 16,390 tons valued at approximately $300 million in 1959.

Concentrate was produced by 25 mills, and 1 additional mill was under construction. Contracts between the AEC and certain mills were amended to provide for the purchase of concentrates through the 1962–66 period. Of the 25 mills operating, 13 had contracts extending through 1966 and 2 had contracts terminating in 1965 because of limited eligible ore supply. Extension of other milling contracts will be considered in light of eligible ore reserves tributary to the mill. In most instances, extensions were based upon ore reserves developed before November 24, 1958. The new contracts provided that after March 31, 1962, with a few minor exceptions, a price of $8 per pound of U_3O_8 would be paid.

In addition to the mills operating there were two proposed mills. A contract held by Petrotomics Co. provided that the company could, at its option, construct a mill in Carbon County, Wyo., for production of U_3O_8 in the 1962–66 period or make arrangements with existing mills. A second mill was planned at Bowman, N. Dak., by

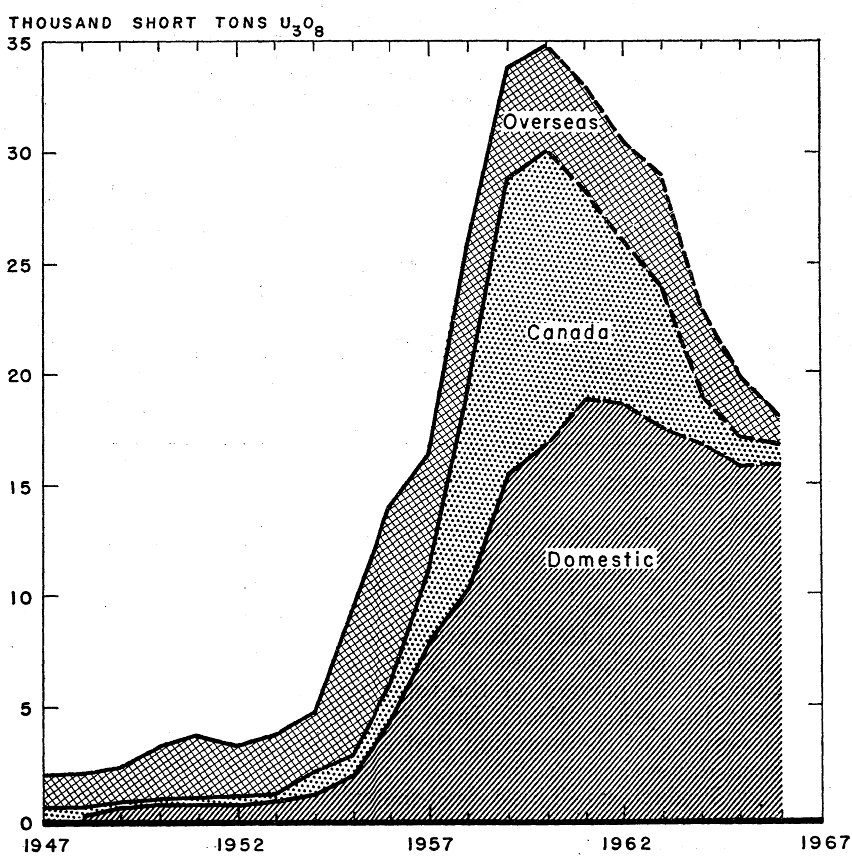

FIGURE 1.—Domestic and foreign U_3O_8 procurement, 1947–66.

International Resources Corp. The negotiations for this mill were based on the construction of a plant to process uraniferous lignites. The pending contract called for a plant to process 200 tons of lignite a day, with a provision for increasing the capacity to 600 tons per day after March 31, 1962. Two previously proposed mills, on the Colorado front range and at Austin, Nev., were dropped from consideration, and existing mill capacity in other areas will handle the output of mines in these areas.

TABLE 3.—Uranium processing plants, December 31, 1960

State and company	Plant location	Present contract terminates	Tons of ore per day	Estimated cost (thousands)
Arizona:				
Rare Metals Corporation of America	Tuba City	Mar. 31, 1962	300	$3,600
Colorado:				
Climax Uranium Co	Grand Junction	Dec. 31, 1966	330	3,088
Cotter Corp	Canon City	Feb. 28, 1965	200	1,800
Gunnison Mining Co	Gunnison	Mar. 31, 1962	200	2,025
Trace Elements Corp	Maybell	do	300	2,208
Union Carbide Nuclear Co	Rifle	do	1,000	8,500
Do	Uravan	do	1,000	5,000
Vanadium Corporation of America	Durango	do	750	813
New Mexico:				
The Anaconda Company	Bluewater	Dec. 31, 1966	3,000	19,358
Homestake-New Mexico Partners	Grants	Mar. 31, 1962	750	5,325
Homestake-Sapin Partners	do	Dec. 31, 1966	1,500	9,000
Kermac Nuclear Fuels Corp	do	do	3,300	16,000
Kerr-McGee Oil Industries, Inc	Shiprock	June 30, 1965	300	3,161
Phillips Petroleum Co	Grants	Dec. 31, 1966	1,725	9,500
Oregon:				
Lakeview Mining Co	Lakeview	Nov. 30, 1963	210	2,600
South Dakota:				
Mines Development, Inc	Edgemont	Mar. 31, 1962	400	1,900
Texas:				
Susquehanna-Western, Inc.[1]	Falls City	Dec. 31, 1966	200	2,000
Utah:[2]				
Texas-Zinc Minerals Co	Mexican Hat	do	1,000	7,000
Uranium Reduction Co	Moab	do	1,500	11,172
Vitro Chemical Co	Salt Lake City	Dec. 31, 1962	600	5,500
Washington:				
Dawn Mining Co	Ford	Dec. 31, 1966	400	3,100
Wyoming:				
Federal-Radorock-Gas Hills Partners	Gas Hills	do	520	3,370
Globe Mining Co	Natrona County	do	490	3,100
Susquehanna-Western, Inc	Riverton	do	500	3,500
Utah Construction & Mining Co	Gas Hills	do	980	6,900
Western Nuclear Inc	Split Rock	do	845	4,300
Total			22,300	143,820

[1] Under construction.
[2] AEC-owned mill at Monticello shut down in December 1959.

Domestic uranium concentrate procurement from fiscal year 1943 through fiscal year 1959 was over 45,000 tons of U_3O_8. Foreign procurement during this period totaled 80,750 tons. Slight peaks in figure 1 for fiscal years 1954 and 1958 indicate beginning deliveries for South Africa and Canada, respectively.

Concentrate receipts from domestic sources in 1960 constituted approximately 52 percent of the total procurement, compared with 48 percent last year. From June 30, 1962, through December 31, 1966, 84 percent of the uranium that AEC is committed to buy will come from domestic sources.

Refinery Production.—Three feed-material plants refined uranium concentrates from foreign and domestic sources. Two refineries were Government-owned plants operated under AEC contracts, and one was privately owned. The operators and locations were as follows:

Mallinckrodt Chemical Works, Weldon Springs, Mo.; National Lead Co., Fernald, Ohio; and the privately owned Allied Chemical Corp., Metropolis, Ill.

Raw material receipts at these feed processing plants were in line with the current requirements of AEC. An indication of the extent to which procurement of commercial processing of fuel from commercial sources had increased is given in table 4, which shows enriched uranium furnished in the form of uranium hexafluoride compared with that furnished in a form requiring processing in AEC facilities.

TABLE 4.—Enriched uranium furnished to all sources excluding the weapons production chain

(Pounds)

	Fiscal year				
	1956	1957	1958	1959	1960
Furnished as UF_6	----------	13,230	52,910	243,170	190,040
Furnished in forms other than UF_6	5,290	8,200	46,300	13,890	7,500
Total	5,290	21,430	99,210	257,060	197,540

Although enriched uranium furnished in 1956 required processing beyond the uranium hexafluoride stage in AEC facilities, in 1960, 96 percent was processed beyond this stage in commercial plants.

TABLE 5.—Employment in domestic uranium mills

Fiscal year	Number of employees	Fiscal year	Number of employees
1953	1,350	1957	2,413
1954	1,619	1958	2,857
1955	1,840	1959	3,185
1956	2,059	1960	3,535

Firms producing uranium fuel materials commercially included: W. R. Grace & Co., Davison Chemical Division, Erwin, Tenn.; M & C Nuclear, Inc., Attleboro, Mass.; Mallinckrodt Nuclear Corp., subsidiary of Mallinckrodt Chemical Works, Hematite, Mo.; National Lead Co., Fernald, Ohio; Nuclear Materials and Equipment Corp., Apollo, Pa.; Spencer Chemical Co., Kansas City, Mo.; Vanadium Corporation of America, New York, N.Y.; Var-Lac-Oid Chemical Co., New York, N.Y.; and Vitro Engineering Co., New York, N.Y.

Production of Fissionable Material.—Enriched uranium (U235) was produced in three Government-owned gaseous diffusion plants operated by private industry. They were: Union Carbide Nuclear Co., Oak Ridge, Tenn., and Paducah, Ky.; and Goodyear Atomic Corp., Portsmouth, Ohio.

Plutonium and related reactor products, intended primarily for use in weapons, were produced in Government facilities by General Electric Co., at the Hanford Works, Hanford, Wash., and by E. I. du Pont de Nemours & Co., Inc., at the Savannah River plant, Aiken, S.C.

Nuclear Fuel Processing.—The AEC in 1960, through five of its plant facilities, reprocessed spent fuel elements for reactor operators. Irradiated fuels were received for processing at the following facilities: Chemical Processing Plant, National Reactor Testing Station, Idaho; Oak Ridge National Laboratory, Oak Ridge, Tenn.; Savannah River plant, Aiken, S.C.; and Hanford Works, Richland, Wash.

Fuel elements from specific reactors were assigned to the closest practicable site for reprocessing. This service was offered by the AEC only until such time as commercial services become available. An industrial group at yearend was studying the economic feasibility of a plan to provide suitable privately owned reprocessing facilities, a key requirement for a self-sufficient nuclear power industry.

CONSUMPTION AND USES

Uranium was used in AEC programs chiefly as material for weapons production and as fuel for nuclear reactors.

Production Reactors.—Plutonium produced in eight graphite-type production reactors in Hanford, Wash., and in five heavy-water-type reactors in Savannah River, S.C., was delivered to the weapons stockpile. The New Production Reactor (NPR) under construction at Hanford, Wash., was of the graphite type, but unlike the other eight, power could be generated from the cooling water if necessary.

Civilian Reactors.—Of the total of 147 civilian reactors in the United States at the end of 1960, 84 were operable, 48 under construction, and 15 planned. In addition, 15 had been operated and then dismantled. Three central station electric prototype plants with a combined output of 350,000 kilowatts were in operation. These were the Shippingport Atomic Power Station, Shippingport, Pa.; Dresden Nuclear Power Station, Morris, Ill.; and Yankee Atomic Electric Co., Rowe, Mass. An additional 350,000 kilowatts of capacity was scheduled to go into production in 1961.

Construction of the nuclear ship *Savannah* was essentially completed in 1960. Initial criticality test of the ship's pressurized water propulsion plant was scheduled for early 1961.

A summary of the types of civilian reactors is presented in table 6.

The planned growth of the U.S. nuclear electric energy capacity for 1961 and 1962 was a little better than double the capacity that went criticial during 1960 as indicated in figure 2.

Of the 53 test and research reactors used in teaching, 35 were operable, 16 being built, and 2 planned at the end of 1960. Twenty-six of the reactors in operation, and 7 of the 18 being built or planned were for universities.

Military Reactors.—The U.S. Navy had 46 nuclear submarines and 3 nuclear surface ships in operation, under construction, or authorized at the end of 1960. The Navy had 14 nuclear-powered craft in operation in 1960, and launched an additional 9 nuclear-powered craft, including 8 submarines and 1 aircraft carrier. There were 24 under various phases of construction. Thirty-seven of the 46 submarines of the nuclear fleet will use the highspeed submarine reactor known as the S5W. The nuclear fleet established innumerable firsts for seagoing vessels during the year. Other reactor plants to see service in naval vessels were the S3G, S1C, A1W, and the D1G. Total military re-

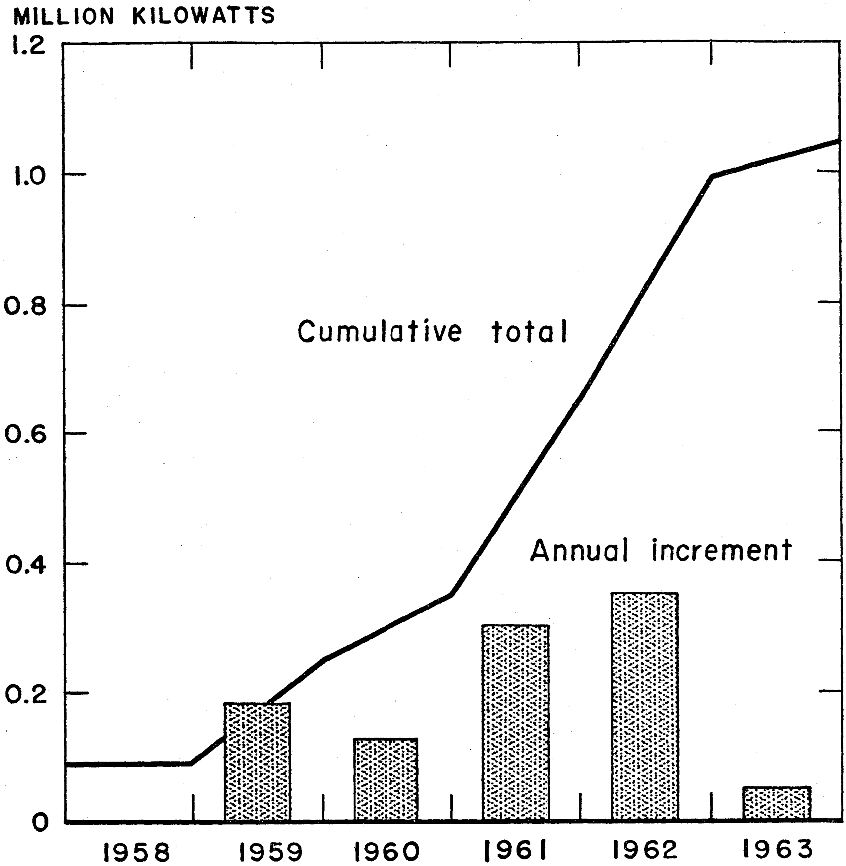

Figure 2.—Growth of U.S. nuclear electric energy capacity, 1958–63.
Source: AEC Annual Report for 1960.

actors were 105, of which 33 were operable, 59 being built, and 13 in the planning stages. Naval propulsion reactors accounted for 59 of this total.

Reactors for Export.—A total of 57 reactors (28 operable, 20 being built, and 9 in the planning stage) were in the works. Power reactors accounted for 7; test, research, and teaching reactors accounted for 50. Central station electric power reactors for export were being built for Italy and West Germany, and others were in the planning stage for France and Japan. A propulsion-type reactor of the S5W type was being built for Great Britain. Testing, research, and teaching reactors were built, or being planned for the following countries: Sweden, Japan, Netherlands, Austria, Brazil, Canada, Denmark, West Germany, Israel, Italy, Spain, Switzerland, Venezuela, Taiwan, Greece, Iran, Philippines, Portugal, Thailand, Turkey, Pakistan, Union of South Africa, Viet Nam, Republic of Korea, Finland, Indonesia, and Yugoslavia.

A total of 18 reactors were being used in the United States for material production and process development, making a total of 163 nuclear

TABLE 6.—Civilian reactors dismantled, operable, being built, and planned

	Operated, later dismantled	Operable	Being built	Planned
Power reactor prototypes:				
Prototypes, large central station plants	----	3	6	5
Prototypes, small central station plants	----	----	4	1
Prototypes, maritime propulsion (seagoing)	----	----	1	----
Experimental reactors and reactor experiments:				
Experimental power reactors (generate electricity)	----	3	4	----
Power reactor experiments (token electrical production, if any)	5	4	4	----
Maritime propulsion experiments	----	----	----	1
Space propulsion experiments (rover)	3	----	----	1
Process heat experiments	----	----	----	2
Test and research reactors:				
General irradiation test (Government-owned)	----	2	1	1
General irradiation test (privately-owned)	----	2	----	----
Special test	----	9	3	----
Research	4	26	9	2
Teaching	3	35	16	2
Total	15	84	48	15

Source: AEC Annual Report for 1960.

TABLE 7.—Military reactors operable, being built, and planned

	Operable	Being built	Planned
Defense power reactor applications:			
Electric power reactors, remote installations	1	2	----
Propulsion reactors (Naval)	14	45	----
Developmental power reactors:			
Electric power reactor experiments and prototypes	3	2	1
Systems for nuclear auxiliary power (SNAP)	1	2	4
Naval propulsion reactor prototypes	5	1	1
Aircraft propulsion reactor experiments	2	1	1
Missile propulsion reactor experiments	----	1	2
Test and research:			
Testing reactors	5	3	----
Research reactors	2	2	4
Total	33	59	13

reactors of various types operating in the United States at the end of 1960.

Radioisotopes.—Uses of radioisotopes continued to increase, although shipments from AEC laboratories declined 14 percent due to a 9-month shutdown of the Fusion Product Pilot Plant (F3P) for remodeling. When the F3P was ready to resume operation at yearend, there was a backlog of orders for radioisotopes which represented many times the total shipped during the previous year. As of November 30, 1960, a total of 191,122 curies valued at $1.9 million had been shipped, compared with 222,703 curies valued at $2.0 million for a like period in 1959. Sale of isotopes from Oak Ridge, Tenn., since the beginning of public distribution in 1946 totaled 1,105,026 curies. Shipments of isotopes to foreign countries continued to increase. The AEC and private processors made 4,857 shipments during 1960, compared with 3,252 shipments during 1959.

Imports of radioactive isotopes from foreign suppliers, primarily Belgium, France, Israel, Canada, and the United Kingdom, also continued to increase.

Price reductions were made on carbon–14, cobalt–60 and other radioisotopes during early 1960.

Abbott Laboratories, using a commercially owned reactor, began producing iodine–131, the first private production of a radioisotope for commercial sale. General Electric Co. and Westinghouse Electric Corp., both announced intentions to use their test reactors for commercial production of cobalt–60.

The AEC encouraged private industry to provide services previously available only from AEC facilities. During the first 11 months of 1960, 1,713 byproduct material licenses and 5,151 amendments and renewals of existing licenses were issued, 252 to Federal and State laboratories, 284 to industrial firms, 357 in the field of medicine, and 54 to users in other fields. The increase in licensees during 1960 was 490, 40 percent of which were for industrial use.

Radioisotopes distributed from Oak Ridge, Tenn., in descending order of magnitude by curies, were cobalt–60, cesium–137, iridium–192, hydrogen–3, krypton–85, promethium–147, iodine–131, strontium–90, phosphorous–32, and carbon–14. These 10 isotopes comprised more than 99 percent of all radioisotopes prepared.

Weapons.—Production of nuclear weapons by AEC continued during 1960 as authorized by President Eisenhower. Production efforts included meeting new weapon system capabilities, modernization of older and less efficient designs in stockpile, and a retirement program for obsolete weapons. The ban on nuclear testing continued.

A special metal-fabrication plant at Oak Ridge, Tenn., was constructed to meet weapons production requirements, and construction of a $2 million plant began at Los Alamos Scientific Laboratories, Los Alamos, N. Mex., to treat radiochemical contaminated liquid waste.

The program on detection of seismic effects resulting from nuclear explosions continued with a series of nonnuclear high-explosive tests at the Nevada Test Site during 1960.

Other Uses.—The AEC's Plowshare program of research and development to investigate possible uses of nuclear explosives included theoretical studies and laboratory and field experiments with high explosives. Research for possible use of depleted uranium and uranium compounds continued, chiefly by Government agencies.

Sales of U_3O_8 concentrates outside of the AEC continued to increase. In the first 6 months, a total of 7,308 pounds had been sold as compared with 8,188 pounds in 1959.

PRICES AND SPECIFICATIONS

Uranium Ore and Concentrate.—Purchase prices for uranium ore established by AEC remained in effect during 1960. Minimum base prices for ores of various types and grades were guaranteed under AEC Domestic Uranium Program Circular 5 (revised) which expires March 31, 1962. An initial production bonus on the first 5 tons of U_3O_8 sold from an eligible mining property, guaranteed under Circular 6, expired March 31, 1960. Haulage and mine development allowances remained in effect. Circulars 5 (revised) and 6 were published in the Uranium and Radium chapter of the 1954 Minerals Yearbook and in Part 60, Title 10, Code of Federal Regulations. Through the period ending March 31, 1962, the price per pound paid for concentrates varies from mill to mill.

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For U_3O_8 purchased after March 31, 1962, the price paid by the AEC, with a few minor exceptions, will be the established price of $8.00 per pound. These exceptions include final deliveries under contracts terminating March 31, 1962, some deferred deliveries as a result of stretchout provisions, and some contracts extended beyond that date. Seventeen uranium concentrate procurement contracts with milling companies were extended in accordance with AEC's announcement of November 24, 1958, which provided for the purchase of uranium concentrates (U_3O_8) in the 1962–66 period.

AEC contracts for the post-1962 period have many similar provisions. The ores to be treated will come only from properties designated in the contracts. The contracts give AEC the option of adding, at any time, specified quantities of U_3O_8 produced by independent mine operators from eligible properties. Subject to suitable license arrangements, there are no restrictions on commercial sales by milling companies above the amount to be sold to AEC. The aggregate quantity of U_3O_8 and concentrates contracted for as of July 1, 1960, for all outstanding contracts was approximately 95,337 tons of U_3O_8, of which 37,153 tons was scheduled for delivery in the pre-1962 period and 58,184 tons in the post-1962 period.

Uranium Metal.—The price of natural uranium metal made available by the AEC to qualified licensed buyers remained at $40 per kilogram.

Special Nuclear Materials.—Charges for U^{235} in the form of UF_6, in varying degrees of enrichment, ranged from $5.62 per gram of contained U^{235} for material with 0.72 percent U^{235} weight fraction to $17.07 for material with 90 percent U^{235} weight fraction.

Base charges for plutonium and U^{233} remained at $12 and $15 per gram, respectively; in each instance the annual lease charge was 4 percent of the base charge.

Depleted Uranium.—Prices for depleted uranium furnished by AEC as UF_6, f.o.b., Paducah, Ky., varied from $5 per kilogram of uranium assaying 0.0036 and lower weight fraction of U^{235}, to $38.45 per kilogram assaying 0.0070 weight fraction.

Radioisotopes.—Price reductions up to 70 percent were made by the AEC for certain forms of cobalt–60, particularly for large shipments and material of high specific activity. All quantities greater than 100,000 curies were priced at $1.00 per curie. The stable isotope helium–3 was made available for sale to the public on July 1, 1960, from AEC's Mound Laboratory, operated by Monsanto Chemical Co. at Miamisburg, Ohio. The price of helium–3 with 99-plus percent isotopic purity was reduced from $1,500 to $150 per liter.

A price of $9.50 per millicurie of carbon–14 became effective July 1, 1960. This was a reduction of 27 percent and followed a reduction in 1959 of 50 percent.

Uranium Concentrate Specifications.—Specifications shown in the Uranium chapter of Minerals Yearbook, 1958, remained in effect.

FOREIGN TRADE

Uranium from foreign sources supplied 48 percent of the Nation's requirement in 1960, compared with 52 percent in 1959. Deliveries to the United States during 1960 totaled 15,770 short tons of contained U_3O_8. Of this quantity, 11,310 tons was imported from Canada and the rest from Australia, Belgium, Republic of the Congo (formerly Belgian), Portugal, and the Union of South Africa, under contracts of the Combined Development Agency (fig. 1). The AEC allowed the import of seven gas centrifuge machines from West Germany to be used for a pilot-scale study of a process claimed to sharply reduce the cost of producing enriched uranium for reactors.

During 1960, Japan ordered one small enriched fuel power reactor from a U.S. corporation.

The shipment of 100 nuclear reactor fuel elements weighing 7½ tons to West Germany's nuclear power station near Frankfurt represented the largest shipment of uranium ever made from the United States for overseas civilian use.

Foreign countries ordered four new research reactors from the United States. Seven reactors for research, training, or testing and two for power production built in the United States went into operation abroad during 1960. Radioisotopes worth $1.5 million were exported during the year.

WORLD REVIEW

Total free world production of uranium was 41,000 tons of uranium oxide, and the North American continent supplied about 75 percent of the output.

The Atoms for Peace program helped stimulate interest in putting atomic energy to work in beneficial applications. Under this program, several nuclear power plants should be operating in Western Europe by 1965. Actions by the governments of India and Japan indicated their firm interest in peaceful nuclear power applications.

TABLE 8.—Free world production of uranium oxide (U_3O_8) by countries [1 2 3]

(Short tons)

Country [1]	1956	1957	1958	1959	1960
North America:					
Canada	2,280	6,635	13,400	15,892	12,714
United States [4]	6,000	8,640	12,570	16,420	17,760
South America:					
Argentina [5]	20	20	20	13	15
Europe:					
Finland [5]				30	40
France [5]		465	660	955	1,600
Germany, West [5]				3	12
Spain [5]					60
Sweden	6	10	10	[5] 10	[5] 10
Africa:					
Congo, Republic of the (formerly Belgian)	1,300	1,300	2,300	2,300	1,200
Malagasy Republic (Madagascar) [5]		70	95	115	115
Rhodesia and Nyasaland, Federation of		25	50	38	
Union of South Africa	4,365	5,700	6,245	6,445	6,409
Oceania:					
Australia [5]	300	400	700	1,000	1,000
Free world total (estimate) [1 2]	14,470	23,470	36,450	36,250	41,140

[1] In addition to the countries listed, uranium is also known to have been produced in Colombia, India, Italy, Japan, Morocco, Mozambique, Portugal, and Spain, but production data are not available; however, an estimate for these countries has been included in the world total.

[2] Uranium is also believed to be produced in Czechoslovakia, East Germany, Hungary, and U.S.S.R., but production data are not available; for these countries no estimate has been included in the world total. Estimates of production for the Communist countries range from 10,000 to 20,000 tons per year.

[3] This table incorporates a number of revisions of data published in previous Uranium chapters. Data do not add exactly to total shown because of rounding where estimated figures are included in the detail.

[4] Includes uranium production from phosphate rock in the eastern United States.

[5] Estimate. Statistics for France are converted from metal production data.

Compiled by Augusta W. Jann, Division of Foreign Activities.

Obstacles to further progress in nuclear power for the free world were being eliminated or lessened through the work of international atomic energy organizations. The International Atomic Energy Agency (IAEA) and other international agencies expected ultimately to take over many of the responsibilities and functions that came under bilateral agreements on peaceful uses of atomic energy between the United States and other countries.

During 1960, IAEA authorized two preliminary technical survey missions. One went to Greece, the Ivory Coast, the Federation of Mali, Morocco, Sudan, and Tunisia. The other visited El Salvador, Guatemala, Mexico, Paraguay, and Peru. These missions assessed the needs for assistance in developing nuclear energy activities such as training, education, equipment, and technical aspects.

Survey missions also were sent to Finland and the Philippines to assist in evaluating their future needs for nuclear power. IAEA completed arrangements to provide Finland with enriched uranium for the TRIGA MARK II research and training reactor purchased in the United States. The United States also agreed to make available through IAEA uranium fuel elements for use in a cooperative research program to be conducted in Norway to obtain basic nuclear data for power reactor design. Yugoslavia made the first request for IAEA assistance in obtaining heavy water for a research reactor at Oskidric Institute.

IAEA increased its number of member States from 70 to 75 during the year. The organization received 170 requests for technical assistance from 33 countries and sent approximately 25 experts to member States for periods ranging from 3 months to 1 year.

NORTH AMERICA

Canada.—Canadian production totaled 12,700 short tons of U_3O_8 valued at $263 million, compared with 15,900 tons valued at $325 million in 1959. Nearly all production was exported to the United States and United Kingdom. Exports to the United States were 11,310 tons of U_3O_8.

Canadian deliveries of uranium were scheduled to continue on a declining scale to stretch out operations. Under existing contracts, anticipated total deliveries were estimated by a representative of the Eldorado Mining and Refining Limited, Canada's ore-buying company, to be for 1961, 9,700; 1962, 8,370; 1963, 6,550; 1964, 3,450; 1965, 1,460; and 1966, 1,100 tons of U_3O_8. Miscellaneous export orders may develop to increase these figures.

During 1960, nine uranium mining operations closed. Several of these were placed in standby conditions.[2]

Rio Algom Mines, formed by the merger of Milliken Lake Uranium Mines, Ltd., Pronto Uranium Mines Ltd., Northspan Uranium Mines, Ltd., and Algom Uranium Mines, Ltd., led reorganization of the Canadian mining companies. Stanleigh Mining Corp. merged with Preston East Dome Mines, a company with substantial holdings in the Rio Tinto Blind River mine. The new company was called the

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[2] Northern Miner (Toronto, Canada), vol. 46, No. 42, Jan. 12, 1961, pp. 1–5.

Preston Mines. These mergers permit shifting of mining from individual mines to concentrated areas for lower cost and larger individual mine production.

Mine employment declined from 11,792 to about 6,000; 4,000 in the Elliott Lake camp and 1,000 each in the Bancroft and Beaverlodge camps.

The Atomic Energy of Canada, Ltd., announced plans to construct a second nuclear research center near Winnipeg, Alberta, to supplement existing facilities at Chalk River. A new laboratory named Whiteshell Nuclear Research Establishment was being built 60 miles east-northeast of Winnipeg. Work at the site began in the summer of 1960, but major installations were not anticipated until 1961. At Chalk River there were five experimental reactors, the ZEEP, NRX, NRU, PTR, and ZED–2. The NRX, a 40,000-kilowatt reactor, and the NRU, a 200,000-kilowatt reactor, were used in nuclear power experiments, for fundamental research, and to produce radioactive isotopes and plutonium. The NRU reactor was the first in the world to be refueled routinely while the reactor continued in operation. The other three were low-power reactors and were used for testing fuel rod arrangements for power reactors, determining the reactivity of fuel samples, and studying the neutron absorption properties of materials. One power project was under construction.

A heavy-water-moderated demonstration power station known as NPD–2, fueled by natural uranium oxide, was under construction at Rolphton, Ontario, with commissioning anticipated in 1961. Electrical capacity was designed at 20,000 kilowatts. Project CANDU, a 200,000-kilowatts power-production facility at Douglas Point, Kincardine, Ontario, was approved and construction was initiated.[3]

The Canadian Department of Mines developed a uranium-bearing steel and applied for patents in the world steel-producing countries. Small quantities of uranium added to steel were reported to enhance fatigue resistance, improve its resistance to stress corrosion, and improve the elevated temperature properties of ordinary steel.[4]

Northwest Territories.—The Port Radium uranium mine of Eldorado Mining and Refining Limited on Great Bear Lake closed in September. Radiore Uranium Mines did extensive exploration in the Wopmay River area where the company discovered a promising structure in 1959 and staked some 50,000 acres for prospecting.[5] Reserves of Radiore were estimated at 1 million tons averaging 0.15-percent U_3O_8.[6]

Ontario.—The Denison Mines, Ltd., maintained production at peak level to complete its full delivery schedule by December 31, 1963. The Denison Mine operation at Elliot Lake was described.[7]

Pronto Uranium Mines, Ltd., in the Elliot Lake area, acquired the Pater Uranium Mines, which contained some 2 percent copper in the ore. The Pronto mill was being converted to a copper concentrating plant with a milling rate of 500 tons per day to handle this ore.

[3] Griffith, J. W., A Preliminary Survey of the Canadian Mineral Industry in 1960: Department of Mines and Tech. Surveys, Ottawa, Mineral Inf. Bull. MR–49, pp. 14–15.
[4] Canadian Mining and Metallurgical Bulletin (Montreal, Canada), vol. 54, No. 585, January 1961, p. 67.
[5] Canadian Mining Journal, vol. 81, No. 3, March 1960, pp. 139–141.
[6] Canadian Mining Journal, vol. 81, No. 12, December 1960, p. 124.
[7] Kostuik, J., and DeBastiani, M. J., Denison Mine Operation at Elliot Lake: Min. Eng., vol. 12, No. 12, December 1960, pp. 1250–1256.

Faraday Uranium Mines, Ltd., continued producing at a steady rate of 6,500 pounds of uranium oxide per month from its Bancroft operation. The mill handles 1,200 tons per day with heads averaging 1.8 pounds of uranium per ton of ore. Although there was sufficient ore above the 750-foot level to complete the contract, the company continued to carry out limited exploration near the shaft at the 900-foot level.[8]

Rio Algom Mines planned to deepen its Nordic shaft from 1,330 to 1,730 feet to develop enough additional ore to enable the mine to operate until Rio Algom Mines completes its contract with Eldorado in 1965. The Nordic was one of two mines that Rio Algom decided to continue in operation. The second was the Milliken Lake property. Both mines had daily production capacity of 3,000 tons. Rio Algom's Panel mine, a third 3,000-ton-per-day production facility, was scheduled to close in June 1961. The Quirke property and mill, closed at the end of 1960, were placed in standby condition ready for a quick resumption of operations in event of an emergency.[9]

The rescheduling of uranium deliveries in Canada caused a reduction in sulfuric acid requirements.[10]

Saskatchewan.—Black Bay Uranium shipped approximately 150 tons of uranium ore per day containing about 0.2 pounds of uranium oxide per ton of ore to the Eldorado Mining and Refining Limited mill from its Fishhook Bay property in the Beaverlodge area.

Eldorado Mining and Refining Limited, the crown-owned uranium concern, improved the mill circuit and its Beaverlodge uranium operations in Saskatchewan, and deepened one of its three mine shafts. The company also considered sinking a fourth shaft. These improvements were said to make the company's holdings more competitive in the tightening world market.[11] Lorado Uranium Mines, Ltd., sold its uranium contract to Eldorado Mining and Refining Limited and disposed of its plant and equipment at Uranium City.

Guatemala.—The Guatemalan Ministry of Economy announced that primary uranium deposits had been found in the country. Seams of primary uranium ore spread in two directions from the Mexican border, one toward Ixcan in the Department of El Quiche, and the other toward the Volcanic area in the Department of San Marcos.[12]

Mexico.—A uranium deposit, described as important, was discovered at an abandoned mercury mine in Cerro de la Cal, Durango. Another deposit, south of Toluca, assaying 0.8 percent uranium oxide, was studied by the Bureau of Natural Resources.[13] The National Atomic Energy Commission began preliminary work for the possible construction of a concentrating plant at this deposit. The Commission, through intensive exploration, had mapped more than 50 uranium ore bodies, the most promising of which were in Sonora, Chihuahua, and Durango. A 10-ton-per-day yellow-cake concentrating pilot plant operated in Mexico City to assist in the design of what will be the first commercial mill in Mexico. The location of the plant will depend upon ore developments.

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[8] Engineering and Mining Journal, vol. 161, No. 7, July 1960, p. 136.
[9] Northern Miner, vol. 46, No. 41, Jan. 5, 1961, pp. 1, 12.
[10] Chemical Week, vol. 87, No. 2, July 9, 1960, p. 73.
[11] Canadian Mining Journal, vol. 81, No. 6, June 1960, pp. 194–195.
[12] Mining Journal (London), vol. 254, No. 6509, May 20, 1960, p. 585.
[13] World Mining, vol. 13, No. 12, November 1960, p. 70.

SOUTH AMERICA

Argentina.—The National Atomic Energy Commission continued to explore for uranium deposits. Geological exploration had raised the reported reserves of uranium in Argentina to 10,000 tons.[14]

Brazil.—Prospecting in Brazil was conducted by the National Nuclear Energy Commission (CNEN) in cooperation with the U.S. Geological Survey, the Brazilian Department of Mineral Production, and the Technological and Radioactive Research Institutes of Minas Gerais and Sao Paulo. Two studies completed in 1960 related to the utilization of monazite sands and the extraction of uranium from zirconium deposits of Minas Gerais. Uraniferous minerals in Aguas da Prata, Sao Paulo, Belo Vale, and Serra da Moeda, Minas Gerais; the occurrence of uranium in the gold-bearing minerals of Jacobina, Bahia; and the extraction of uranium and thorium from pyrochlore deposits of Araxa, Minas Gerais, were investigated. A uranium processing plant with an annual capacity of 10,000 tons of ore, from which about 60 tons of impure sodium uranate will be produced, was being built by the Brazilian Government at Pocos de Caldas.[15]

Technicians also studied means of extracting uranium from the Olinda phosphates.[16] The Institute of Atomic Energy, University of Sao Paulo, announced the production of small quantities of atomically pure uranium at a pilot plant that went into operation in March 1960. A larger plant with a monthly productivity capacity of about 1 ton was expected to start operating in 1961.

The first Brazilian-constructed research reactor using locally produced fuel was expected to be operating by the end of 1960.[17]

Peru.—The decree of February 12, 1958, which reserved for a 2-year period all uranium deposits in the Department of Cuzco, Peru, was extended through February 1961.

Venezuela.—The Ministry of Mines of Venezuela announced that during recent surveys of mineral reserves in the Andean region near Lobatera, phosphate rock deposits were found containing about 10 grams of uranium oxide per ton.[18]

EUROPE

The program of the European Atomic Energy Community (Euratom) and the U.S. joint reactor program received only one acceptable proposal for a power reactor to be in operation by December 31, 1963. Contract negotiations for construction of this reactor progressed satisfactorily.

The original joint program agreement of February 18, 1959, was supplemented by an additional agreement for cooperation between the United States and Euratom on July 25, 1960. Subject to congressional authorization, the supplemental agreement provided for the United States to make available special nuclear materials to meet certain urgent needs outside the scope of the U.S.-Euratom joint program. The third annual report of Euratom estimated that by

[14] Skillings' Mining Review, vol. 49, No. 19, Aug. 6, 1960, p. 22.
[15] Mining Journal (London), vol. 254, No. 6498, Mar. 4, 1960, p. 271.
[16] Mining Journal (London), vol. 254, No. 6501, Mar. 25, 1960, p. 353.
[17] Bureau of Mines, Mineral Trade Notes: Vol. 51, No. 1, July 1960, p. 37.
[18] Mining Journal (London), vol. 255, No. 6536, Nov. 25, 1960, p. 602.

1980 about 30 percent of the total western European electricity requirements could and should be met from nuclear sources.

The Italian Utility Societa Ellectronucleare Nazionale (SENN) proposed a 150,000-kilowatt boiling-water reactor near the mouth of the Garigliano River in Italy.

A Euratom supply agency was formally established on June 1 to administer transactions involving the supply of nuclear materials for Euratom member States. Responsibilities included preparation of estimated requirements, selection of supplies, allocation of scarce materials, and specification of terms and conditions of sale. The nuclear research center at Ispra, Italy, was to be controlled by Euratom under the terms of an agreement ratified by the Italian Government in July 1960. Euratom agreements for research programs were also negotiated with West Germany, the Netherlands, and Belgium to provide for nuclear research at Karlsruhe, West Germany; Petten, the Netherlands; and Mol, Belgium.

Austria.—International regulations for safe transport of radioactive materials were approved by the Governors of International Atomic Energy Agency (IAEA) at their meeting in Vienna on September 13, 1960. The regulations were strongly recommended as a model for revelant national legislation. The regulations apply to the shipment of radioisotopes for scientific, industrial, and medical purposes as well as to fissionable materials and large radiation sources.

Belgium.—Belgium was sole producer of metallic uranium and its chief compounds. Société Genérale Métallurgique de Hoboken suspended uranium processing when a contract with the U.S. Atomic Energy Commission ended.[19]

A conventional purex-type plant was chosen by Eurochemie Co., Mol, Belgium, to dispose of spent nuclear fuels recovered from reactors spread throughout Europe in the Euratom program. Designed to take about 770 pounds per day of fuel elements consisting of aluminum- or magnesium-jacketed natural uranium or about 450 pounds per day of ziroconium- or stainless steel-jacketed uranium oxide, the plant, due to start in 1964, may serve as a guide to U.S. nuclear fuel processors because of the wide variety of materials to be handled. Eurochemie Co. is a semigovernmental-semiprivate international shareholding company with members from 13 western European countries.

Czechoslovakia.—Rich uranium deposits occur in Czechoslovakia, particularly in the western part. On the basis of mining operations, Czechoslovakia was said to be one of the most important uranium fields in the world.[20]

Uranium ore deposits north of Karlovy Vary in the Czechoslovakia region of western Bohemia were reported to be almost exhausted. Workers from several of the mines already closed were directed to the brown coal workings along the Czech-German border.[21]

Finland.—Geology of the Koli region of northern Finno-Karelia [22] is similar to the Canadian Blind River area, suggesting that the ultimate uranium ore potential of the deposit may be large. The beneficia-

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[19] Mining Journal (London), vol. 255, No. 6535, Nov. 18, 1960, p. 571.
[20] Metal Bulletin, (London), No. 4470, Feb. 12, 1960, pp. 1–3.
[21] Canadian Mining Journal, vol. 82, No. 1, January 1961, p. 82.
[22] Mining Magazine (London), Uranium Deposits in Finland: Vol. 103, No. 4, October 1960, pp. 222–223.

tion plant at Paukkanjanvaars, which began production in August 1959, was expected to produce about 200 tons of concentrate annually for export to Sweden and West Germany from the milling of 30,000 tons of crude ore containing 0.2 percent U_3O_8.

France.—Although reserves of uranium were thought to be sufficient for its nuclear energy programs, France continued to explore for radioactive minerals in France and countries of the French community. Extensive research at the Mounanan deposit of uranium and vanadium ore in Gabon, Africa, disclosed reserves at 20 million tons of ore containing 4,000 to 5,000 tons of uranium. A new company, La Compagnie des Mines d'Uranium de France-Ville, planned to mine and mill the ore, beginning early in 1961. The beneficiation plant will produce a concentrate containing 15 percent uranium, which will be shipped to France for further treatment.[23]

The French Atomic Energy Commission was to build a factory for plutonium extraction at the Cap de Lahague, northwest of Sherbourne. The new factory mainly will treat used fuel from reactors now under construction for Electricite de France near Chinon and from a heavy water reactor to be built in Brittany. The production of uranyl nitrate was recently started at Saint-Priest-la-Prugne, in the Loire. The plant's capacity was equivalent to 300 tons of uranium.[24]

France exploded a plutonium-based nuclear device on February 13, deep in the Sahara desert, and thereby joined other nations that have developed nuclear explosives. Plutonium production was carried out on a large scale at Marcoule near Avignon. Three large graphite-moderated reactors, G1, G2, and G3, were operated as well as a chemical extraction plant producing about 220 pounds of plutonium annually. Each reactor used about 100 tons of natural uranium as fuel and 1,000 tons of graphite as moderator. The three reactors were operated for electrical power generation by the Electricite de France, a State-owned electrical supply company.

Electricite de France was building three natural uranium reactors to produce electrical power at Avoine near Chinon in the Loire valley. EDF–1 and –2 graphite moderated gas-cooled reactors will have a total capacity of 230,000 kilowatts. EDF–1 (60,000 kilowatts) was to begin operation at the end of 1960, and the EDF–2 should begin operation at the end of 1961. EDF–3 (300,000 kilowatts) is scheduled for completion in 1962–63. Electricity produced by nuclear reactors will amount to 850,000 kilowatts by 1965 and 8 million by 1975, or 25 percent of the electrical power used in France.[25]

Germany, East.—The research reactor Dresden continued to operate, and radioisotopes for industrial and medical uses were imported from the U.S.S.R.

Germany, West.—Baverische Berg-Hutten-und-Salzwerke A.G. of Munich began exploration of uranium deposits at its Silberfeld mines in Bavaria. The Government of Baden-Wurttemberg gave permission to four German prospecting companies to seek uranium deposits within the State boundary, particularly in the area around Wolfach, Badenweiler, Lahr, Oberkirch, and Belchen.[26]

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[23] World Mining, vol. 13, No. 3, March 1960, p. 71.
[24] Chemistry and Industry (London), No. 33, Aug. 13, 1960, p. 1053.
[25] Chemical and Process Engineering, vol. 41, No. 5, May 1960, p. 179.
[26] Mining Journal (London), vol. 255, No. 6517, July 15, 1960, p. 77.

Closer studies were being made of the uranium deposits in the southern part of the Black Forest to ascertain whether the uranium could be economically mined.[27]

West Germany's first uranium processing plant began operation at Ellweiler in the Hunsruek Hills. The processing plant, with a capacity of 50 tons per day, is not expected to operate economically on locally mined ore. However, the operation will provide experience for future West German plants.[28]

West Germany was building three nuclear reactors: one each for research, testing of materials, and power. The water-moderated swimming-pool research reactor, which has 14 irradiation channels, is fueled by enriched uranium. The material-testing reactor uses enriched uranium fuel and is a heavy-water-moderated type with 48 irradiation channels. The 15,000-kilowatt nuclear power station owned by Rhenisch-Westfaelisches Elektrizitatswerk and Bayenwerk, West Germany utilities companies near Frankfurt, went critical at the end of 1960.[29] The 100 nuclear reactor fuel elements from the United States that went into this power reactor weighed nearly 7½ tons.

Euratom and West German governments were building a research center at Karlsruhe, West Germany, to study the feasibility of using transuranium elements as reactor fuels. West Germany was not a potential major uranium market, as its requirements were expected to be only about 140 tons of uranium annually.[30]

Italy.—The AGN-201 nuclear research reactor at the Technical Institute of Palermo, University Engineering College, was put into critical phase in February 1960. The initial 1/10-watt power of the reactor can be easily increased to 5 watts, but the maximum power of 1,000 watts can only be employed after extensive precautionary safety measures have been taken. Italatom of Milan, Italy, a new international company to produce nuclear fuel materials in Italy, planned to make natural, depleted, and enriched uranium and thorium compounds as well as uranium metal.[31]

Three commercial-scale nuclear power plants were being built in Italy. One was in the province of Vercelli, another on the Garigliano River, midway between Rome and Naples, and a third near Rome. Size of the Vercelli plant was not disclosed; the other two stations were rated at 230,000 kilowatts and 200,000 kilowatts, respectively. The experimental nuclear reactor installed by Sorin near its own nuclear research center at Saluggia reached full power in February 1960. The reactor will be utilized for industrial developments and will be employed for the first industrial production of radioisotopes in Italy.[32]

Vitro International planned to construct, by early 1961, a 5,000-kilowatt pool-type reactor for CAMEN, Italian Government agency, to be used in training Italian naval cadets and engineering students at the University of Pisa. The Italian committee for nuclear research reached an agreement with Allis-Chalmers Manufacturing Co. and

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27 Mining Journal (London), vol. 255, No. 6535, Nov. 18, 1960, p. 568.
28 Bureau of Mines, Mineral Trade Notes: Vol. 49, No. 6, December 1959, p. 33.
29 Chemical and Engineering News, vol. 38, No. 48, Nov. 28, 1960, p. 30.
30 Foreign Commerce Weekly, vol. 63, No. 13, Mar. 28, 1960, p. 27.
31 Chemical Trade Journal and Chemical Engineer, vol. 146, No. 3803, Apr. 22, 1960, p. 925.
32 Chemistry and Industry (London), No. 18, Apr. 30, 1960, p. 491.

an Italian firm, Bombrini, Parodi, Delfino, to carry out the Uranium-Thorium Full Cycle Development Program, designed to develop uranium-thorium U^{233} as fuel for power reactors.[33]

Netherlands.—The first British-built reactor to be completed and put into operation in a European common marketing country was the Reactor Centrum Nederland Jason that went critical November 1.[34]

Spain.—The uranium-ore processing plant at Andujar, north central Andalusia, was officially opened by General Franco on February 13, 1960. The official capacity was 200 tons of ore and was to be increased at a later date to 500 tons. Exhaustive search by Spanish Nuclear Energy Board had disclosed some 300 deposits of uranium in the province of Salamanca.[35]

The Spanish Government offered the IAEA some 150 tons of uranium to be contained in concentrates or salts, 40 tons to be delivered in 1960 and 50 tons in each of the years 1961 and 1962.

Sweden.—A large share of Sweden's uranium requirements after 1964 will be met by the Ramstad Works where some 9,000 tons of crude schists will be processed to produce 120 tons per year of U_3O_8. The Simpvarp reactor is likely to become Sweden's first industrial power-producing atomic plant. Construction started early in 1960 on the projected 60-megawatt reactor. The R3R Atom Plant, which will become operative in 1963, is primarily intended for district heating of the Stockholm suburb Farsta, and will supply only a minor amount of electrical energy.

Switzerland.—In February 1960, the world's second largest atom smasher was dedicated at Meyrin. Thirteen western European nations pooled their natural and scientific resources to produce the atom smasher which will accelerate protons almost to the speed of light in 1 second.

United Kingdom.—Reconnaissance surveys for uranium in the United Kingdom uncovered no commercial deposits.

United Kingdom Atomic Energy Authority (UKAEA) withdrew its offer to buy uranium from Swaziland, Kenya, Uganda, Tanganyika, British Guiana, and Rhodesia because of the work oversupply and the lack of uranium discoveries.[36]

The UKAEA perfected a process to extract radioactive technetium from waste fusion production solutions. The UKAEA's Windscale works produced 20 grams of pure technetium by processing over 100 tons of waste fission products.[37]

Eight Calder Hall-type nuclear reactors with a combined electrical output of 300 megawatts were operating in Britain.

The DIDO Heavy Water Moderated Reactor at the Atomic Energy Research Establishment at Harwell was loaded with a new redesigned uranium fuel core which was expected to increase the reactor power level from 10 to 13 megawatts with no increase in thermal neutron flux. The reactor was used for testing materials and components of future reactor systems and was a basic research tool that might be used for production of isotopes.[38]

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[33] Foreign Trade (Ottawa), vol. 113, No. 13, June 18, 1960, p. 11.
[34] Chemical Age (London), vol. 84, No. 2157, Nov. 12, 1960, p. 822.
[35] Mining Journal (London), vol. 255, No. 6535, Nov. 18, 1960, p. 569.
[36] Canadian Mining Journal, vol. 81, No. 8, August 1960, p. 118.
[37] South African Mining and Engineering Journal, vol. 71, No. 3503, Mar. 25, 1960, p. 727.
[38] Chemistry and Industry (London), No. 53, Dec. 31, 1960, p. 1631.

In October 1960, uranium fuel elements began arriving at the Bradwell Power Plant which was expected to go critical in June 1961 and would produce a total of 300 megawatts.[39]

ASIA

China.—More than 400 foreign geologists, mostly from the Soviet Union and Eastern Europe, were actively engaged in geological investigations in China, but no important uranium deposits had been discovered.[40]

India.—A drilling and mining program by the Atomic Minerals Division indicated about 2.8 million tons of uranium ore at Jadugoda, Singhbhum district, Bihar. Two levels had been developed in producing about 2,500 tons of ore.

Engineering experiments and facilities for ore dressing, ore extraction, and chemical engineering investigations were expected to be completed by the end of 1960. Also it was intended to develop reactors which would utilize the country's vast thorium reserves.

A new prospect was added to the three already known in Umra near Udaipur.[41] The amenability of Salem uraniferous granite assaying 0.06 percent U_3O_8 to beneficiation by flotation was tested in the laboratory. The ore concentration ratio was 5:1, with a 90-percent recovery.

A notable achievement of the year by the Department of Atomic Energy of India was the successful production of fuel elements from uranium ore mined in India. The first prototype fuel elements for the Canadian-India reactor were fabricated. India's first atomic power station, to be built at Tarapur, some 62 miles north of Bombay, will produce about 300,000 kilowatts.

Iran.—French and Iranian geologists were reported to have discovered uranium in Azerbaijan near the Russian border.[42]

Japan.—New high-grade uranium deposits were discovered in Katamo, Tottori Prefecture, Hanamakin Iwate Prefecture, and Asahimura Yamagata Prefecture, Japan.[43] Ore containing 0.12 to 0.25 percent uranium was found in the Kanamaru Mine in Yamagata Prefecture.[44]

Japanese Atomic Power Co. began construction in March 1960 of a 150,000-kilowatt Calder Hall-type nuclear powerplant at the Tokai-Mura site, adjacent to the Japanese Atomic Energy Research Institute facilities. The project was expected to be completed in 4½ years.[45]

Japanese Atomic Fuel Corp. was reported to have purchased 7 tons of uranium concentrate (U_3O_8) from Denison Mines, Ltd. In each of the past 2 years Japan purchased 14 tons of uranium oxide. Estimated Japanese requirements for 1961 called for the delivery of 22 tons with increasing quantities scheduled for succeeding years. About 100 kilograms of uranium with up to 20 percent of U^{235} will be leased from the U.S. AEC for a semi-homogeneous critical facility,

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[39] Chemical Age (London), vol. 84, No. 2155, Oct. 29, 1960, p. 724.
[40] Northern Miner (Toronto), vol. 46, No. 41, Jan. 5, 1961, p. 6.
[41] Bureau of Mines, Mineral Trade Notes: Vol. 51, No. 1, July 1960, pp. 38–39.
[42] Mining Journal (London), vol. 256, No. 6547, Feb. 10, 1961, p. 155.
[43] Mining Journal (London), vol. 255, No. 6521, Aug. 12, 1960, p. 182.
[44] Mining Journal (London), vol. 255, No. 6524, Sept. 2, 1960, p. 262. World Mining, vol. 13, No. 1, January 1960, p. 59.
[45] Foreign Commerce Weekly, vol. 63, No. 7, Feb. 15, 1960, p. 25.

an aqueous homogeneous critical reactor, and a fast-breeder expotential experiment to be built by the Japanese Atomic Energy Research Institute at Tokai Mura.[46]

Lebanon.—Deposits of rich uranium ore have reportedly been found in the Lebanese mountains.[47]

Turkey.—The existence of uranium ore in Sebinkarahisar, Kirikkale, Kecarli, Milas, Sivrihismr, Bemirci, Gordes, Felahiye, Soke, Cine, and Yatagan regions was established after 5 years of exploration by the Mineral Research and Exploration Institute of Turkey.

AFRICA

Congo, Republic of the (Formerly Belgian).—Union Minière du Haut-Katanga in Brussells announced in April the closure of the uranium mine at Shinolowbwe in Katanga Province because the ore was exhausted. Stockpiled uranium ore was expected to keep the concentrating plant operating until March 1961. Approximately 1,000 tons of uranium oxide was produced in 1960.[48]

Gabon Republic.—Initial production from the France-Ville mine in Mounanan was expected in the spring of 1961. Mining will be open pit with benches ranging from 80 yards to 200 yards. Uranium produced in Gabon will be bought by the French Atomic Energy Commission on a long-term contract.[49]

Malagasy Republic.—Malagasy official signed a contract with the French Commission of Atomic Energy to prospect for uranium ores in the western part of the island. The Commission also planned to produce about 500 tons of uranium ore annually from the region of Antsirabe.[50]

Rhodesia and Nyasaland, Federation of.—Prospecting for minable quantities of radioactive materials in the Northern Rhodesian Copper Belt was not successful. No uranium deposits of economic significance were found in Southern Rhodesia. A number of uranium-bearing refractory minerals had been discovered in Nyasaland. The largest occurrence was at Tanbani.[51]

Union of South Africa.—The uranium industry of South Africa reached new agreements with the South African Atomic Energy Board, calling for a stretch out of deliveries of uranium to 1970. New contracts were to become effective January 1, 1961, with 17 mines supplying uranium to 13 treatment plants during the years 1961–63. Plans called for reducing the number of operating plants to 11 in 1964 and 8 in 1966. For the remaining 4 years, 1967 through 1970, 6 mines would supply 5 treatment plants.

The Atomic Energy Board in the Chamber of Mines of South Africa constructed in Johannesburg a pilot plant to produce nuclear-grade uranium metal and nuclear fuel compounds. The plant, on the site of the Government Metallurgical Laboratories, was expected to be in production by the end of 1960. It was estimated that the plant would be capable of producing 100 tons of uranium metal a year,

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46 Chemical and Engineering News, vol. 38, No. 19, May 9, 1960, p. 40.
47 World Mining, vol. 13, No. 9, August 1960, p. 64.
48 Chemical Age (London), vol. 84, No. 2151, Oct. 1, 1960, p. 543.
49 Mining Journal (London), Mineral Resources of the Gabon: Vol. 255, No. 6521, Aug. 12, 1960, p. 174.
50 Mining Journal (London), vol. 255, No. 6536, Nov. 25, 1960, p. 602.
51 Rhodesian Mining and Engineering (Salisbury, Southern Rhodesia), Uranium and Thorium in the Federation: Vol. 25, No. 6, June 1960, pp. 37–38.

requiring 120 tons of pure uranium oxide, about 2 percent of the South African production.[52]

TABLE 9.—South African uranium production program[1]

(Short tons U_3O_8)

Area	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	Total
Springs and Brakpan	274	253	253	104	26						910
Krugersdorp and Randfontein	1,797	1,622	1,572	1,415	1,024	234	234	234	234	170	8,536
West Wits. Line	497	423	424	454	455	254					2,507
Klerksdorp	1,732	1,737	1,736	1,257	1,207	1,207	1,207	1,207	1,207	1,148	13,645
Welkom	102										102
Virginia	395	347	347	524	532	193	122	122	68		2,650
Total	4,797	4,382	4,332	3,754	3,244	1,888	1,563	1,563	1,509	1,318	28,350

[1] For sale of 28,350 short tons of U_3O_8 to United States and UKAEA between Jan. 1, 1961, and Dec. 31, 1970.

Source: Mining Journal (London), vol. 256, No. 6547, Feb. 10, 1961, p. 167.

United Arab Republic (Egypt region).—Under the Soviet-Egyptian economic assistance agreement of January 1958, plans were made to construct a 250-ton-per-year plant to separate thorium and uranium salts from Egyptian monazite sands.

OCEANIA

Australia.—United Uranium N.L. produced ore from the El Sharana open cut and an underground mine at Coronation Hill for hauling to the treatment plant at Moline. Capacity at the Moline plant was approximately 125 tons per day. Ore reserves of United Uranium N.L. at Moline were estimated at 92,653 tons containing 554,815 pounds of uranium oxide. The first successful application of the solvent extraction process for the recovery of uranium oxide in Australia was made by United Uranium N.L., at its Moline plant. Mine and mill production of the South Alligator Uranium N.L. continued throughout the year.

Territory Enterprises Pty., Ltd., completed 7 years operation of the Commonwealth's government uranium project at Rum Jungle. Production of uranium oxide decreased slightly because of the treatment of lower grade ore.

A new ore body was discovered at Rum Jungle Creek South, the extent of which was not defined.[53]

Production at the Radium Hill mine remained steady during the year and extensive search disclosed two new ore bodies adjacent to the mine.[54] The Rum Jungle and Radium Hill uranium mines are government owned.

Mary Kathleen Uranium, Ltd., completed its second full year of production in 1960 with the development of a reserve of over 5 million tons of ore with an average grade estimated at 3.5 pounds of uranium oxide per ton, indicating a much longer life for the deposit than had been supposed. The installation of an electronic ore sorter to dif-

[52] South African Mining and Engineering Journal (Johannesburg), vol. 71, No. 3504, Apr. 1, 1960, p. 769.
[53] World Mining, vol. 13, No. 9, August 1960, p. 67.
[54] Mining and Chemical Engineering Review (Melbourne, Australia), vol. 52, No. 12, Sept. 15, 1960, p. 10.

ferentiate between radioactive material and waste in the ore resulted in lower operating costs by reducing the quantity of waste material through the mill.[55] The milling methods used at the Mary Kathleen mine were described.[56]

A low-level aerial scintillographic survey indicated areas in which radioactive deposits could occur. Ground investigations are being carried on near Kalgoorlie.[57]

The Australian Atomic Energy Commission awarded a contract to a U.S. firm for a second nuclear reactor at Lucas Heights. The new reactor (UTR–10) will produce 10 kilowatts of heat and will be used to study the physics of reactor materials and sample cores for future power reactor systems.[58]

New Zealand.—An extensive new uranium field, which could be the largest in Oceania, was examined by the West Coast Co. in Butler Gorge, Paparoa Region.[59]

WORLD RESERVES

Known free world reserves of uranium totaled 1 million tons of U_3O_8; assumed additional reserves, based on geologic estimates, also totaled at least 1 million tons according to a report of AEC.[60]

TABLE 10.—Free world uranium resources [1]

(Thousand short tons U_3O_8)

	Reasonably assured at $8–$10 per pound	Possible additional discoveries	Presumed available from submarginal material in presently exploited areas	Potentially recoverable from known low-grade deposits
North America	640	600	400	400
South America	3			100
Europe	40	100		1,000
Africa	380			1,200
Oceania	10		20	
Total (estimate)	1,000	1,000 to 4,000		

[1] Estimated U_3O_8 recoverable at an average of approximately $16–$20 per pound.

As of December 31, 1960, estimated domestic uranium reserves totaled 8.2 million tons containing 0.28 percent U_3O_8, a decrease of only about 4 million tons from the previous yearend estimate despite the fact that nearly 8 million tons was mined during 1960. In addition, approximately 1.3 million tons of ore was in Government and private stockpiles at the end of 1960.

TECHNOLOGY

Geophysical methods were used in the Rocky Mountains to trace uranium channels, locate narrow veins, and determine the depth of

[55] Mining Magazine (London), vol. 102, No. 5, May 1960, p. 301.
[56] Nelson, A., The Mary Kathleen Uranium Project: Mine and Quarry Eng., vol. 26, No. 3, March 1960, pp. 94–101.
[57] Financial Standard (Melbourne, Australia), vol. 115, No. 2909, Aug. 11, 1960, p. 25.
[58] Mining and Chemical Engineering Review (Melbourne, Australia), vol. 53, No. 1, Oct. 15, 1960, p. 65.
[59] Chemical Age (London), vol. 83, No. 2123, Mar. 19, 1960, p. 499.
[60] Atomic Energy Commission, Energy from Uranium and Coal Reserves: TID–8207, Office of Technical Services, Washington, D.C.

desert sands and gravel.[61] The discovery of mineralized areas through the use of geophysical methods, the trend toward smaller equipment such as transitorized units, and faster, more easily operated, equipment such as the new magnetometers helped renew interest in the use of geophysical instrumentation for exploration in remote areas. Geophysical exploration had not been used as extensively in the Rocky Mountains as in the eastern and southwestern United States and Canada, due to extreme weather conditions and inaccessibility during severe winter months.

Botanical methods of prospecting for uranium in the Colorado Plateau area were discussed in a report by the U.S. Geological Survey.[62] One of the discoveries was that tree analyses may be used effectively to outline mineralized ground to a maximum depth of about 70 feet. Such developments improve the outlook for continued discovery of new mineralized areas.

Improved mining methods, better application of equipment, and more detailed knowledge of location, grade, irregularities, and physical characteristics of ore bodies in the Ambrosia Lake area were shown in 1960. Many of the improvements were brought about by a technique which consists of driving drifts in gangue beneath the ore body. At intervals of 25, 50, and 75 feet along these drifts, a series of long holes are drilled to form a fan of 150° above the drift. These holes are used for drainage and to locate, sample, and outline ore bodies. Through the technique of draining ore bodies prior to mining, the loss of uranium values in the mine water has been reduced and the drained rock has shown greater strength. Increasing attention has been paid to the problems of pumping muddy mine drainage water. Some mines use the method of underground settling sumps which feed clear water to the main mine pumps. Others use bucket elevators, operating continuously to discharge the material collected in the shaft sump. Great emphasis was placed on bolting wire fabric to the roof and walls of all openings over 10 feet wide to improve safety.[63]

An article describing the open-pit operations in the Gas-Hills area of Wyoming reported that mining costs varied from $4.63 to $10 per ton.[64] Earth-moving equipment used and methods of controlling mining operations also were described for the companies active in the area.

Various phases of the mining operations, including design, planning, control, equipment, methods, service, and organization of the Consolidated Dension Mining Operations in Canada, were reviewed.[65]

Descriptions such as these make available to the mining industry the benefit of experience and lead to more efficient mine development.

The high moisture content, a high proportion of clay, and friability of certain uranium ores has caused problems in the crushing of mine ore prior to milling. The use of a moving-breaker-plate hammer mill for overcoming crushing difficulties of this nature and the mill cir-

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[61] Melbye, Charles E., Geophysics: Min. World, vol. 22, No. 7, June 1960, pp. 37–40.

[62] Cannon, Helen L., The Development of Botanical Methods of Prospecting for Uranium on the Colorado Plateau: Geol. Survey Bull. 1085–A, 1960, 49 pp.

[63] Argall, George O., Jr., New Methods Developed for Mine Drainage: Min. World, vol. 22, No. 8, July 1960, pp. 30–33.

[64] Coulson, Roy, Open Pit Operations in the Gas-Hills Area of Wyoming: Min. Cong. Jour., vol. 46, No. 11, November 1960, pp. 54–57.

[65] McCutcheon, A. D., and Futterer, Edward, Mining Operations at Consolidated Denison Mines, Limited: Canadian Min. and Met. Bull., vol. 53, No. 575, March 1960, pp. 157–172.

cuitry at the Maybell mill in Colorado were described.[66] After crushing, the low-grade and high-grade ores are stored separately. In the mill, the low-grade ore is repulped with water, the barren sands are removed, and the slimes are acid-leached. The crushed high-grade ore is first acid-leached and then washed in counter-current classifers. The resulting slimes and values in solution join the leached low-grade slimes and both are treated in a counter-current resin-in-pulp (RIP) circuit. The pregnant effluent from the RIP process is precipitated with ammonia, and the resulting concentrate is filtered and dried.

Uranium ores do not lend themselves generally to flotation or similar physical concentration procedures, and other methods had to be developed. Extensive installations based on ion-exchange methods have been made throughout the uranium concentrating industry, since first used commercially in 1952. Researchers have looked at this technique for possible application to other metal ions. Development of new ion-exchange resins for adaptation to a particular metal recovery problem was under way in many laboratories in 1960. The solid ion-exchange technique will continue to be used for the extraction of metal from solutions of very low metal concentrations, while liquid ion-exchange systems will tend to be used for the recovery of metal from solutions of intermediate and high-metal concentrations.

In leaching or solubilizing uranium ores, many other elements, such as vanadium, molybdenum, scandium, and rhenium, are dissolved. This represents a new source of supply of these elements if means of recovering them can be found. Industrial and governmental research efforts have been directed toward recovery of these minor constituents from uranium mill circuit solutions to enhance the economic position of the uranium industry and obtain maximum conservation and utilization of our natural resources. Most uranium ores contain some molybdenum, which may cause mill processing difficulties such as the poisoning of resins, the precipitation of organo-molybdenum complexes, or the buildup of molybdenum in the recycle stream.[67]

A generalized procedure was developed in the laboratory for recovering molybdenum from these solutions. It consists of using secondary and tertiary amine extracts to remove molybdenum from either the sodium carbonate scrub liquor of the acid leach process or from the bleed stream of the alkaline leach uranium mill circuit. Additional work is required to more clearly define the effect of the variables involved and to obtain more refined economic data.

Conventional types of contactors cannot be used for solvent extraction of solutes from slurries, since phase disengagement is inhibited by the solids present, and solvent losses by entrainment are economically prohibitive. The rotary film contactor, however, provides an adequate interfacial area per unit volume for mass transfer without actually dispersing one phase in the other.[68]

The impact of technological developments in the ion exchange field for producing uranium concentrate will be felt in major portions of the extractive metallurgy field for years to come.

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[66] Engineering and Mining Journal, Maybell Mill Crushes Wet Uranium Ore: Vol. 161, No. 3, March 1960, pp. 91–92.

[67] Lewis, C. J., and House, J. E., The Recovery of Molybdenum by Liquid-Liquid Extraction From Uranium Mill Circuits: Pres. at Annual Meeting of the AIME, New York, N.Y., Feb. 14–18, 1960.

[68] Chemical Trade Journal and Chemical Engineer, (London), vol. 147, No. 3829, Oct. 21, 1960, p. 906.

The British reported the methods used at the Springfields plant in England in processing of uranium ore concentrates and recycle residues to a purified uranyl nitrate solution as one of their methods of approaching this problem.[69] The uranium ore concentrate is dissolved in nitric acid, and the resulting solution is filtered on a precoat rotary vacuum unit and finally purified by the solvent extraction process. The solid residues arising from the overall process are treated by similar means. The development of the process and design on which the plant was based were discussed in detail.

A second paper in the same series described the fluidized solids dry-way process for the production of uranium tetrafluoride at Springfields. A description of the direct thermal denitration of purified uranyl nitrate to uranium oxide and the conversion of uranium oxide to uranium tetrafluoride was given. Pilot plant work indicated that there should be little difficulty in converting the system to a full-scale continuous operation.

Early in 1960, German scientists reported on a centrifuge process for separating U^{235} from other isotopes of uranium. Professor Wilhelm Groth, Director of Physical Chemistry at Bonn University in West Germany, was granted a patent for the gas centrifuge method of refining uranium. Immediate reaction was fear that a means for mass producing atomic bombs had been found. However, further study showed that the centrifuge was unable to produce material rich enough for nuclear weapons. Theoretically, the centrifuge is simple to operate; gaseous uranium is introduced into a twirling cylinder and the heavier the gas the greater the centrifugal force. The lighter U^{238} tends to collect in the center where it can be drawn off. Although the centrifuge apparently cannot provide a cheap means of producing enough of the bomb-essential U^{235}, it still has a use in producing nuclear fuel for power reactors,[70] and could be of interest to smaller countries.

Other research indicated that enriched uranium hexafluoride can be produced by a nozzle technique.[71] In this technique, the gaseous mixture of isotopes to be separated is fed under pressure to a nozzle from which the gas emerges as an expanding supersonic jet. Since the lighter component of the gas is more concentrated in the peripheral region and the heavier component in the core region, by proper direction and nozzle design a skimmer diaphragm will make a separation of the component. The nozzle technique promises greater reliability and higher separation per stage than diffusion plants, but probably the capital investment and power requirements per stage will be greater.

These last three articles point up the scientific competition which was again taking place as new worldwide commercial companies entered the field of uranium enrichment.

In the search for nuclear reactor fuels which have greater stability and longer life than uranium metal and its alloys, the nuclear fuel technologist is turning increasingly from metal to nonmetallic compounds, and thus from metallurgy to chemistry. The preparation,

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[69] Page, H., Shortis, L. P., and Dukes, J. A., The Processing Uranium Ore Concentrates and Recycle Residues to Purified Uranyl Nitrate Solution at Springfields: Trans. Inst. Chem. Eng. (London), vol. 38, No. 4, August 1960, pp. 185–196.

[70] Precambrian, Mining in Canada: Vol. 33, No. 11, November 1960, p. 23. Financial Standard (Melbourne, Australia), vol. 115, No. 2917, Dec. 1, 1960, p. 14.

[71] Levoy, Myron, Uranium Isotope Separation by Nozzles: Nucleonics, vol. 18, No. 4, April 1960, pp. 68–70.

fabrication, and properties of uranium dioxide, one of the more promising chemical fuels, have been described.[72] Another example of nonmetallic fuel material which has received increased attention is uranium monocarbide. Materials of this nature offer many promises of improved fabrication efficiencies through less scrap, more complete burnup, and more easily obtained fuel configurations.

Renewed interest in the production of high-purity uranium metal by the fused-salt electrowinning technique led to a basic study of the electrochemical standard potentials of uranium in fused salt.[73] The investigation indicated that the electrodeposition of pure uranium from a four-valence state in a molten chloride salt was a step wise reduction. The studies indicated that electrolytes must be purified before electrolysis to avoid contaminating the resulting uranium metal.

The Canadian Department of Mines applied for worldwide patents on the use of small percentages of uranium in steel, which, it is reported, produced improvements in strength, resistance to corrosion, and high-temperature properties.[74] If this and similar research being carried on elsewhere should prove successful, increased nonenergy utilization of uranium would result. A wider range of application and potentially greater utilization of uranium through alloying became apparent by the development of new alloys and the better understanding of their physical properties.

A columbium alloy containing up to 20 percent uranium was reported to have excellent tensile strength and hardness even at 1,600° F., which makes it an excellent fuel for high-temperature, high-efficiency, compact nuclear reactors such as gas-cooled units. Most metallic-uranium fuel elements swell and become unserviceable above 1,200° F.[75] Discussion of the properties and structure of uranium-molybdenum alloys at 1,100°, 1,200°, and 1,300° C. was given by British scientists as a result of metallographic, X-ray, and thermosection studies. The addition of 3.5 percent molybdenum to uranium increased its stability during thermal cycling, and its creep and tensile strengths at 900° F. The addition of 0.1 percent aluminum also increased both creep and tensile properties at 900° F.

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[72] Martin, F. S., and Steele, B. R., Uranium Dioxide Fabrication: Chem. and Proc. Eng., vol. 41, No. 7, July 1960, pp. 291–294.
[73] Hill, Derek L., Perano, Jeanne, and Osteryoung, Robert A., An Electrochemical Study of Uranium in Fused Chlorides: Jour. Electrochem. Soc., vol. 107, No. 8, August 1960, pp. 698–704.
[74] Work cited in footnote 4.
[75] Chemical and Engineering News, vol. 38, No. 25, June 20, 1960, p. 47.

Vanadium

By Horace T. Reno [1]

UNITED STATES production of vanadium-bearing ore and concentrate reached a new record in 1960, 29 percent more than the previous record in 1956. Domestic mines increased their output to supply more vanadium for export to Austria, France, West Germany, Netherlands, and Japan. The increased demand for vanadium in foreign countries apparently resulted from the high level of activity in the steel and ferroalloy industries of those countries, because the vanadium foreign trade pattern closely followed the patterns of most of the other ferroalloy metals.

High-purity vanadium shapes and ingots were produced commercially in the United States.

TABLE 1.—Salient vanadium statistics

(Short tons of contained vanadium)

	1951-55 (average)	1956	1957	1958	1959	1960
United States:						
Production:						
Ore and concentrate processed	4,241	5,701	7,307	6,829	8,026	8,800
Recoverable vanadium [1]	2,813	3,867	3,691	3,030	3,719	4,971
Value thousands	(2)	(2)	(2)	$10,817	$13,278	$17,748
Vanadium pentoxide	2,744	3,937	3,612	2,791	4,092	5,495
Imports:						
Ore and concentrate	332				3	3
Exports:						
Ferrovanadium and other vanadium alloying materials containing over 6 percent vanadium (gross weight)	[3] 115	139	134	76	152	162
Vanadium pentoxide, vanadic oxide, vanadium oxide, and vanadates [4]	191	928	500	631	1,240	3,690
World: Production	3,834	4,229	4,295	4,235	5,324	6,980

[1] Measured by receipts at mills.
[2] Figures withheld to avoid disclosing individual company confidential data.
[3] Classified as ferrovanadium 1951-52.
[4] Classified as "Ore and concentrate," 1951-52, but probably included vanadium pentoxide.

LEGISLATION AND GOVERNMENT PROGRAMS

On April 22, 1960, the Atomic Energy Commission (AEC) called for bids from industry on 22 lots of vanadium pentoxide totaling 1,581,000 pounds. At the public bid opening May 23, at Grand Junc-

[1] Assistant chief, Branch of Ferrous Metals, Division of Minerals.

tion, Colo., the Vanadium Corporation of America was the successful bidder at $1 a pound. On November 21, AEC announced the public sale of an additional 1.5 million pounds of vanadium pentoxide. The material was part of that purchased by AEC over the years from uranium-processing mills.

In a press release August 5, 1960, the General Services Administration announced its intention to dispose of 4,310 short tons of lead-vanadate ore, 2,950 tons of lead-vanadate concentrate, and about 35,350 pounds of fused vanadium oxide. These items, considered surplus to defense requirements, may be sold 6 months after public announcement of plans for their sale.

DOMESTIC PRODUCTION

Ore.—Domestic production of vanadium in ore and concentrate in 1960 was 34 percent more than in 1959 as uranium ore processes recovered more vanadium in byproduct operations.

A new solvent-extraction unit for recovering a high-purity vanadium concentrate was installed at the Kerr-McGee mill, Shiprock, N. Mex. in February. Ore for the mill came from mines in the Lukachukai mountains in northeastern Arizona. The concentrate produced in 1960 was reportedly sold in foreign markets.[2] The "Four Corners" area of the Colorado Plateau, consisting of southwestern Colorado, northwestern New Mexico, northeastern Arizona, and southeastern Utah, continued as the principal source of domestically produced vanadium.

TABLE 2.—Recoverable vanadium in ore and concentrate produced in the United States, by States

(Short tons of contained vanadium)

State	1951–55 (average)	1956	1957	1958	1959	1960
Colorado	2,102	2,791	3,132	2,395	2,949	4,026
Utah	253	549	508	376	536	462
Arizona and other States[1]	458	527	51	259	234	483
Total	2,813	3,867	3,691	3,030	3,719	4,971

[1] Includes Idaho, 1951–54; Montana, 1957; New Mexico, 1951–54, 1956–60; South Dakota, 1954, 1960; and Wyoming, 1954, 1956–58, 1960.

TABLE 3.—Vanadium and recoverable vanadium[1] in ore and concentrate produced in the United States

(Short tons)

Year	Mine production	Recoverable vanadium	Year	Mine production	Recoverable vanadium
1951–55 (average)	4,237	2,813	1958	7,266	3,030
1956	5,635	3,867	1959	7,392	3,719
1957	7,294	3,691	1960	8,047	4,971

[1] Measured by receipts at mills.

[2] Skillings' Mining Review, New Vanadium Unit in Operation: Vol. 49, No. 10, June 4, 1960, p. 12.

TABLE 4.—Production of vanadium pentoxide in the United States[1]

(Short tons)

Year	Gross weight	V_2O_5 content	Year	Gross weight	V_2O_5 content
1951-55 (average)	5,538	4,900	1958	5,470	4,983
1956	7,963	7,030	1959	7,906	7,305
1957	7,224	6,449	1960	10,767	9,812

[1] Includes a relatively small quantity recovered as a byproduct of Peruvian concentrate and foreign chrome ore.

Oxide.—Production of vanadium pentoxide increased 34 percent over 1959. Vanadium pentoxide from domestic ores was produced in six plants, two more than in 1959. Data in table 4 include vanadium pentoxide produced as a byproduct of foreign chromium ores, 1951–60; produced from Peruvian concentrate, 1951–55; and produced as a byproduct of domestic phosphate rock, 1951–54.

Ferrovanadium.—Ferrovanadium was produced in the United States principally by Vanadium Corporation of America, Union Carbide Metals Co., and Shieldalloy Corp. Output in 1960 was about the same as in 1959.

Vanadium Metal.—Reported production of 99-percent-purity vanadium was about 29 short tons, little more than was produced in 1959, despite the wide publicity ductile vanadium had received in the past few years.

CONSUMPTION AND USES

Ore and Concentrate.—Domestic and foreign vanadium-bearing ores and concentrates consumed at domestic plants contained 8,800 tons of vanadium, 774 tons more than was in ores and concentrates processed in 1959.

Alloys and Compounds.—Approximately 74 percent of the 2,016 tons of processed vanadium consumed was in ferrovanadium, 6 percent in vanadium oxide, 6 percent in ammonium metavanadate, and the remaining 14 percent in nonferrous metal alloys, in vanadium-bearing chemical compounds, and in nonclassified other materials.

TABLE 5.—Vanadium consumed and in stock in the United States in 1960 by forms

(Short tons of vanadium)

Form	Stocks at consumer plants, Dec. 31, 1959	Consumption	Stocks at consumer plants, Dec. 31, 1960
Ferrovanadium	269	1,488	259
Oxide	19	132	24
Ammonium metavanadate	28	121	29
Other	35	275	63
Total	351	2,016	375

TABLE 6.—Vanadium consumed in the United States in 1960, by uses

Use	Short tons	Use	Short tons
Steel:		Steel—Continued:	
High-speed	293	Gray and malleable castings	18
Hot-work tool	72	Nonferrous alloys	263
Other tool	88	Chemicals	160
Stainless	30	Other	46
Other alloy [1]	929		
Carbon	117	Total	[2] 2,016

[1] Includes some vanadium used in high-speed or other tool steels not specified by reporting firms.
[2] Represents approximately 90 percent of total consumption.

Steelmakers used more than 75 percent of the vanadium consumed in the United States in 1960. They used about the same quantity as in 1959 but reported 30 percent less used in high-speed steel, 26 percent less in other tool steel, and 12 percent more in other alloy steel. This division in uses may not be precise as the steelmakers do not always classify their products in the same way. The concerns producing nonferrous vanadium-bearing alloys reported that they used more than twice as much vanadium as in 1959. Those producing vanadium chemicals reported that they used 18 percent more. Nickel-base alloys, alloy hard-facing rods and bars, and welding rods were the chief nonferrous end-use items of vanadium in 1960. Availability of high-purity vanadium resulted in its increased use in research, and mill products (tube, rod, wire, plate, foil, and machined ingots) of ductile 99.5 percent vanadium minimum were produced commercially.

STOCKS

Stocks of various forms of vanadium held at consumers' plants December 31, 1960, were 7 percent more than on December 31, 1959.

PRICES

Vanadium pentoxide contained in ore was quoted at 31 cents per pound. This quotation disregards penalties based upon the grade of ore or the presence of objectionable impurities, such as lime, which are important to the refiners because impurities vitally affect recoveries.

The quoted price on vanadium pentoxide (Technical grade) was $1.38 a pound of V_2O_5; the price of ferrovanadium ranged from $3.20 to $3.40 a pound of contained vanadium (depending upon the grade of alloy). Vanadium metal for alloying, in 100-pound lots, ranged from $3.45 to $3.65 a pound. High-purity metal (over 99 percent vanadium) was quoted at $40 a pound.

FOREIGN TRADE [3]

The United States exported almost three times as much vanadium in ore, concentrate, and oxides in 1960 as in 1959. Austria, Nether-

[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

lands, Japan, and France were the principal importers, receiving 42, 23, 10, and 9 percent, respectively, of the total. Compared with 1959, Austria received about twice as much, Japan more than twice as much, France about 3 times as much, and Netherlands more than 19 times as much. Apparently, Netherlands was only a point of transfer for most of the vanadium it received from the United States, but Austria, Japan, and France may have retained most of the vanadium they received for use in their own ferroalloy industries. The pattern of world trade in vanadium was essentially the same as the trade patterns in other ferroalloy metals.

Imports of ferrovanadium totaled 30,485 pounds, valued at $44,182; 20,000 pounds came from West Germany and 10,485 pounds from Sweden. Concentrate, totaling 10,000 pounds and containing 9,800 pounds of vanadium pentoxide valued at $9,432, was imported from West Germany. Other imports of vanadium-bearing material were negligible.

TABLE 7.—U.S. exports of vanadium, by countries

(Pounds)

Destination	Ferrovanadium and other vanadium alloying materials containing over 6 percent vanadium (gross weight)		Vanadium ore, concentrates, pentoxide, vanadic oxide, vanadium oxide, and vanadates (except chemically pure grade) (vanadium content)		Vanadium fine dust and other vanadium waste materials (vanadium content)	
	1959	1960	1959	1960	1959	1960
North America:						
Canada	301, 086	290, 962	12, 507	8, 851		
Mexico			2, 800	7, 369		
Nicaragua				61		
Total	301, 086	290, 962	15, 307	16, 281		
South America:						
Argentina			2, 793	392		
Brazil	1, 000		4, 323	2, 914		
Chile		6, 050		196		
Venezuela	1, 000					
Total	2, 000	6, 050	7, 116	3, 502		
Europe:						
Austria			1, 563, 524	3, 125, 590		
Belgium-Luxembourg		220	1, 023	50, 489		3, 472
Czechoslovakia				61, 711		
France		2, 205	216, 986	659, 579		
Germany, West			5, 059	533, 581		
Italy			50, 229	190, 147		
Netherlands		23, 358	86, 720	1, 702, 777	78, 300	70, 593
Sweden			33, 379	249, 821		
Switzerland		114				
Trieste			168, 567			
United Kingdom		300	1, 423	28		
Total		26, 197	2, 126, 910	6, 573, 723	78, 300	74, 065
Asia:						
India			994	956		
Japan			330, 016	784, 970	4, 881	3, 769
Total:			331, 010	785, 926	4, 881	3, 769
Grand total:						
Quantity	303, 086	323, 209	2, 480, 343	7, 379, 432	83, 181	77, 834
Value	$529, 697	$506, 624	$4, 667, 764	$14, 123, 653	$40, 317	$59, 389

Source: Bureau of the Census.

WORLD REVIEW

Gabon.—Vanadium, associated with uranium, occurs in the Mounanan deposits. Although the vanadium content of the deposits was not reported, reserves were estimated at 20 million tons containing 4,000 to 5,000 tons of uranium.[4]

Hungary.—Laboratory-scale studies for the production of vanadium metal were started at the Hungarian State-owned alumina plant at Ajka.[5]

TABLE 8.—World production of vanadium in ores and concentrates by countries [1]

(Short tons)

Country	1951-55 (average)	1956	1957	1958	1959	1960
North America: United States (recoverable vanadium)	[2] 2,813	3,867	3,691	3,030	3,719	4,971
South America:						
Argentina	(3)	(3)	(3)	4	7	(4)
Peru (content of concentrate)	323					
Europe: Finland		43	290	430	557	[5] 550
Africa:						
Angola		11	1	20	3	
Rhodesia and Nyasaland, Federation of: Northern Rhodesia (recovered vanadium)	72					
South-West Africa (recoverable vanadium)	626	308	305	435	719	839
Union of South Africa (Transvaal)			8	316	319	[5] 620
World total (estimate) [1 6]	3,834	4,229	4,295	4,235	5,324	6,980

[1] This table incorporates some revisions.
[2] Includes vanadium recovered as a byproduct of phosphate-rock mining, 1951-54.
[3] Less than 1 ton.
[4] Data not available.
[5] Estimate.
[6] Total represents data only for countries shown in table and excludes vanadium in ores produced in Republic of Congo (formerly Belgian), Mexico, Morocco, Norway, Spain, and U.S.S.R., for which figures are not available; the table also excludes quantities of vanadium recovered as byproducts from other ores and raw materials.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

Union of South Africa.—Controlling interest in Minerals Engineering of South Africa, Ltd., a company that produces vanadium pentoxide at Witbank in the Transvaal, was acquired by the Anglo-American Corporation of South Africa, Ltd.[6]

Transvaal Vanadium Co. (Pty.), increased the capacity of its processing plant at Ferrobank to treat 600 tons of ore daily. The company expects to obtain 2,000 to 2,500 tons of vanadium pentoxide annually from the plant operating at the new capacity.[7]

TECHNOLOGY

The Federal Bureau of Mines continued its research on hyperpurity vanadium production, scaling up successful laboratory work preparatory to producing enough pure metal for physical and cor-

[4] World Mining, International Africa, Gabon: Vol. 13, No. 3, March 1960, p. 71.
[5] Mining Journal (London), Hungarian Metal Developments: Vol. 255, No. 6517, July 15, 1960, p. 69.
[6] H. F. Openheimer, Chairman's Statement, 1960, Anglo-American Corporation of South Africa, Ltd.: 1960, p. 5.
[7] Bureau of Mines, Mineral Trade Notes: Vol. 52, No. 4, April 1961, pp. 44-45.

rosion testing projects. The pure metal produced will also be used in determining vanadium alloying characteristics and in irradiation studies. Bureau metallurgists finished their investigation of the techniques of producing vanadium by open-vessel reduction of the oxides and began a project to produce vanadium-bearing alloys by the same method. In chemical and galvanic corrosion investigations, the metallurgists found that ductile vanadium has good resistance to salt water, 60 percent sulfuric acid, 20 percent hydrochloric acid, and 3 percent nitric acid, but that it corrodes very rapidly in 17 percent nitric acid.

Scientists of the Institute for Atomic Research and the Department of Chemistry of Iowa State University described a method of producing high-purity V_2O_5 from Technical grade oxide.[8] They first made $VOCl_3$ by chlorinating the impure oxide in the presence of carbon, then hydrolizing the $VOCl_3$ in aqueous NH_3 to precipitate NH_4VO_3, which they ignited to the high-purity V_2O_5.

Scientists of the Titanium Metals Corp. of America developed an inter-layer welding technique using either vanadium plugs or a thin continuous sheet as a "butter" between titanium and steel to counter the usual problems in welding dissimilar metals.[9]

Vanadium-base alloys containing 20 to 50 percent columbium display good high-temperature strength and good corrosion-resistance in both oxidizing and reducing environments and can be fabricated by conventional hot-working techniques in air, according to a recent report by S. T. Wlodek, research metallurgist at the laboratories of Union Carbide Metals Co.[10] He found that in the warm-worked condition vanadium-columbium alloys have ultimate tensile strengths of 120,000 to 35,000 pounds per square inch over the temperature range of 700° to 1,000° C. and stress-rupture properties at 700° C. corresponding to 100-hour life at stresses in excess of 100,000 pounds per square inch. Both the aqueous-corrosion resistance and oxidation resistance of the alloys were also considerably higher than those of pure vanadium. Maximum oxidation resistance is obtained by titanium and aluminum additions.

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[8] McCarley, R. E., and Roddy, J. W., The Preparation of High-Purity Vanadium Pentoxide by a Chlorination Procedure: Jour. Less Common Metals (Netherlands), vol. 2, No. 1, February 1960, pp. 29–35.

[9] Metal Progress, Vanadium Butters Titanium-Steel Sandwich: Vol. 78, No. 4, October 1960, p. 169.

[10] Wlodek, S. T., Properties of Vanadium-Columbium Alloys: Jour. Electrochem. Soc., vol. 107, No. 11, November 1960, pp. 923–929.

Vermiculite

By John W. Hartwell [1] and Nan C. Jensen [2]

VERMICULITE consumption in the United States dropped slightly in 1960 due to lower industrial activity. Imports of crude vermiculite from the Union of South Africa rose 5 percent.

TABLE 1.—Salient vermiculite production statistics

(Thousand short tons)

	1951–55 (average)	1956	1957	1958	1959	1960
United States:						
Production:						
Crude	201	193	184	191	207	199
Average value per ton	$12.96	$13.17	$14.15	$14.28	$14.89	$15.62
Exfoliated	[1] 152	159	161	155	153	151
Average value per ton	$68.45	$60.84	$61.55	$63.13	$62.69	$68.23
World: Production, crude	243	254	248	246	260	269

[1] Average for 1954–55.

DOMESTIC PRODUCTION

Crude Vermiculite.—Three domestic producers of crude vermiculite reported production of 199,000 short tons in 1960, a drop of 4 percent from 1959. However, the value increased nearly 1 percent to $3,108,000. This reflected an average increase of 73 cents per ton.

Exfoliated Vermiculite.—Production of exfoliated vermiculite was 151,000 tons, a drop of about 2,000 short tons. The average value per ton increased $5.54, resulting in an 8-percent gain in value to $10,302,000.

Low-grade vermiculite deposits in central Texas were described. This material was not of commercial grade, but the reserve was large and prospects for exploitation were considered good.[3]

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[1] Commodity specialist, Division of Minerals.
[2] Supervisory statistical assistant, Division of Minerals.
[3] Calabaugh, S. E., and Barnes, V. E., Vermiculite in Central Texas: Texas Univ., Bureau Econ. Geol. Rept. of Investigations No. 40, 1959, 32 pp.

TABLE 2.—Screened and cleaned domestic crude vermiculite sold or used by producers in the United States

(Thousand short tons and thousand dollars)

Year	Quantity	Value	Year	Quantity	Value
1951-55 (average)	201	$2,604	1958	191	$2,728
1956	193	2,542	1959	207	3,082
1957	184	2,603	1960	199	3,108

TABLE 3.—Exfoliated vermiculite sold or used by producers in the United States

(Thousand short tons and thousand dollars)

	Operators	Plants	States	Quantity	Value
1954-55 (average) [1]	27	52	33	152	$10,404
1956	27	55	33	159	9,674
1957	26	54	35	161	9,910
1958	25	51	35	155	9,785
1959	25	52	34	153	9,591
1960	27	52	33	151	10,302

[1] Data not compiled before 1954.

CONSUMPTION AND USES

The building plaster, lightweight concrete, loose-fill insulation, and soil conditioning markets continued to use most of the exfoliated vermiculite. Miscellaneous uses included insulation for pipes, stoves, refrigerators, and safes; seed propagation; and herbicide, fungicide, fertilizer, and fumigant carriers.

PRICES

E&MJ Metal and Mineral Markets quoted nominal yearend prices for crude vermiculite as follows: Per short ton, f.o.b. mines, Montana, $9.50 to $18; South Africa, c.i.f. Atlantic ports, $24.75 to $38.50.

The average mine value of all domestic crude vermiculite sold or used in 1960 was $15.62 per ton, compared with $14.89 in 1959, and $14.28 in 1958.

The average value of all exfoliated vermiculite, f.o.b. processors' plants, was $68.23, compared with $62.69 in 1959.

FOREIGN TRADE

Crude vermiculite is imported into the United States duty free. The Union of South Africa continued to be virtually the only source of imports. The United States received 20 percent of the South African exports, the same as in 1959, but the quantity imported was greater by 569 tons.

WORLD REVIEW

Canada.—Production of exfoliated vermiculite was 344,000 cubic yards in 1959, a 13-percent increase over 1958. Five companies at 11 locations exfoliated the vermiculite imported from the Union of South Africa and the United States. Seventy-two percent of the exfoliated material was used as loose insulation, 20 percent in insulating plaster, 2 percent as an aggregate in concrete, and 6 percent in other products.[4]

A vermiculite deposit at Stanleyville, Ontario, was being developed by Olympus Mines as an open pit operation. The deposit was reported to contain 64 percent vermiculite, and the company planned to build a mill to process 200 tons of ore a day.[5]

Imports from Union of South Africa decreased 25 percent under 1959 shipments. Most crude vermiculite exfoliated in Canada came from the United States.

India.—The geology of a vermiculite deposit in Mysore State and the theory concerning its origin were published.[6]

TABLE 4.—World production of vermiculite by countries [1] [2]

(Short tons)

Country [1]	1951–55 (average)	1956	1957	1958	1959	1960
Argentina	604	614	287	161	[3] 165	[3] 165
Australia	33	1	----------	----------	----------	----------
India	85	1,038	----------	----------	2	17
Kenya	255	497	33	96	112	283
Morocco	----------	----------	147	----------	----------	----------
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	110	305	460	280	50	----------
Tanganyika	----------	----------	----------	91	125	20
Union of South Africa	40,778	58,717	62,619	54,314	52,398	69,022
United Arab Republic (Egypt Region)	175	----------	33	302	331	[3] 330
United States (sold or used by producers)	201,405	192,628	183,987	190,564	206,579	199,036
World total [1] [2]	243,445	253,800	247,566	245,808	259,762	268,873

[1] Vermiculite is produced in Brazil and U.S.S.R., but data are not available, and no estimates of their production are included in the total.
[2] This table incorporates some revisions.
[3] Estimate.

Compiled by Helen L. Hunt, Division of Foreign Activities.

Italy.—A large industry using vermiculite in various ways, particularly as lightweight aggregate and for thermal and acoustical insulation, has developed since World War II.[7] Imports of crude ore from the Union of South Africa increased from about 2,000 short tons in 1950 to over 8,000 tons in 1960.

Morocco.—A vermiculite deposit near Tetuan in northern Morocco was leased by the Moroccan-American Development Co. of Casablanca. This company planned to mine and process the ore for export.[8]

Pakistan.—A vermiculite deposit discovered in the Western Ras Koh Range south of Dalbandin in 1957 was reported to contain a large quantity of low-grade ore. The area was leased by a mining company in 1960, and plans were made to develop the property.[9]

[4] Wilson, H. S., Lightweight Aggregates, 1959 (Prelim.): Department of Mines and Tech. Surveys, Canadian Miner. Ind., Ottawa, Canada, Review 27, May 1960, 6 pp.
[5] Northern Miner (Toronto), Olympus Planning Vermiculite Output: Vol. 46, No. 28, Oct. 6, 1960, p. 13.
[6] Murthy, Rama R. K., Occurrence of Vermiculite in Mysore State: The Quart. Jour. of the Geol. Min. and Met. Soc. of India (Calcutta), vol. 32, No. 2, June 1960, pp. 87–91.
[7] Mining Journal (London), Mining Miscellany: Vol. 255, No. 6536, Nov. 25, 1960, p. 603.
[8] Mining World, International News, Morocco: Vol. 22, No. 1, January 1960, p. 73.
[9] Mining Journal (London), Mineral Production of Pakistan: Vol. 254, No. 6500, Mar. 18, 1960, p. 325.

Union of South Africa.—Transvaal Ore Company, Ltd., mined and processed 99 percent of the vermiculite produced in the Union of South Africa. The deposit, 25 miles northeast of Mica in the northeastern Transvaal, contains ore averaging 20 to 30 percent vermiculite. In 1960 the monthly ore production was 60,000 tons, from which 6,000 tons of vermiculite was obtained. Only 54 percent vermiculite was recovered from the ore because of losses that occurred during hand-sorting before milling.[10]

TABLE 5.—Union of South Africa: Exports of crude vermiculite by countries [1]

(Short tons)

Destination	1959	1960
North America:		
Canada	4,449	3,335
Mexico	50	143
United States	11,827	12,396
South America: Uruguay	46	103
Europe:		
Austria	160	214
Belgium	169	766
Denmark	1,844	1,415
Finland	------------	225
France	6,340	6,620
Germany, West	4,444	5,704
Italy	6,100	8,054
Netherlands	811	1,633
Sweden	275	533
Switzerland	187	389
United Kingdom	16,272	16,255
Asia:		
Bahrain	198	------------
Iraq	154	------------
Israel	41	284
Japan	627	774
Kuwait	719	667
Turkey	174	216
Africa:		
Algeria	100	449
Mali, Republic of	98	175
Rhodesia and Nyasaland, Federation of	301	288
Oceania: Australia	2,077	1,913
Other countries	553	487
Total	58,016	63,038
Total value [2]	$1,120,747	$1,192,650
Average value	$19.31	$18.92

[1] This table incorporates some revisions.
[2] Converted to U.S. currency at the rate of SAF-US$2.7983 (1959) and US$2.7971 (1960).

Source: Compiled from Customs Returns of Union of South Africa by Corra A. Barry, Division of Foreign Activities.

TECHNOLOGY

A book published on the geology of industrial rocks and minerals contained information on vermiculite. Data included description and location of occurrences, chemical and physical properties, production, uses, and 24 references.[11]

Mining and milling of vermiculite near Enoree, S. C., by the Zonolite Co. were described.[12]

[10] U.S. Consulate General, Johannesburg, Union of South Africa, State Department Dispatch 185: Dec. 30, 1960, p. 1.
[11] Bates, R. L., Geology of Industrial Rocks and Minerals: Harper and Brothers, New York, 1960, pp. 340–347.
[12] North, Oliver S., Vermiculite Sparkles in Modern Industry: Rock Products, vol. 63, No. 10, October 1960, pp. 94–97.

Because vermiculite has a high cation exchange capacity, the ion exchange of radioactive wastes with this mineral was investigated.[13]

New developments in vermiculite and allied products of interest to the construction industry were discussed at the 19th annual meeting of the Vermiculite Institute, held at Chandler, Ariz., in March 1960.[14]

A new lightweight roof assembly consisting of a 2-inch slab of vermiculite insulating concrete over a vented corrugated steel deck was awarded a 2-hour fire rating by the Underwriters' Laboratories. The underside of the steel deck was also fireproofed with 7/8 inch of vermiculite acoustical plastic.[15]

Refractory linings made from a mixture of vermiculite and cement were designed by H. and E. Lintott, Ltd., Horsham, Sussex, England. These linings have a high resistance to thermal shock and withstand temperatures up to 2,400° F.[16]

Uses of vermiculite as an anti-spatter agent in welding operations, as a lubricant, and in a liquid dispersion to prevent seizure of nuts and bolts used in high-pressure and temperature equipment, were described.[17]

A packaging material using vermiculite was developed for shipping bromine.[18]

The use of vermiculite as a flameproof material with high compressive strength for filling large roof cavities in coal mines was described.[19]

A method of producing exfoliated vermiculite with exact standards and control was patented. The freshly exfoliated material was taken from the kiln-discharge stream periodically to determine the percent shrinkage and the furnace heat then adjusted as needed.[20] This patent was similar to Canadian Patent No. 598,269, dated May 17, 1960.

A lightweight packing and insulating material was made of exfoliated vermiculite mixed with kaolin and waterglass and the mixture treated with a metal salt to form a metal silicate.[21]

A patented insulating compound for the metal parts of rockets or missiles consisted of asbestos, exfoliated vermiculite, a fire resistant rubber vehicle, plasticizer, pigment, and an aromatic solvent.[22]

A composition for protecting buried pipelines was made by using mixtures of granular petroleum asphalts and aggregates such as exfoliated vermiculite.[23]

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[13] Schnepfe, Marian M., Cation Exchange With Vermiculite: Geol. Survey Res. 1960, Geol. Survey Prof. Paper 400–B, 1960, p. B161.

[14] Mining Record, Vermiculite Group Tells of Meeting: Vol. 71, No. 15, Apr. 21, 1960, p. 4.

[15] Concrete, New Lightweight-Roof System Earns Two-Hour Rating: Vol. 68, No. 4, April 1960, p. 37.

[16] Chemical Age (London), Vermiculite/Ciment Fondu Refractory Linings for Process Heaters: Vol. 84, No. 2163, Dec. 24, 1960, p. 1050.

[17] South African Mining and Engineering Journal (Johannesburg), Fresh Uses for Vermiculite: Vol. 71, No. 3523, Aug. 12, 1960, p. 351.

[18] Chemical Age (London), Vermiculite Packaging Reduces Bromine Hazards: Vol. 83, No. 2122, Mar. 19, 1960, p. 310.

[19] Wright, H., Vermiculite in Coal Mines: Iron and Coal Trades Rev. (London), vol. 181, No. 4802, July 29, 1960, pp. 231–241.

[20] Ziegler, G. E. (assigned to Zonolite Co., Chicago, Ill.), Production of Exfoliated Vermiculite: U.S. Patent 2,945,820, July 19, 1960.

[21] Glaser, O., British Patent 795,823, May 28, 1960.

[22] Shenk, A. M. (assigned to Ideal Chemical Products, Inc., Culver City, Calif.), Flame-Resistant, High-Heat Insulating Composition: U.S. Patent 2,938,937, May 31, 1960.

[23] Gzemski, F. C., and Ford, K. D. (assigned to Atlantic Refining Co., Philadelphia, Pa.). Composition for Protecting Metallic Structures: U.S. Patent 2,935,412, Mar. 5, 1960.

An asphaltic coating composition for protecting utility poles, railroad ties, and other exposed wood articles from fire and weather was patented. The composition contained 5 to 15 percent exfoliated vermiculite and other minerals and compounds.[24]

A fire-resistant and heat-insulating material was produced by mixing exfoliated vermiculite with sodium or potassium silicate in an aqueous solution, forming into the required shape, and exposing the shape to an atmosphere of carbon dioxide.[25]

A patented fire-retardant composition was made from fatty acid soap, gilsonite, and a finely divided mineral filler such as talc with exfoliated vermiculite.[26]

A patent was granted for making wood fiber base acoustical tile or fiberboard, using exfoliated vermiculite and swelling bentonite.[27]

An acoustical plaster composed of calcined gypsum, exfoliated vermiculite or other suitable medium, and an air-entraining agent was patented.[28]

A method was patented for making clay brick or other structural units having controlled bulk density by using exfoliated vermiculite or similar material.[29]

A process was patented in Great Britain for making waterproof concrete using exfoliated vermiculite as an aggregate.[30]

Another British patent was granted for the use of exfoliated vermiculite to make lightweight concrete for holding rigid the induction coil in an induction melting furnace.[31]

An oil well drilling mud composition made of magnetite and crude or exfoliated vermiculite was patented.[32]

A friction belt with a flexible adhesive backing coated with exfoliated vermiculite was patented.[33] The belt was used to apply a glossy finish to wall panels, flush doors, and other surfaces.

A patent described the use of exfoliated vermiculite as an absorbent for liquid fertilizers. After drying, the vermiculite is used as an aid for growing plants.[34]

Insecticide compositions were made by absorbing patented insecticides onto exfoliated vermiculite or like material.[35]

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[24] Wilkinson, C. E. (assigned to Texaco, Inc.), Coating Composition and Coated Structures: U.S. Patent 2,939,794, June 7, 1960.

[25] Murphy, W. (assigned to Decorators, Ltd., Liverpool, England), Canadian Patent 609,305, Nov. 22, 1960.

[26] Hodnefield, O. T. (one-half assigned to Kay O. Anderson), Fire Retardant Composition Comprising Gilsonite, Mineral Filler, and Fatty Acid Soap: U.S. Patent 2,940,942, June 14, 1960.

[27] Hart, J. C., and Lauring, E. A. (assigned to Minnesota and Ontario Paper Co., Minneapolis, Minn.), Fissured Coated Fiberboard and Method of Manufacture: U.S. Patent 2,947,647, Aug. 2, 1960.

[28] Sucetti, G., Acoustical Composition: U.S. Patent 2,921,862, Jan. 19, 1960.

[29] Robinson, G. C. (assigned to Zonolite Co., Evanston, Ill.), Structural Clay Products and Method of Making the Same: U.S. Patent 2,922,719, Jan. 26, 1960.

[30] Watkins, C. M. (assigned to Council for Scientific and Industrial Research), British Patent 842,592, July 27, 1960.

[31] Segsworth, R. S., British Patent 827,665, Feb. 10, 1960.

[32] Thompson, J. V. (assigned to self and Alfred G. Hoyl, in partnership), Well Drilling Mud and Method of Making the Same: U.S. Patent 2,944,019, July 5, 1960.

[33] Dimond, L. E. (assigned to General Plywood Corp., Louisville, Ky.), High Speed Frictional Glossifying Medium: U.S. Patent 2,949,623, Aug. 23, 1960.

[34] Kelley, J. A., and Ridgeway, J. L. (assigned to Zonolite Co., Chicago, Ill.), Method for Handling Liquid Materials and for Granulating and Conditioning Solids: U.S. Patent 2,931,716, Apr. 5, 1960.

[35] Trademan, L., Molina, M. A., and Wilks, L. P. (assigned to Velsicol Chemical Corp., Chicago, Ill.), Insecticide Formulations and Methods of Making Same: U.S. Patent 2,927,882, Mar. 8, 1960.

Ziegler, G. E., and Fotach, L. P. (assigned to Zonolite Co., Chicago, Ill.), Pesticidal Composition: U.S. Patent 2,923,659, Feb. 2, 1960.

The use of exfoliated vermiculite as a soil fumigant carrier was patented.[36]

A cigarette filter was patented consisting of exfoliated vermiculite and tobacco.[37]

A method was patented for making a vitreous refractory containing vermiculite or mica.[38]

Other United States and foreign patents were issued during the year on processes or products containing exfoliated vermiculite. These patents included: Filler in natural or synthetic rubber; [39] filler for ceramic material; [40] insulating refractory; [41] roofing felt; [42] fiberboard construction; [43] and lightweight aggregate.[44]

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[36] Hammer, O. H. (assigned to Dow Chemical Co.), Canadian Patent 601,798, July 19, 1960.

[37] North, O. S., Smoking Tobacco Products: U.S. Patent 2,955,060, Oct. 4, 1960.

[38] Grim, R. E. (assigned to Mineral and Chemicals Corp. of America, Menlo Park, N.J.), Vitreous Refractory Composition and Method for Making Same: U.S. Patent 2,945,768, July 19, 1960.

[39] Hauser, E. A. (assigned to National Lead Co., New York), Clay Complexes With Conjugated Unsaturated Aliphatic Compounds of Four or Five Atoms: U.S. Patent 2,951,097, Aug. 30, 1960.

[40] Wessel, H., British Patent 836,423, June 1, 1960.

[41] Burnett, W. H. (assigned to Wm. H. Burnett in Trust), Canadian Patent 558,901, June 17, 1960.

[42] Campbell, C. H., British Patent 851,522, Oct. 19, 1960.

[43] Hart, J. C., and Lauring, E. A. (assigned to Minnesota & Ontario Paper Co., Minneapolis, Minn.), Fissured Coated Fiberboard and Method of Manufacture: U.S. Patent 2,947,647, Aug. 2, 1960.

[44] Taylor, J. B. (assigned to British Plaster Board Holdings, Ltd.), British Patent 832,256, Apr. 6, 1960.

Water

By Robert T. MacMillan [1]

EXCEPT for continued drought in the Southwest, the water supply in the United States was mostly in the median range in 1960. Increased public awareness of the long-range water problems facing the Nation was created by the activities of many governmental and nongovernmental groups organized to define and cope with problems of providing an adequate water supply.

LEGISLATION AND GOVERNMENT PROGRAMS

A bill to amend the Federal Water Pollution Control Act, increasing the grants for constructing sewage treatment works and for other purposes, was vetoed by President Eisenhower on the grounds that the problem of sewage disposal was primarily a local responsibility and too much Federal participation would tend to discourage rather than stimulate State and local action in this field. The Secretary of the Department of Health, Education, and Welfare was asked to arrange a national conference on water pollution to draw the attention of taxpayers and business concerns to the gravity of the problem and to help them realize their part and obligation in preventing pollution.[2]

The Conference on National Water Pollution was held in Washington, D.C., December 12–14, 1960. Although no agreement was reached among the 1,150 delegates, regarding the issue of extending the power of the Federal Government into the field of water pollution, the Conference adopted 14 recommendations for a program to clean up the Nation's rivers and other water resources. The program included planning for comprehensive development of each major river basin; accelerating the collection of information on industrial, municipal, and agricultural wastes; increased construction of municipal and industrial waste-treatment facilities; training more engineers and scientists to advance the technologic and economic aspects of water pollution control; and expanding programs of public information designed to bring public opinion to bear on the problem.[3]

[1] Commodity specialist, Division of Minerals.
[2] Federal Water Pollution Control Act—Veto Message From the President of the United States: H. Doc. 346; Congressional Record, 86th Cong., 2d sess., vol. 106, No. 31, Feb. 23, 1960, pp. 2993–2994.
[3] Mullins, H. J., Pollution Conference Recommends Points for Water Control Program: The Constructor, vol. 43, No. 1, January 1961, pp. 37, 40.
U.S. Department of Health, Education, and Welfare, Proc. of Nat. Conf. on Water Pollution, December 12–14, 1960: U.S. Government Printing Office, 607 pp.

After more than 2 years of hearings before a Special Master of the Supreme Court, recommendations were made concerning the allocation of water rights of the lower Colorado River. Witnesses placed future needs of California from the Colorado River at over 6 million acre-feet a year; however, the recommendation of the Special Master divided the first 7.5 million acre-feet of water made available by the Department of the Interior as follows: 4.4 million acre-feet for California, 2.8 million acre-feet for Arizona, and 300,000 acre-feet for Nevada. If accepted by the Supreme Court, the allocation formula would tend to reactivate the long-dormant Central Arizona Irrigation Project and curtail water supplies expected to be needed in the future by the Metropolitan Water District of California.[4]

The Senate Select Committee on National Water Resources completed its activities and made ready a final report to be released early in 1961. Thirty-one individual Committee reports were published covering each phase of the investigation, said to be the most comprehensive study ever undertaken of the present and future water supply problems of the Nation.[5]

The Office of Saline Water, U.S. Department of the Interior, reported that three of the five saline water-conversion demonstration plants authorized by Congress were under construction. One plant at Freeport, Tex., was approaching completion and will use the long-tube-vertical 12-effect distillation cycle. It was designed to produce 1 million gallons per day of potable water from sea water, using 1,000 B.t.u. of heat energy for each 9.5 pounds of water converted.

The second construction contract was for a multistage flash-distillation plant under construction at San Diego, Calif. Designed capacity was 1 million gallons per day. The third demonstration plant was under construction at Webster, S. Dak., for converting brackish water, containing 1,800 parts per million total solids and significant quantities of iron and calcium. The plant utilizes the electrodialysis principle and was designed to produce 250,000 gallons of fresh water per day.

Still in the design stage was a 1-million-gallon-per-day, forced-circulation, vapor compression distillation plant to be erected at Roswell, N. Mex. It will convert brackish water to fresh water.

The fifth demonstration plant of the series was to be erected at an East Coast site. The plant will operate on a freezing cycle and have a capacity of 250 million gallons per day.[6]

Activities of the Joint Federal-State Anthracite Mine Water Control Program continued at a slow pace. Only three control projects at a total cost of about $400,000 were approved for Federal participation in 1960.

DOMESTIC SUPPLY

The water supply of the United States is primarily dependent on the quantity and distribution of precipitation. A convenient measure

[4] Sullivan, J. B., A New Course for the Colorado: Eng. News-Record, vol. 164, No. 20, May 19, 1960. pp. 25–27.

[5] Select Committee on National Water Resources, Water Resource Activities in the United States: U.S. Senate Committee Print Nos. 1–31, 1960.

[6] U.S. Department of the Interior, Saline Water Conversion Report for 1960: January 1961, 135 pp.

of potential water supply is the flow or runoff of major streams. In 1960 the runoff was in the median range for most of the States; areas of excessive streamflow in the Northeastern, North Central, and Southeastern States were balanced by areas of deficiency in the Southwest, particularly in Arizona, California, Nevada, Utah, and Wyoming.

The average flow of the Mississippi River at Vicksburg in 1960 was 101 percent of the median, and the flow of the Colorado River near Grand Canyon, Ariz., was 72 percent. At The Dalles, Oreg., the flow of the Columbia River was 114 percent of the median after adjusting for changes in storage in eight reservoirs, and the flow of the St. Lawrence River from Lake St. Lawrence was 107 percent of the median. Elevation of Great Salt Lake, 1.15 feet below the 1959 level, was the lowest ever recorded. No major floods were recorded; however, periods of flooding occurred in many of the Eastern and Central States and Texas.

Water storage in major power and municipal and industrial reservoirs was slightly above average in 1960. Storage in irrigation reservoirs was generally below average. Water levels in the Great Lakes ranged from 2 feet below average in Lakes Michigan and Huron to slightly above average in Lake Superior. A chart of the yearly range of average monthly stages of Lake Michigan-Huron for 100 years from 1860 to 1960 showed a fluctuation in water level of less than 6 feet. Although only 4 percent of the United States is drained by the Great Lakes and St. Lawrence River, 24 percent of the industrial water of the Nation was derived from the Great Lakes and St. Lawrence River basin.

Ground-water levels were above average along the Atlantic coast, in parts of the Great Lakes region, and in certain midcontinent areas. In most other areas and in the Western States, ground-water levels ranged from below average to far below average.[7]

An important step was taken in developing the water resources of California when the $1.75-billion bond issue for the Feather River project was approved by the electorate. This project, which had been studied for many years, would transfer excess water from the Feather River north of Sacramento through a system of canals and tunnels to the highly industrialized but sparsely watered areas of southern California.[8]

Tremendous expansion in construction for public water supply in the next 20 years was predicted at the American Water Works Association Convention. A total annual construction figure of $1.155 billion was estimated to be needed for correcting deficiencies in present water systems and providing for population increases and water quality improvement. Estimated expenditure for 1960 was $450 million.

Complete control of river flows by dams and reservoirs, a condition now existing only in a few arid regions, was said to be needed to provide adequate future water supplies for the United States. Total

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[7] Geological Survey (in collaboration with Canada Department of Northern Affairs and Natural Resources), Water Resources Review: Annual Summary, Water Year 1960: Oct. 26, 1960, 20 pp.

[8] Engineering News-Record, California Bonds Win—Barely: Vol. 165, No. 20, Nov. 17, 1960, pp. 24–25.

water needs for the Nation in 1980 were estimated at approximately 600 billion gallons per day, a figure recognized by some engineers as the total quantity of water practically available but only about half the average runoff of all streams.[9]

Separation of heavy water (D_2O) from ordinary water continued at the Savannah River plant of the Atomic Energy Commission. Heavy water is used as a moderator and coolant in some nuclear reactors where it has the advantage over light water in conserving neutrons. Consignments of D_2O to foreign countries were as follows:

Country:	*Sold, pounds*	*Leased, pounds*
Australia	1,000	
Canada	6,000	------
France	------	36,500
Germany, West	------	2,000
Japan	6,835	------
India	------	500
Norway	13,500	------

CONSUMPTION AND USES

Approximately half of the water withdrawn from all sources in 1960 was used by industry, according to estimates of the U.S. Department of Commerce; 42 percent was used for irrigation; and 8 percent was for public supply. Total withdrawals were estimated to be about 320 billion gallons per day. Water used for generating hydroelectric power was excluded from these estimates because it was available for reuse without treatment. Nonwithdrawal uses of water included navigation, recreation, waste dilution, and conservation of wild life.[10]

Per capita consumption ranged from 143 gallons per day per person in communities where 99 percent of the water was metered to 174 gallons per day in unmetered systems.[11]

Estimates were made by Federal Bureau of Mines engineers of the quantity of water injected into oil-bearing strata in the secondary recovery of oil and in pressure maintenance of producing fields. About 2.7 billion barrels of water (1 barrel equals 42 gallons) was used in the secondary recovery of 275 million barrels of oil in 1960; 35 percent was fresh water and 65 percent saline. Production of 260 million barrels of oil from producing fields, was attributed to the injection of 800 to 900 million barrels of water for pressure maintenance. Of the injected water, 20 percent was fresh and the remainder saline. Various meanings assigned to the terms "secondary recovery" and "pressure maintenance" were discussed in an article.[12] The difference in meaning hinged on whether fluid was injected into the field before or after economic production limits of the field were approached.

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[9] Engineering News-Record, Experts See Heavy Spending Ahead: Vol. 164, No. 21, May 26, 1960, pp. 24–25.

[10] Iron Age, Planning and Research Can Help Meet Industry's Water Needs: Vol. 186, No. 17, Oct. 27, 1960, pp. 55–57.

[11] Select Committee on National Water Resources, Water Resources Activities in the United States: U.S. Senate Committee Print No. 7, 1960, 23 pp.

[12] Jersin, A. J., Secondary Recovery?—Pressure Maintenance?: The Interstate Oil Compact Commission Bull., vol. 2, No. 2, December 1960, pp. 56–58.

PRICES

Cost of public water delivered at the tap in various municipal areas varied from 10 cents per thousand gallons in Chicago to 39 cents in San Francisco. Average municipal water costs for water-resource regions varied from 14 to 28 cents per thousand gallons.[13]

Water used by industry was largely self-supplied, and costs depended on the quality and treatment needed. Irrigation water was usually less expensive than municipal water.

The price of heavy water was maintained at $28 per pound. It was available for sale or lease by the Atomic Energy Commission in 125- and 500-pound stainless steel containers also charged to the customer. Leasing charges were 4 percent per year of the monetary value of the water. The lease period for domestic reactors was 5 years subject to renewal; for foreign reactors it was for the estimated life of the reactor.

Costs of desalted water per 1,000 gallons at several locations were as follows:

Location:	*Cost, per 1,000 gallons*
Aruba (sea water)	$1.25–$1.75
Morro Bay, Calif. (sea water)	2.50
Coalinga, Calif. (brackish water)	1.43
Union of South Africa (brackish water)	0.50

Cost of desalted water from the three saline water demonstration plants now under construction was calculated to be about $1 per thousand gallons.[14]

WORLD REVIEW

Japan.—The construction of dams in Japan probably exceeded that of any other nation in 1960. Ninety-one dams over 50 feet high were completed, of which 12 were about 200 feet and 4 were between 300 and 400 feet high. Ninety-nine more were reported to be under construction. The chief reason for the dam-building activity was said to be the demand for power.[15]

United Kingdom.—The first sea-water distillation plant to be erected in the temperate zone was officially opened at Guernsey, an island having moderate rainfall but with geological features unfavorable to retention of fresh water. The capacity of the plant was 500,000 gallons of fresh water per day to be used largely for agriculture.[16]

TECHNOLOGY

The technology of saline water conversion advanced steadily in 1960. Several new processes were made known and many older systems were revised and improved. Fundamental studies on materials

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[13] Work cited in footnote 11.

[14] Engineering News-Record, Water Re-Use Beats Desalting: Vol. 165, No. 18, Nov. 3, 1960, p. 24.

[15] Bowman, W. G., Japanese Dambuilding is a Flourishing Art: Eng. News-Record, vol. 165, No. 23, Dec. 8, 1960, pp. 30–33, 36, 38.

[16] Chemical Trade Journal and Chemical Engineer (London), Fresh Water From Sea Water: Vol. 147, No. 3825, Sept. 23, 1960, p. 660.

and methods were carried out. Processes under investigation fell into the following groups: (1) Distillation with the use of fuels; (2) solar heat distillation; (3) membrane processes; (4) separation by freezing; and (5) other chemical, electrical, or physical conversion methods.[17]

A major part of the saline water development effort was directed toward freezing techniques. These processes have an inherent advantage over distillation processes because less energy is required to operate them. Improvements in the formation of the ice crystals helped to overcome the problem of separating ice crystals from the adhering brine. The most promising methods were the direct freezing methods, in which the refrigerant was evaporated in direct contact with the saline water, permitting high heat-transfer coefficients. In some cases the refrigerant was an immiscible compound such as freon or butane and sometimes it was part of the water content of the brine evaporated at a very low pressure. A pilot plant, using a direct freezing method, was successfully operated, and a demonstration plant, using a freezing process, was planned.

A notable example of a process that advanced very rapidly was the demineralization of sea water by the formation of gas hydrates. These hydrates were formed when saline water, under the proper conditions of temperature and pressure, was treated with certain organic reagents, such as propane or a halogenated derivative. The hydrates or clathrate crystals contained, for example, 1 mole of propane and 17 moles of water. After the crystals were separated from the residual brine they were melted to produce potable water and propane for recycling to the process.

The method is similar to freezing processes but has an advantage in that gas hydrates may be formed at temperatures considerably above those required to freeze ice, thus permitting more efficient use of refrigeration equipment.

A wiped-film evaporator was tested in which a thin film of brine was maintained on the inside of a copper tube by a revolving wiper blade assembly. The outside of the tube was heated by condensing steam, causing the films to evaporate. The wiper blade also aided brine discharge and prevented scale formation. High heat-transfer coefficients were obtained in bench-scale tests.

A distillation process, using heat generated by radioisotope pellets, was under study. Certain calcined fission products that resulted from nuclear fuel reprocessing were formed into pellets and encapsulated in ceramic or metal. Heat generated by the capsules was said to be competitive with conventional fuels at some locations and to last 15 years. A fluidized-bed type reactor was envisioned.

Government-operated heating and power plants continued to receive consulting boiler-water service from the Bureau of Mines through its Industrial Water Laboratory. Boiler water testing equipment and reagents were distributed to various plants to provide quality control of both boiler-feed-water and condensate return. Accuracy of control testing was verified periodically by analyzing samples sent to the Industrial Water Laboratory. Over 13,600 samples

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[17] U.S. Department of the Interior, Saline Water Conversion Report for 1960; January 1961, 135 pp.

were analyzed and an estimated 10,000 boilers received service through the Industrial Water Laboratory. The Laboratory also conducted research designed to improve methods for controlling corrosion and scale formation in boilers and condensate return lines. Carbonic acid was found to be a corrosive agent in boiler water. Replacing sodium carbonate with sodium hydroxide as a feed-water treatment reagent and decreasing the quantity of makeup water added to the system were found to be corrective.

The search for methods to retard evaporation from the surface of reservoirs received increasing attention in 1960. Over 150 compounds and compositions of matter were screened as potential retardants. The homologous straight-chain fatty alkanols were most promising. Disruption of the monomolecular layer by wind and biochemical oxidation of the reagent were two important problems remaining to be solved. Not more than 20 percent reduction of evaporation on the larger reservoirs was reported.[18]

The study of problems related to weather modification continued to increase. Aerial seeding of clouds in Arizona with silver iodide crystals resulted in larger storms with more lightning strokes and the initiation of precipitation in clouds which would not have precipitated normally.[19]

Another series of tests was designed to induce a space charge on cumulus clouds. A 4-mile-long stainless steel wire was stretched 30 feet above the ground and charged to a potential of 10 kilovolts. Space charge of the air in the vicinity of the wire was increased 1,000-fold and some of the charge was carried to cloud level; however, the space charge source was too small to affect meteorological conditions significantly.

Most of the research expenditure was divided into small grants to study fundamental chemical and physical problems related to the larger problem of weather control. An important factor in the progress of the work was the lack of trained manpower.

The world's first boiling heavy-water reactor went critical at Holden, Norway. Built inside a mountain, the new-type reactor supplied process steam to a papermill. Using 7 tons of uranium fuel elements and 16 tons of heavy water in a closed cycle the reactor generated about 20,000 kilowatts of heat energy.[20]

An evaluation of 98 potential processes for producing heavy water indicated little hope for significant reduction in cost of D_2O production. Established methods of production were not included in the survey. The following eight processes were thought to be promising: (1) Exchange between hydrogen and water, (2) hydrogen and water-hydrazine, (3) phosphine and water, (4) hydrogen iodide and water, (5) ammonia distillation, (6) reversible electrolysis of water, (7) direct electrolysis of deuterium and (8) char absorption of water.[21]

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[18] Cruse, R. R., and Harbeck, G. E., Evaporation Control Research 1955–58: Geol. Survey Water Supply Paper 1480, 1960, 45 pp.

[19] National Science Foundation, Weather Modification: 2d Ann. Rept., 1960, 22 pp.

[20] Guerin, E. T., Norway Builds World's First Boiling Heavy Water Reactor: Research/Development, vol. 11, No. 12, December 1960, pp. 56–60.

[21] Barr, F. T., and Drews, W. P., The Future for Cheap Heavy Water: Chem. Eng. Prog., vol. 56, No. 3, March 1960, pp. 49–56.

Zinc

By H. J. Schroeder[1] and Esther B. Miller[2] [3]

Contents

THE DOMESTIC zinc industry in 1960 recorded slightly larger mine and smelter production, but output was hampered by strikes during May through December. Consumption of slab zinc was relatively large in the first 6 months but declined considerably in the last half of the year and totaled 8 percent less than in 1959.

Producers' stocks increased, and consumers' stocks decreased by approximately the same quantity, resulting in little change in total industry stocks. No contracts were made for zinc to be added to Government stockpiles.

Import quotas remained in effect, and imports decreased 12 percent for ores and concentrates and metal combined. Foreign demand was high, and U.S. exports of slab zinc increased six-fold to 75,100 tons.

Prices increased from 12.5 to 13 cents a pound, East St. Louis, in early January and remained at this level until December when two reductions of ½ cent each resulted in a 12-cent quotation at yearend.

The International Lead-Zinc Study Group held two meetings and concluded that the anticipated excess of world production over consumption was not large enough to require action.

LEGISLATION AND GOVERNMENT PROGRAMS

The International Lead-Zinc Study Group held meetings in Geneva, Switzerland, during January 27-February 3 and September 12–15. At the earlier meeting it was concluded that world zinc consumption and production were approximately in balance. However, at the September meeting, an indicated 82,000 tons excess of production over consumption was predicted for the year. The situation was not be-

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.
[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from reports of the U.S. Department of Commerce, Bureau of the Census.

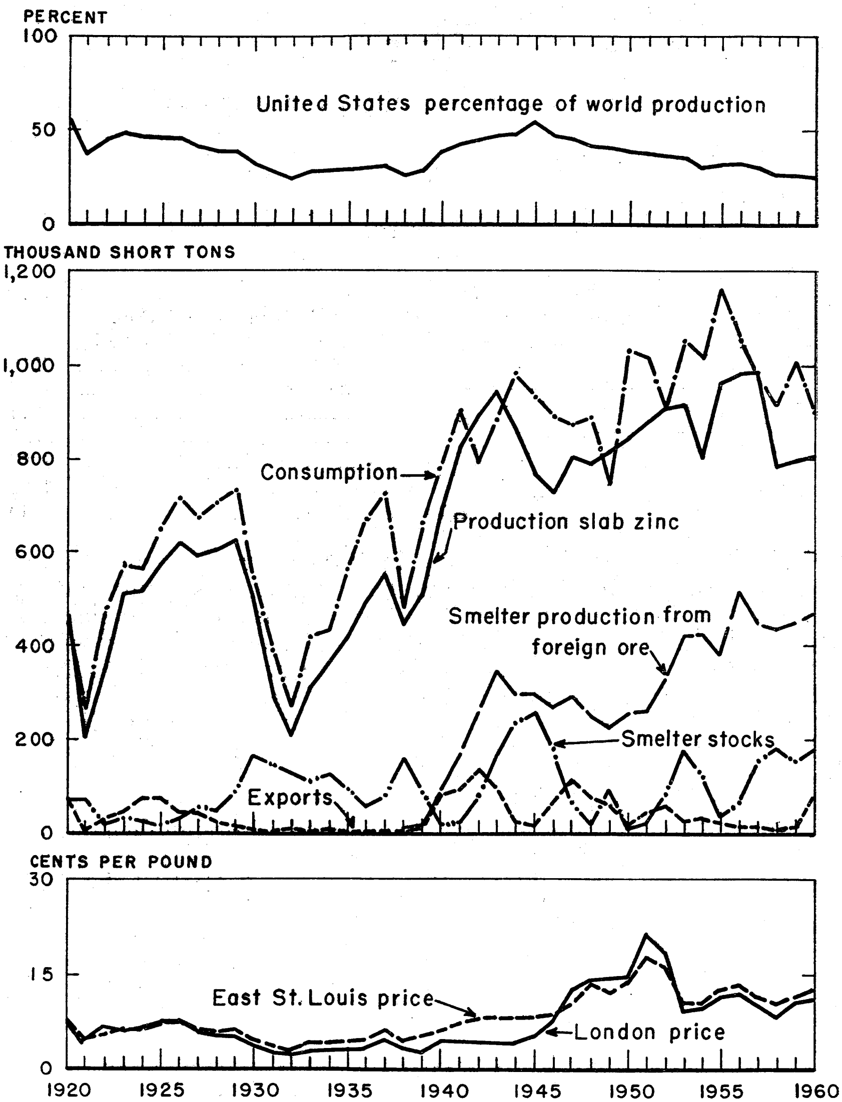

FIGURE 1.—Trends in the zinc industry in the United States, 1920–60. Consumption figures represent primary slab zinc plus zinc contained in pigments made directly from ore.

lieved to require any action, and it was urged that member governments should not impose any new trade restrictions.

Import quotas on zinc metal and ore, established by President Eisenhower, effective October 1, 1958, were in effect throughout 1960. The quotas were set at 80 percent of the U.S. average annual competitive import rate from 1953 through 1957—379,840 tons of zinc in ore and 141,120 tons of zinc in pigs, slabs, and certain other forms.

TABLE 1.—Salient zinc statistics

	1951–55 (average)	1956	1957	1958	1959	1960
United States:						
Production:						
Domestic ores, recoverable content------short tons--	576, 552	542, 340	531, 735	412, 005	425, 303	435, 427
Value---------thousands--	$165, 284	$148, 503	$123, 235	$84, 113	$97, 787	$112, 365
Slab zinc:						
From domestic ores short tons--	531, 263	470, 093	539, 692	346, 240	348, 443	336, 875
From foreign ores--do--	362, 366	513, 517	446, 104	435, 006	450, 223	466, 845
From scrap--------do--	58, 140	72, 127	72, 481	46, 605	57, 818	68, 731
Total----------do--	951, 769	1, 055, 737	1, 058, 277	[1] 827, 851	[1] 856, 484	[1] 872, 451
Secondary zinc [2]---------do--	242, 042	209, 935	192, 367	184, 182	219, 027	197, 810
Imports (general):						
Ores (zinc content)------do--	439, 922	525, 350	526, 014	461, 560	[3] 500, 115	456, 221
Slab zinc--------------do--	158, 176	244, 978	269, 007	195, 199	156, 963	120, 767
Exports of slab zinc----------do--	31, 051	8, 813	10, 785	2, 073	11, 629	75, 144
Stocks, December 31:						
At producer plants------do--	89, 931	66, 875	155, 833	184, 020	[3] 156, 210	187, 981
At consumer plants------do--	91, 161	104, 094	88, 342	93, 609	[3] 102, 428	67, 760
Consumption:						
All classes [4]-------------do--	1, 305, 978	1, 323, 022	1, 231, 593	1, 142, 165	[3] 1, 278, 376	1, 158, 938
Price, Prime Western, East St. Louis-------cents per pound--	13. 49	13. 49	11. 40	10. 31	11. 46	12. 95
World:						
Production:						
Mine------------short tons--	2, 960, 000	[3] 3, 430, 000	[3] 3, 440, 000	[3] 3, 320, 000	[3] 3, 360, 000	3, 510, 000
Smelter------------------do--	2, 630, 000	3, 100, 000	3, 190, 000	2, 990, 000	[3] 3, 090, 000	3, 220, 000
Price: Prime Western London, cents per pound--	14. 11	12. 19	10. 18	8. 24	10. 27	11. 05

[1] Includes production of zinc used directly in alloying operations.
[2] Excludes redistilled slab zinc.
[3] Revised figure.
[4] Includes slab zinc, recoverable zinc content of ores and secondary.

The General Services Administration (GSA) continued to be responsible for stockpile procurement and administration, procurement under foreign-aid programs as agent of the International Cooperation Administration (ICA) and administration of Defense Production Act (DPA) programs, including domestic purchase programs. Foreign zinc, received at GSA warehouses under barter agreements, totaled 1,840 tons (27,787 tons in 1959) and was placed in the supplemental stockpile. The American Zinc Institute reported that domestic manufacturers made no shipments of zinc produced from domestic ores (3,000 tons in 1959) for addition to the national stockpile.

At the request of the U.S. Senate, the Tariff Commission conducted public hearings on January 12–15, and 18 and submitted a report on March 31 on the condition of the lead-zinc industry. On September 30, a report submitted to the President advised that conditions had not changed enough to warrant a formal inquiry into the question of relaxing existing regulations on imports of unmanufactured lead and zinc. A request by the domestic rollers of zinc sheets for an increase in import duties was rejected by the Tariff Commission by a vote of 3 to 2 on January 14, ruling that imports of zinc sheets were not causing serious injury.

Enabling legislation to provide subsidy payments to small lead-zinc producers passed Congress but was vetoed by the President.

The Office of Minerals Exploration (OME), authorized in 1958 as the successor to the Defense Minerals Exploration Administration, continued to encourage exploration of strategic and critical minerals and metals. Exploration assistance for zinc amounts to Government participation to the extent of 50 percent of the approved costs of qualifying projects. During 1960, OME received 17 applications requesting aid in exploring for zinc or zinc and other metals. Four of these applications were denied or withdrawn, six were still under consideration, and seven contracts were awarded for Government participation, totaling $27,285. Also during this period, six discoveries were certified on DMEA projects.

Under authority of Public Law 480 (1954) and the Office of Defense Mobilization (ODM), predecessor agency to the Office of Civil and Defense Mobilization (OCDM), authorization of 1956, the Department of Agriculture, through the Commodity Credit Corporation (CCC), continued to trade perishable surplus agricultural products for zinc and other commodities of foreign origin. In 1960, CCC did not make any contracts for zinc metal (29,041 tons in 1959) to be added to the Government supplemental stockpile.

DOMESTIC PRODUCTION

MINE PRODUCTION

Mines in the United States produced 435,400 tons of recoverable zinc, an increase of 3 percent over that of 1959, thus maintaining the slow rise from the unusually low output of 412,000 tons in 1958. Production in the early months continued the rising trend of late 1959. However, labor strikes at mines in Idaho from May through December and at mines in Colorado, Pennsylvania, Tennessee, and Virginia from August through November, curtailed production during these months. States east of the Mississippi River produced 55 percent of total output; Western States, 43 percent; and West Central States, 2 percent.

TABLE 2.—OME contracts involving lead and zinc executed in 1960, by States

State and contractor	Property	County	Date approved	Total amount[1]
California:				
Shasta Minerals & Chemical Co	(2)	Shasta	June 10	$89,620
Georgia:				
Little Bob Mining Co.[3]	Little Bob	Paulding	May 18	18,800
Montana:				
Northern Milling Co., Inc	Marietta Mine	Broadwater	Sept. 2	102,300
Nevada:				
Gold Eagle Mines, Inc	Sally Louise Group	Esmeralda	Mar. 18	20,660
Utah:				
Brennan Hannifin	Bullion Beck	Juab	May 3	47,550
United Park City Mines Co	Daly West Project	Salt Lake, Summit, and Wasatch	May 5	165,930
Keystone Mining Co	Keystone	Summit	June 16	111,710
Total				556,570

[1] Government participation was 50 percent in exploration projects for lead and zinc in 1960.
[2] Unidentified.
[3] Little Bob Mining Co. contract canceled October 6, 1960.

TABLE 3.—Mine production of recoverable zinc in the United States, by States
(Short tons)

State	1951-55 (average)	1956	1957	1958	1959	1960
Arizona	34,364	25,580	33,905	28,532	37,325	35,811
Arkansas	15	----	----	----	49	50
California	6,526	8,049	2,969	51	78	465
Colorado	43,445	40,246	47,000	37,132	35,388	31,278
Idaho	67,887	49,561	57,831	49,725	55,699	36,801
Illinois	18,255	24,039	22,185	24,940	26,815	29,550
Kansas	23,324	28,665	15,859	4,421	1,017	2,117
Kentucky	1,537	417	837	1,258	673	869
Missouri	9,026	4,380	2,951	362	92	2,821
Montana	75,510	70,520	50,520	33,238	27,848	12,551
Nevada	8,463	7,488	5,292	91	217	420
New Jersey	43,373	4,667	12,530	607	----	----
New Mexico	25,010	35,010	32,680	9,034	4,636	13,770
New York	46,086	59,111	64,659	53,014	43,464	66,364
North Carolina	----	----	2	----	----	----
Oklahoma	45,299	27,515	14,951	5,267	1,049	2,332
Oregon	1	----	----	----	----	----
Pennsylvania	----	----	----	10,812	16,718	13,746
Tennessee	37,133	46,023	58,063	59,130	89,932	91,394
Texas	5	----	----	----	----	----
Utah	34,807	42,374	40,846	44,982	35,223	35,476
Virginia	14,497	19,196	23,080	18,472	20,334	19,885
Washington	24,583	25,609	24,000	18,797	17,111	21,317
Wisconsin	17,406	23,890	21,575	12,140	11,635	18,410
Total	576,552	542,340	531,735	412,005	425,303	435,427

Mine output in Tennessee, the leading zinc-producing State, increased 1 percent to a new record. This output was achieved despite prolonged strikes at several mines. Exploration drilling by American Zinc, Lead & Smelting Co. was successful in outlining ore bodies in the measured plus indicated ore categories, containing a conservative 5 million tons of 60-percent-zinc concentrate. The company also announced that it had entered into an option agreement with Tri-State Zinc, Inc., whereby a new organization, New Market Zinc Co., will build a mill of 3,600 tons daily ore capacity and develop the ore bodies south-west of New Market, Tenn.[4]

New York's production increased 53 percent to 66,400 tons, a record quantity for the State and ample to regain its 1958 position, second in the Nation. The entire output came from the Balmat and Edwards mines of St. Joseph Lead Co. in St. Lawrence County.

In the northern Illinois-Wisconsin district, Tri-State Zinc, Inc., and the Vinegar Hill Division of American Zinc, Lead & Smelting Co. mined throughout the year. Eagle-Picher Co. mines operated all year except when closed by a strike in October. Piquette Mining Co. closed its mine in July and remained closed at yearend.

Zinc output in Virginia decreased slightly. The New Jersey Zinc Co. Austinville mill, which treated ore from the Austinville and Ivanhoe mines, operated at near capacity until closed by a labor strike on August 5. Production resumed after the strike ended on November 25. Tri-State Zinc Co., Inc., operated its mine at Timberville throughout the year.

In Pennsylvania, The New Jersey Zinc Co. continued to develop the lower levels at the Friedensville mine and increased the daily productive capacity. Total output, however, declined because of a labor strike in the latter part of the year.

[4] American Zinc, Lead & Smelting Co., Annual Report, 1960, pp. 11–13.

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In the southern Illinois-Kentucky district, zinc produced as a byproduct of fluorspar mining increased slightly. Major producers were Aluminum Company of America, Minerva Oil Co., and Ozark-Mahoning Co.

No production was reported from New Jersey; however, The New Jersey Zinc Co. continued to maintain its Sterling mine in Sussex County on a standby basis.

Idaho production of 36,800 tons of zinc declined 34 percent but retained its leading position among western zinc-mining States and ranked third in the Nation. Labor strikes closed mines of American Smelting and Refining Company and The Bunker Hill Co. in the Coeur d'Alene district from May until late December. The Star mine of The Bunker Hill Co., operated by Hecla Mining Co., was not closed by the strike and continued to be the largest zinc mine in the State.

The Iron King mine of Shattuck Denn Corp. and the Old Dick mine of Cyprus Mines Corp. continued to lead and rank second as producers, respectively, in Arizona.

Mine output in Utah increased slightly; the United States and Lark mine of United States Smelting, Refining and Mining Co. was the leading zinc producer in the State. Other producers included mines of United Park City Mines Co. and the Mayflower-Galena mine of New Park Mining Co.

Reduced output in Colorado was in large part due to the closure of The New Jersey Zinc Co. Eagle mine from August 5 through November 25. The Eagle mine, nevertheless, remained the leading producer. Other major zinc mines were the Idarado Mining Co. group, Emperius mine of Emperius Mining Co., and the Rico mine of Rico Mining Co.

In Washington, the principal producing mines were the Pend Oreille of Pend Oreille Mines and Metals Co. and the Grandview of American Zinc, Lead & Smelting Co. Pend Oreille milled 727,800 tons of ore, yielding 14,564 tons of zinc in concentrates, increases of 17 and 35 percent, respectively.[5] The Mineral Rights mine, adjacent to the Grandview mine, was developed during the year and contributed some ore to the 14,307 tons of combined zinc-lead concentrates produced. By the end of 1961, the Grandview mine was expected to supply only a small tonnage and the Mineral Rights mine to provide most of the company output.[6]

TABLE 4.—Mine production of recoverable zinc in the United States, by months

(Short tons)

Month	1959	1960	Month	1959	1960
January	35,830	37,350	August	31,728	34,451
February	36,441	38,130	September	30,025	30,734
March	37,428	42,821	October	31,608	28,101
April	38,709	41,774	November	36,025	28,014
May	38,742	40,830	December	39,538	36,728
June	36,921	39,240			
July	32,308	37,254	Total	425,303	435,427

[5] Pend Oreille Mines & Metals Co., Annual Report, 1960, p. 2.
[6] American Zinc, Lead & Smelting Co., Annual Report, 1960, p. 11.

Mine output in New Mexico increased from 4,600 to 13,800 tons, largely because the Hanover unit of New Jersey Zinc Co., which reopened in August 1959, operated throughout the year. Peru Mining Co. was reactivating its Kearney mine, which has been closed for 3 years and was planning to begin production in 1961.

Production of zinc in Montana was reduced 55 percent. The output came mostly from The Anaconda Company zinc-fuming plant at East Helena, which resumed operation after a 6-month strike terminated on February 16. The Anselmo mine was not reopened after the strike; the mining of accessible ore from the Alice pit was completed, and operation terminated July 29. The zinc concentrator at Anaconda resumed operation in April but was closed by the company in September owing to market conditions.

Mines in the West Central States of Kansas, Oklahoma, and Missouri produced 7,270 tons of zinc, an increase over the 2,200 tons in 1959 but still less than 2 percent of the Nation's total. This production was only a fraction of the output from what was the leading zinc-producing district in the United States for 60 years before 1950. Production resulted largely from treatment of mill slimes. A few small mines were active, and some byproduct zinc was recovered from lead mining in southeast Missouri.

The 25 leading zinc-producing mines in the United States in 1960, listed in table 5, yielded 80 percent of the total domestic output of zinc. The three leading mines supplied 23 percent, and the first six contributed 37 percent.

SMELTER AND REFINERY PRODUCTION

The zinc smelting and refining industry at 16 primary reduction plants and 10 secondary plants produced slab zinc, zinc pigments, zinc dust, and zinc alloys. Some manufacturers of chemicals, pigments, die-casting alloys, rolled zinc, and brass also produced secondary zinc.

The Anaconda and Great Falls, Mont., plants of The Anaconda Company, that had been closed since August 1959, resumed operations in February. The electrolytic zinc plant at Anaconda was closed again by the end of the year, but the Great Falls plant continued to treat zinc concentrates. A strike in May closed the smelter of The Bunker Hill Co., and in August The New Jersey Zinc Co. smelters at Depue and Palmerton were shut down by labor strikes. By the end of November, The New Jersey Zinc Co. had settled its strike, and by the end of December employees of The Bunker Hill smelter had returned to work. Athletic Mining and Smelting Co. at Fort Smith, Ark., shut down on December 31, 1959, and resumed operations during 1960.

Primary Smelters and Electrolytic Plants.—The primary reduction plants processed zinc ore and concentrate, zinc fume from Waelz kilns and slag-fuming plants, other primary zinc-bearing materials, and about 60 percent of all zinc-base scrap used for redistilled slab zinc.

Production at primary zinc plants totaled 843,700 tons of slab zinc, of which 40,000 tons was redistilled. In addition to slab zinc, primary plants produced zinc oxide, zinc dust, and zinc-base alloys.

TABLE 5.—Twenty-five leading zinc-producing mines[1] in the United States in 1960 in order of output

Rank	Mine	District or region	State	Operator	Source of zinc
1	Balmat	St. Lawrence County.	New York	St. Joseph Lead Co.	Lead-zinc ore.
2	Jefferson City	Eastern Tennessee	Tennessee	The New Jersey Zinc Co.	Zinc ore.
3	Star	Coeur d'Alene	Idaho	The Bunker Hill Co	Lead-zinc ore.
4	Iron King	Big Bug	Arizona	Shattuck Denn Mining Corp.	Do.
5	United States & Lark.	West Mountain (Bingham).	Utah	United States Smelting, Refining and Mining Co.	Gold-silver-lead-zinc ore.
6	Young	Eastern Tennessee	Tennessee	American Zinc Co. of Tennessee.	Zinc ore.
7	Eagle	Red Cliff (Battle Mountain).	Colorado	The New Jersey Zinc Co.	Copper-lead-zinc ore.
8	Zinc Mine Works	Eastern Tennessee	Tennessee	United States Steel Corp., Tennessee Coal & Iron Division.	Zinc ore.
9	Pend Oreille	Metaline	Washington	Pend Oreille Mines & Metals Co.	Lead-zinc ore.
10	Friedensville	Lehigh County	Pennsylvania	The New Jersey Zinc Co.	Zinc ore.
11	Mascot No. 2	Eastern Tennessee	Tennessee	American Zinc Co. of Tennessee.	Do.
12	Austinville	Austinville	Virginia	The New Jersey Zinc Co.	Lead-zinc ore.
13	Treasury Tunnel—Black Bear—Smuggler Union.	Upper San Miguel	Colorado	Idarado Mining Co	Copper-lead-zinc ore.
14	Edwards	St. Lawrence County.	New York	St. Joseph Lead Co	Zinc ore.
15	Hanover	Central	New Mexico	The New Jersey Zinc Co.	Do.
16	Gray	Upper Mississippi Valley.	Illinois	Tri-State Zinc, Inc.	Do.
17	United Park City	Park City Region	Utah	United Park City Mines Co.	Copper-lead-zinc ore.
18	Burra-Boyd	Polk County	Tennessee	Tennessee Corp	Copper-zinc ore.
19	Grandview	Metaline	Washington	American Zinc, Lead & Smelting Co.	Lead-zinc ore.
20	Bowers-Campbell	Rockingham County.	Virginia	Tri-State Zinc, Inc.	Zinc ore.
21	Shullsburg	Upper Mississippi Valley.	Wisconsin	The Eagle-Picher Co.	Do.
22	Flat Gap	Eastern Tennessee	Tennessee	The New Jersey Zinc Co.	Do.
23	Old Dick	Eureka	Arizona	Cyprus Mines Corp.	Copper-zinc ore.
24	Graham-Snyder-Spillane.	Upper Mississippi Valley.	Illinois	The Eagle-Picher Co.	Zinc ore.
25	Page	Coeur d'Alene	Idaho	American Smelting and Refining Company.	Lead-zinc ore.

[1] Excludes old slag dumps.

Primary-plant capacity for slab zinc at yearend was reported to be 1,165,400 tons in the 16 operating zinc plants. The five electrolytic plants reported 2,388 of their 4,072 electrolytic cells in use at yearend and an output of 319,800 tons (67 percent of their 480,100 tons of capacity). The seven horizontal-retort plants reported 32,592 of their 43,648 retorts in use during the year. The four remaining primary smelters were the continuous-distilling vertical-retort plants at Meadowbrook, W. Va.; Depue, Ill.; Palmerton, Pa.; and Josephtown, Pa. The first three used New Jersey Zinc Co. externally gas-fired vertical retorts, and the one at Josephtown used electrothermic distillation retorts. Combined horizontal and vertical-retort production of 483,900 tons was only 71 percent of the reported 1960 capacity of 685,300 tons.

The list of primary smelters published in the Zinc chapter of the 1957 Minerals Yearbook was unchanged.

Slag-Fuming Plants.—Many lead smelters recover a zinc fume product from lead blast-furnace slags containing 7.5 to 12.5 percent zinc.

Five such plants in the United States treated 621,700 tons of hot and cold lead slag (including some crude ore and zinc residue), which yielded 105,000 tons of oxide fume, containing 74,300 tons of recoverable zinc. Corresponding figures for 1959 were 616,400; 111,300; and 73,300 tons, respectively.

Secondary Zinc Smelters.—Zinc-base scrap (a term that includes skimmings and drosses, die-cast alloys, old zinc, engravers' plates, new clippings, and chemical residues) was smelted chiefly at secondary smelters, although about one-fourth usually is reduced at primary smelters and most sal ammoniac skimmings are processed at chemical plants. Secondary smelters depended on the galvanizers and scrap dealers for their supply of scrap materials. The list of secondary zinc smelters given in the Zinc chapter of the 1957 Minerals Yearbook and the addition listed in the 1958 Yearbook remained unchanged.

Primary and secondary smelting plants treating zinc-base scrap produced 68,700 tons of redistilled zinc, 4,900 tons of remelt, and 30,800 tons of zinc dust. The zinc content of these products totaled 103,200 tons.

Additional details on 108,200 tons of zinc recovered in processing copper-base scrap (table 8) may be obtained in the Secondary section of the Copper chapter of this volume.

SLAB ZINC

Domestic smelter output of slab zinc increased 2 percent over 1959. Included in the 872,400 tons of slab zinc production was molten zinc used directly in alloying operations. Of the output, 803,700 tons was primary metal and 68,700 redistilled secondary zinc. Primary production was 42 percent from domestic ores and 58 percent from foreign ores; 40 percent was electrolytic, and 60 percent was distilled slab zinc. Primary smelters produced 58 percent of the redistilled secondary slab zinc; the remainder was obtained from secondary smelters.

Special High Grade zinc, which furnished 41 percent of the total (39 percent in 1959), was the principal grade produced. Prime Western constituted 39 percent (42 percent in 1959); Brass Special, 10 percent (9 percent); High Grade, 8 percent (8 percent); and Intermediate, 2 percent (2 percent).

Texas led in production of slab zinc; Pennsylvania ranked second; and Oklahoma, third. The slab-zinc output of Pennsylvania, West Virginia, Oklahoma, and Arkansas was distilled and that of Montana and Idaho was electrolytic. Part of the Illinois and Texas slab output was distilled, and part was electrolytic.

TABLE 6.—Stocks and consumption of new and old zinc scrap in the United States in 1960

(Short tons, gross weight)

Class of consumer and type of scrap	Stocks Jan. 1 [1]	Receipts	Consumption: New scrap	Consumption: Old scrap	Consumption: Total	Stocks Dec. 31
Smelters and distillers:						
New clippings	194	1,476	1,508		1,508	162
Old zinc	573	3,566		3,455	3,455	684
Engravers' plates	680	3,870		4,197	4,197	353
Skimmings and ashes	10,815	46,130	52,629		52,629	4,316
Sal skimmings	669	1,030	1,280		1,280	419
Die-cast skimmings	2,078	7,682	8,429		8,429	1,331
Galvanizers' dross	5,285	51,394	51,605		51,605	5,074
Die castings	4,628	35,815		34,946	34,946	5,497
Rod and die scrap	1,199	2,619		3,439	3,439	379
Flue dust	188	5,237	5,198		5,198	227
Chemical residues	3,699	9,185	9,390		9,390	3,494
Total	30,008	168,004	130,039	46,037	176,076	21,936
Chemical plants, foundries and other manufacturers:						
New clippings	18	334	326		326	26
Old zinc	3	155		152	152	6
Engravers' plates	2	70		70	70	2
Skimmings and ashes	1,743	6,238	5,938		5,938	2,043
Sal skimmings	10,427	21,095	21,006		21,006	10,516
Die-cast skimmings						
Galvanizers' dross	23		1		1	22
Die castings	156	1,385	445	948	1,393	148
Rod and die scrap	2	59		52	52	9
Flue dust	51	1,315	1,335		1,335	31
Chemical residues	1,782	17,170	16,575		16,575	2,377
Total	14,207	47,821	45,626	1,222	46,848	15,180
Grand total:						
New clippings	212	1,810	1,834		1,834	188
Old zinc	576	3,721		3,607	3,607	690
Engravers' plates	682	3,940		4,267	4,267	355
Skimmings and ashes	12,558	52,368	58,567		58,567	6,359
Sal skimmings	11,096	22,125	22,286		22,286	10,935
Die-cast skimmings	2,078	7,682	8,429		8,429	1,331
Galvanizers' dross	5,308	51,394	51,606		51,606	5,096
Die castings	4,784	37,200	445	35,894	36,339	5,645
Rod and die scrap	1,201	2,678		3,491	3,491	388
Flue dust	239	6,552	6,533		6,533	258
Chemical residues	5,481	26,355	25,965		25,965	5,871
Total	44,215	215,825	175,665	47,259	222,924	37,116

[1] Figures partly revised.

TABLE 7.—Production of secondary zinc and zinc-alloy products in the United States

(Short tons, gross weight)

Product	1951-55 (average)	1956	1957	1958	1959	1960
Redistilled slab zinc	[1] 58,140	[1] 72,127	[1] 72,481	46,605	[1] 57,818	[1] 68,731
Zinc dust [2]	27,399	28,048	26,715	26,512	32,758	30,788
Remelt spelter	4,013	7,900	6,404	5,236	4,718	4,883
Remelt die-cast slab	8,107	12,900	10,328	12,980	13,150	7,800
Zinc-die and die-casting alloys	4,429	4,306	6,440	6,082	5,864	6,945
Galvanizing stocks	204	369	240	249	245	222
Rolled zinc	3,034	2,179	185	10	14	18
Secondary zinc in chemical products	32,328	30,675	33,361	32,482	40,204	38,007

[1] Includes redistilled slab made from remelt die-cast slab.
[2] Includes zinc dust produced from other than scrap.

TABLE 8.—Zinc recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

Kind of scrap	1959	1960	Form of recovery	1959	1960
New scrap:			As metal:		
Zinc-base	106,420	116,222	By distillation:		
Copper-base	93,909	79,351	Slab zinc [1]	57,227	68,010
Aluminum-base	2,024	1,802	Zinc dust [2]	32,119	30,144
Magnesium-base	53	76	By remelting	[3] 4,918	5,031
Total	202,406	197,451	Total	[3] 94,264	103,185
Old scrap:			In zinc-base alloys	17,611	13,738
Zinc-base	38,532	38,056	In brass and bronze	[3] 120,032	107,422
Copper-base	33,487	28,866	In aluminum-base alloys	[3] 3,964	3,277
Aluminum-base	1,734	1,381	In magnesium-base alloys	179	191
Magnesium-base	95	66	In chemical products:		
			Zinc oxide (lead-free)	19,362	17,679
Total	73,848	68,369	Zinc sulfate	(4)	(4)
			Zinc chloride	13,625	11,994
Grand total	276,254	265,820	Miscellaneous	7,217	8,334
			Total	[3] 181,990	162,635
			Grand total	276,254	265,820

[1] Includes zinc content of redistilled slab made from remelt die-cast slab.
[2] Includes zinc content of dust made from other than scrap.
[3] Revised figure.
[4] Included with "Miscellaneous."

TABLE 9.—Primary and redistilled secondary slab zinc produced in the United States

(Short tons)

Year	Primary			Redistilled secondary	Total (excludes zinc recovered by remelting)
	From domestic ores	From foreign ores	Total		
1951–55 (average)	531,263	362,366	893,629	58,140	951,769
1956	[1] 470,093	[1] 513,517	983,610	72,127	1,055,737
1957	539,692	446,104	985,796	72,481	1,058,277
1958	[1] 346,240	435,006	[2] 781,246	46,605	[2] 827,851
1959	348,443	450,223	[2] 798,666	57,818	[2] 856,484
1960	[2] 336,875	466,845	[2] 803,720	68,731	[2] 872,451

[1] Includes a small tonnage of slab zinc further refined into high-grade metal.
[2] Includes production of zinc used directly in alloying operations.

TABLE 10.—Distilled and electrolytic zinc, primary and secondary, produced in the United States, by method of reduction

(Short tons)

Year	Electrolytic primary	Distilled	Redistilled secondary		Total
			At primary smelters	At secondary smelters	
1951–55 (average)	351,838	541,791	21,833	36,307	951,769
1956	410,417	573,193	30,221	41,906	1,055,737
1957	409,483	576,313	35,215	37,266	1,058,277
1958	326,449	454,797	24,297	22,308	[1] 827,851
1959	280,813	517,853	28,451	29,367	[1] 856,484
1960	319,777	483,943	40,009	28,722	[1] 872,451

[1] Includes production of zinc used directly in alloying operations.

TABLE 11.—Distilled and electrolytic zinc, primary and secondary, produced in the United States, by grades

(Short tons)

Year	Special High Grade	High Grade	Inter-mediate	Brass Special	Select	Prime Western	Total
1951–55 (average)	307,711	161,878	19,287	59,683	6,834	396,376	951,769
1956	356,756	162,467	37,691	96,291	2,400	400,132	1,055,737
1957	354,042	152,317	32,262	84,291	1,150	434,215	1,058,277
1958	298,442	86,859	19,388	81,841	1,300	340,021	[1] 827,851
1959	331,312	71,792	17,493	75,305	1,414	359,168	[1] 856,484
1960	360,907	71,834	15,841	83,507	73	340,289	[1] 872,451

[1] Includes production of zinc used directly in alloying operations.

TABLE 12.—Primary slab zinc produced in the United States, by States where smelted

(Short tons)

Year	Arkan-sas	Idaho	Illinois	Mon-tana	Okla-homa	Pennsyl-vania	Texas and West Virginia[1]	Total	
								Short tons	Value
1951–55 (average)	18,771	53,375	109,770	201,441	154,443	194,888	160,941	893,629	$248,647,692
1956	27,651	57,799	101,826	214,755	166,173	198,968	216,438	983,610	270,099,306
1957	23,080	68,831	[2] 107,294	198,036	157,633	[3] 247,836	[4] 183,086	985,796	229,493,309
1958	17,952	55,454	[2] 82,844	148,921	122,138	[3] 187,243	[4] 166,694	[5] 781,246	159,686,682
1959	15,964	61,191	102,708	86,620	152,072	[3] 217,368	[4] 162,743	[5] 798,666	183,213,980
1960	1,521	26,449	[2] 88,291	132,290	161,894	[3] 198,718	[4] 194,557	[5] 803,720	206,716,784

[1] Includes Missouri, 1951–53, 1955, 1956.
[2] Includes Missouri.
[3] Includes West Virginia.
[4] Texas only.
[5] Includes production of zinc used directly in alloying operations.

BYPRODUCT SULFURIC ACID

Sulfuric acid was made from sulfur dioxide gases produced in roasting zinc sulfide concentrate at some primary zinc smelters. At several plants elemental sulfur was burned to increase acid-making capacity. Acid production at zinc-roasting plants from zinc sulfide was 770,900 short tons valued at $11.9 million and from elemental sulfur, 68,700 tons valued at $1.1 million.

ZINC DUST

Zinc dust included in data in tables 7, 8, and 13 is restricted to commercial grades that comply with close specifications as to percentage of unoxidized metal, evenness of grading, and fineness of particles, and it does not include blue powder. The zinc content of the dust produced ranged from 95.0 to 99.8 percent, averaging 97.9 percent. Total shipments of zinc dust were 30,400 tons, of which 400 tons was shipped abroad. Producer stocks of zinc dust were 2,200 tons at the end of the year.

Most of the zinc dust was made from zinc scrap, chiefly galvanizers' dross, but some was recovered from refined metal.

TABLE 13.—Zinc dust[1] produced in the United States

Year	Short tons	Value: Total	Value: Average per pound	Year	Short tons	Value: Total	Value: Average per pound
1951–55 (average)	27,787	$9,288,814	$0.167	1958	26,512	$7,253,683	$0.137
1956	28,048	9,368,032	.167	1959	32,758	9,683,265	.148
1957	26,715	7,859,583	.147	1960	30,788	10,283,192	.167

[1] All produced by distillation.

CONSUMPTION AND USES

Zinc consumed as refined metal in slab or pig form totaled 877,900 tons (956,200 tons in 1959); as ore and concentrate to make pigments and salts and used directly in galvanizing, 88,300 tons (108,100); and as scrap to make alloys, zinc dust, pigments and salts, 192,800 tons (214-300). These uses totaled 1,158,900 tons of primary and secondary zinc, a decrease of 9 percent from the 1,278,500 tons in 1959. The quantity of zinc consumed directly in making pigments and salts is reported in table 20. Zinc consumed in scrap form and the manufactured products other than remelt and redistilled are reported in tables 6, 7, and 8.

Slab-zinc consumption, as reported by 700 plants, declined 8 percent below the 1959 total but was 1 percent higher than the 1958 total. Slab zinc used in galvanizing steel products increased 3 percent to 371,600 tons (42 percent of the total) and regained the leading use in industry. Die castings and zinc-base alloys consumed 13 percent less slab zinc in 1960 than in 1959 but supplied 39 percent of the total. Slab zinc used in brass products declined 30,000 tons to 99,000 tons and represented 11 percent of the total. The remaining 8 percent was used in rolled zinc, zinc oxide, slush castings, wet batteries, zinc dust, chemicals, bronze powders, desilverizing lead, light-metal alloys, and zinc used for cathodic protection.

Rolling mills used 38,700 tons of slab zinc and remelted and rerolled 11,300 tons of metallic scrap produced in fabricating plants operated in connection with the rolling mills. In addition a small quantity of purchased scrap (new clippings and old zinc) was melted and rolled. Small quantities of alloying metals were added for some uses. The rolled-zinc industry, however, classifies these alloys as rolled zinc.

TABLE 14.—Consumption of zinc in the United States

(Short tons)

	1951–55 (average)	1956	1957	1958	1959	1960
Slab zinc	955,358	1,008,790	935,620	868,327	956,197	877,884
Ores (recoverable zinc content)	115,750	113,388	[1] 110,311	[1] 94,938	[1] 108,070	[1] 88,275
Secondary (recoverable zinc content)	[2] 234,870	200,844	185,662	178,900	[3] 214,109	192,779
Total	1,305,978	1,323,022	1,231,593	1,142,165	[3] 1,278,376	1,158,938

[1] Includes ore used directly in galvanizing.
[2] Excludes redistilled slab and remelt zinc.
[3] Revised figure.

TABLE 15.—Slab-zinc consumption in the United States, by industries [1]

(Short tons)

Industry and product	1951–55 (average)	1956	1957	1958	1959	1960
Galvanizing:[2]						
Sheet and strip	167,353	203,713	168,221	194,196	175,691	196,057
Wire and wire rope	47,518	42,937	36,468	35,638	35,602	35,262
Tubes and pipe	84,958	86,277	70,463	67,318	59,830	56,680
Fittings	12,596	10,652	9,965	8,904	10,239	9,258
Other	95,487	[3] 95,567	[3] 82,640	[3] 75,173	[3] 79,665	[3] 74,332
Total galvanizing	407,912	439,146	367,757	381,229	361,027	371,589
Brass products:						
Sheet, strip, and plate	70,836	56,207	52,873	46,967	61,234	45,870
Rod and wire	44,186	39,413	33,711	32,568	40,286	29,971
Tube	15,716	13,666	11,915	9,645	11,808	8,504
Castings and billets	7,105	6,337	5,818	4,423	4,967	4,699
Copper-base ingots	7,256	7,197	7,286	7,094	10,276	9,412
Other copper-base products	1,220	1,184	787	678	707	567
Total brass products	146,319	124,004	112,390	101,375	129,278	99,023
Zinc-base alloy:						
Die castings	300,596	349,200	363,830	309,408	383,358	331,112
Alloy dies and rod	9,624	9,322	10,149	5,400	3,745	3,442
Slush and sand castings	2,224	1,985	2,060	2,022	2,228	3,819
Total zinc-base alloy	312,444	360,507	376,039	316,830	389,331	338,373
Rolled zinc	53,825	47,359	41,269	40,616	42,949	38,696
Zinc oxide	19,447	19,160	20,428	13,331	18,248	15,593
Other uses:						
Wet batteries	1,449	1,345	1,336	846	1,244	1,152
Desilverizing lead	2,479	2,939	2,808	2,521	1,949	2,521
Light-metal alloys	3,870	5,830	4,958	3,657	3,363	3,181
Other [4]	7,613	8,500	8,635	7,922	8,808	7,756
Total other uses	15,411	18,614	17,737	14,946	15,364	14,610
Total consumption [5]	955,358	1,008,790	935,620	868,327	956,197	877,884

[1] Excludes some small consumers.
[2] Includes zinc used in electrogalvanizing and electroplating, but excludes sherardizing.
[3] Includes 27,760 tons used in job galvanizing in 1956, 28,286 tons in 1957, 28,502 tons in 1958, 31,521 tons in 1959, and 31,616 tons in 1960.
[4] Includes zinc used in making zinc dust, bronze powder, alloys, chemicals, castings, and miscellaneous uses not elsewhere mentioned.
[5] Includes 5,230 tons of remelt zinc in 1956, 6,805 tons in 1957, 8,073 tons in 1958, 5,209 tons in 1959, and 6,622 tons in 1960.

Output of salable rolled zinc declined to 37,000 tons. Stocks of rolled zinc at the mills increased slightly to 3,200 tons by yearend. Besides shipments of 18,000 tons of rolled zinc, the rolling mills consumed 30,200 tons rolled zinc in manufacturing 19,400 tons of semifabricated and finished products.

Rolled zinc was used to make sheet, strip, ribbon, foil, plate, rod, and wire. In the United States, its major use was for dry-cell battery cases and similar extruded cases for radio condensers and tube shields. Weather-stripping, roof flashing, photoengraving plates, and household electric fuses were other uses.

Of the commercial grades of slab zinc used, Special High Grade was 45 percent of the total; Prime Western, 35 percent; Brass Special, 10 percent; High Grade, 8 percent; Intermediate, 1 percent; Select and Remelt together, 1 percent. All grades of slab zinc were used in making brass products, and all except Select grade were used in galvanizing. More than 98 percent of the slab zinc used in making zinc-base alloys was Special High Grade.

TABLE 16.—Rolled zinc produced and quantity available for consumption in the United States

	1959			1960		
	Short tons	Value		Short tons	Value	
		Total	Average per pound		Total	Average per pound
Production:						
Sheet zinc not over 0.1 inch thick	13,015	$7,989,799	$0.307	12,897	$8,023,358	$0.311
Boiler plate and sheets over 0.1 inch thick	432	185,730	.215	171	75,471	.221
Strip and ribbon zinc [1]	25,406	10,831,946	.213	22,186	9,343,955	.211
Foil, rod, and wire	1,814	967,978	.267	1,741	1,146,333	.329
Total rolled zinc	40,667	19,975,453	.246	36,995	18,589,117	.251
Imports	951	310,855	.163	904	301,667	.167
Exports	3,529	2,708,039	.384	3,324	2,443,165	.368
Available for consumption	37,311			34,439		
Value of slab zinc (all grades)			.114			.129
Value added by rolling			.132			.122

[1] Figures represent net production. In addition, 14,653 tons of strip and ribbon zinc in 1959 and 11,290 tons in 1960 were rerolled from scrap originating in fabricating plants operating in connection with zinc rolling mills.

TABLE 17.—Slab-zinc consumption in the United States in 1960, by grades and industries

(Short tons)

Industry	Special High Grade	High Grade	Intermediate	Brass Special	Select	Prime Western	Remelt	Total
Galvanizers	15,044	9,291	2,898	73,886		268,326	2,144	371,589
Brass mills [1]	22,412	51,559	1,073	6,454	2,061	13,489	1,975	99,023
Die casters [2]	333,760	1,237	101			1,819	1,456	338,373
Zinc rolling mills	13,519	8,261	6,120	10,577		219		38,696
Oxide plants	2,375			9		12,950	259	15,593
Other	5,242	1,183	344	91		6,962	788	14,610
Total	392,352	71,531	10,536	91,017	2,061	303,765	6,622	877,884

[1] Includes brass mills, brass ingot makers, and brass foundries.
[2] Includes producers of zinc-base die castings, zinc-alloy dies, and zinc-alloy rods.

CONSUMPTION OF SLAB ZINC BY GEOGRAPHIC AREAS

Among 37 States consuming slab zinc for galvanizing, Ohio, Pennsylvania, Indiana, and Illinois continued to lead, using 57 percent of the total. The iron and steel industry used zinc to galvanize steel sheets, wire, tube, pipe, cable, chain, bolts, railway-signal equipment, building and pole-line hardware, and many other items.

Connecticut, with 33 percent of the total, again led in use of slab zinc in brassmaking. Of 25 States using zinc to make zinc-base alloys, Michigan led, followed by Illinois and Ohio.

States using slab zinc in rolled products, in descending order of use, were Illinois, Indiana, New York, Pennsylvania, Massachusetts, Connecticut, and Iowa.

TABLE 18.—Slab-zinc consumption in the United States in 1960, by industries and States

(Short tons)

State	Galvanizers	Brass mills [1]	Diecasters [2]	Other [3]	Total
Alabama	(4)	(4)	----------	(4)	33,170
Arizona	(4)	----------	----------	(4)	(4)
Arkansas	----------	----------	----------	(4)	(4)
California	20,983	(4)	12,274	(4)	35,282
Colorado	(4)	(4)	----------	----------	(4)
Connecticut	3,041	32,008	(4)	(4)	37,421
Delaware	----------	(4)	(4)	----------	(4)
District of Columbia	----------	(4)	----------	----------	(4)
Florida	(4)	----------	(4)	----------	646
Georgia	(4)	----------	----------	----------	(4)
Hawaii	(4)	----------	----------	----------	(4)
Idaho	----------	----------	(4)	(4)	(4)
Illinois	40,803	14,339	62,653	17,674	135,469
Indiana	41,866	(4)	21,290	(4)	80,595
Iowa	821	----------	----------	(4)	1,504
Kansas	----------	(4)	(4)	----------	(4)
Kentucky	(4)	(4)	(4)	----------	(4)
Louisiana	712	----------	----------	----------	712
Maine	(4)	----------	----------	----------	(4)
Maryland	(4)	(4)	----------	----------	(4)
Massachusetts	3,796	1,555	----------	(4)	6,620
Michigan	(4)	10,643	84,163	(4)	99,223
Minnesota	1,893	(4)	----------	(4)	1,917
Mississippi	(4)	----------	----------	----------	(4)
Missouri	3,867	(4)	3,008	(4)	7,756
Montana	----------	----------	----------	(4)	(4)
Nebraska	(4)	(4)	(4)	(4)	(4)
New Hampshire	----------	(4)	----------	----------	(4)
New Jersey	4,186	5,572	16,331	1,057	27,146
New York	6,015	(4)	30,706	(4)	49,168
North Carolina	(4)	----------	(4)	----------	(4)
Ohio	75,155	(4)	46,071	(4)	129,262
Oklahoma	(4)	----------	(4)	(4)	5,789
Oregon	(4)	(4)	(4)	6	897
Pennsylvania	54,129	6,598	13,759	(4)	97,240
Rhode Island	558	(4)	(4)	(4)	592
South Carolina	(4)	----------	----------	----------	(4)
Tennessee	(4)	----------	(4)	(4)	1,896
Texas	11,873	(4)	(4)	(4)	36,950
Utah	(4)	(4)	----------	----------	(4)
Virginia	(4)	(4)	(4)	(4)	294
Washington	936	----------	(4)	(4)	1,375
West Virginia	6,006	(4)	----------	(4)	6,127
Wisconsin	1,978	(4)	(4)	(4)	10,052
Total [5]	369,445	97,048	336,917	67,852	871,262

[1] Includes brass mills, brass ingotmakers and brass foundries.
[2] Includes producers of zinc-base diecastings, zinc-alloy dies, and zinc-alloy rods.
[3] Includes slab zinc used in rolled-zinc products and in zinc oxide.
[4] Figure withheld to avoid disclosing individual company confidential data.
[5] Includes States not individually shown; excludes remelt zinc.

ZINC PIGMENTS AND SALTS [7]

Production.—Production of zinc pigments and salts was below the 1959 output. The value of public and private construction was up slightly, and the value of paint, varnish, and lacquer shipments remained unchanged at $1.8 million; however, consumption of natural and synthetic rubber, a large outlet for zinc oxide, decreased 3 percent to 1.6 million long tons.

Production of lead-free and leaded zinc oxide was 15 and 39 percent, respectively, below 1959. Output of zinc chloride decreased 5 percent and that of zinc sulfate decreased 33 percent. Data for production of 50° Baumé zinc chloride have been changed to show the zinc chlo-

[7] Prepared by John E. Shelton, commodity specialist, and Esther B. Miller, statistical assistant.

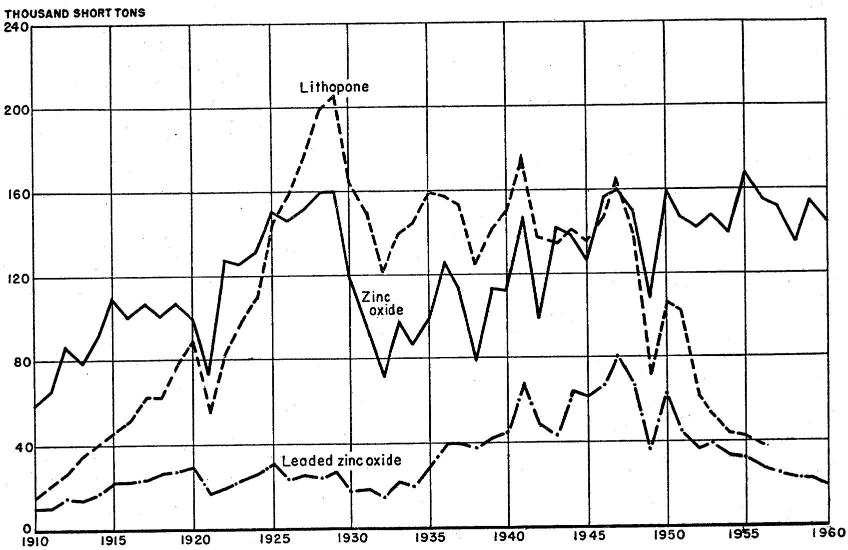

Figure 2.—Trends in shipments of zinc pigments, 1910–60.

ride equivalent of zinc ammonium chloride and chromated zinc chloride.

Pigments and salts were made from various zinc-bearing materials including ore, slab zinc, scrap, and residues. The zinc in pigments and salts produced directly from ore, both domestic and foreign, exceeded 78,900 tons; that in zinc oxide and zinc chloride from slab zinc exceed 15,400 tons; and the zinc derived from secondary material in zinc pigments and salts exceeded 37,300 tons.

TABLE 19.—Production and shipments of zinc pigments and salts[1] in the United States

Pigment or salt	1959				1960			
	Production (short tons)	Shipments			Production (short tons)	Shipments		
		Short tons	Value[2]			Short tons	Value[2]	
			Total	Average per ton			Total	Average per ton
Zinc oxide[3]	161, 676	154, 234	$41, 483, 742	$269	138, 128	144, 778	$38, 538, 393	$266
Leaded zinc oxide[3]	23, 550	22, 626	6, 037, 604	267	14, 379	19, 278	5, 187, 006	269
Zinc chloride, 50° B[4]	[5] 58, 797	[5] 58, 985	([6])	([6])	55, 802	55, 037	([6])	([6])
Zinc sulfate	41, 353	40, 670	6, 322, 882	155	27, 628	28, 796	4, 480, 683	156

[1] Excludes lithopone; figure withheld to avoid disclosing individual company confidential data.
[2] Value at plant, exclusive of container.
[3] Zinc oxide containing 5 percent or more lead is classed as leaded zinc oxide.
[4] Includes zinc chloride equivalent of zinc ammonium chloride.
[5] Corrected figure.
[6] Figure withheld to avoid disclosing individual company confidential data.

TABLE 20.—Zinc content of zinc pigments[1] and salts produced by domestic manufacturers, by sources

(Short tons)

Pigment or salt	1959					1960				
	Zinc in pigments and salts produced from—				Total zinc in pigments and salts	Zinc in pigments and salts produced from—				Total zinc in pigments and salts
	Ore		Slab zinc	Secondary material[2]		Ore		Slab zinc	Secondary material[2]	
	Domestic	Foreign				Domestic	Foreign			
Zinc oxide	71,126	16,339	18,000	23,680	129,145	57,296	13,028	15,393	24,716	110,433
Leaded zinc oxide	4,820	2,798	--------	--------	7,618	5,704	2,831	--------	--------	8,535
Total pigments	75,946	19,137	18,000	23,680	136,763	63,000	15,859	15,393	24,716	118,968
Zinc chloride[3]	--------	--------	(4)	[5] 13,663	[5] 13,663	--------	--------	(4)	12,625	12,625
Zinc sulfate	(4)	(4)	--------	(4)	14,254	(4)	(4)	--------	(4)	9,740

[1] Excludes zinc sulfide and lithopone; figures withheld to avoid disclosing individual company confidential data.
[2] These figures are higher than those shown in the report on Secondary Metals—Nonferrous because they include zinc recovered from byproduct sludges, residues, etc., not classified as purchased scrap material.
[3] Includes zinc content of zinc ammonium chloride.
[4] Figure withheld to avoid disclosing individual company confidential data.
[5] Corrected figure.

Lead-free zinc oxide was made by several processes: 64 percent from ores and residues by the American process, 24 percent from metal by the French process, and 12 percent by "Other" process from scrap residues and scrap materials. Leaded zinc oxide was made from ores; zinc chloride, from slab zinc and secondary zinc materials; and zinc sulfate, from ores and scrap zinc.

Four grades of leaded zinc oxide, classified according to lead content, were produced. Only a very small quantity of 5 percent or less leaded zinc oxide was produced; the grade of more than 5 to 35 percent lead constituted most of the production. Small quantities of the more than 35 through 50 percent and over 50 percent grades were produced.

Both ordinary and high strength (titanated) lithopone were produced.

Consumption.—Shipments of lead-free zinc oxide were 6 percent below 1959. Shipments to floor-covering industries increased 9 percent; to rubber, paint, ceramics and other industries decreased 6 percent; and to the coated fabric and textile industries declined 37 percent.

Consumption of leaded zinc oxide by the paintmaking industries (91 percent of the total consumption) declined 15 percent below 1959.

Lithopone was used in paint, varnish and lacquer, floor covering, coated fabrics and textiles, rubber, printing inks, and chemicals.

Statistics on distribution of zinc chloride shipments were not available. The principal uses were for soldering and tinning fluxes, battery making, galvanizing, vulcanizing fiber, preserving wood, refining oil, and fungicides.

Rayon and agriculture were the chief consumers of zinc sulfate, receiving 55 and 15 percent, resepectively, of the total shipments. Other uses were in chemicals, floation reagents, glue manufacturing, and the medicinal, mineral, and rubber industries; these combined industries received 30 percent of the shipments. Zinc sulfate consumed by rayon manufacturers decreased 40 percent; agricultural uses decreased 18 percent; and other uses decreased 6 percent, compared with 1959.

TABLE 21.—Distribution of zinc oxide shipments, by industries

(Short tons)

Industry	1951-55 (average)	1956	1957	1958	1959	1960
Rubber	76,091	80,459	81,745	68,176	79,505	75,120
Paints	32,273	32,485	32,605	33,335	33,708	31,610
Ceramics	9,311	10,160	8,459	9,095	10,486	9,840
Coated fabrics and textiles [1]	7,966	8,447	3,623	2,327	2,125	1,331
Floor coverings	2,358	1,436	1,249	971	1,207	1,316
Other	21,477	21,968	23,586	22,087	27,203	25,561
Total	149,476	154,955	151,267	135,991	154,234	144,778

[1] Includes the following tonnages for rayon: 1956—7,721; 1957—2,838; and 1958—1,149. Figure for 1959 and 1960 withheld to avoid disclosing individual company confidential data.

TABLE 22.—Distribution of leaded zinc oxide shipments, by industries

(Short tons)

Industry	1951-55 (average)	1956	1957	1958	1959	1960
Paints	37,286	26,825	23,904	23,021	20,748	17,616
Rubber	430	339	299	267	1,878	1,662
Other						
Total	37,716	27,164	24,203	23,288	22,626	19,278

TABLE 23.—Distribution of zinc sulfate shipments by industries

(Short tons)

Year	Rayon		Agriculture		Other		Total	
	Gross weight	Dry basis	Gross weight	Dry basis	Gross weight	Dry basis	Gross weight	Dry basis
1951-55 (average)	8,922	7,525	6,545	5,683	6,177	4,735	21,644	17,943
1956	21,083	18,825	7,051	6,291	4,066	3,190	32,200	28,306
1957	19,903	17,785	9,818	8,261	3,899	3,465	33,620	29,511
1958	19,796	17,747	11,525	9,819	2,416	2,191	33,737	29,757
1959	26,062	23,354	5,262	4,696	9,346	7,428	40,670	35,478
1960	15,727	14,097	4,320	3,848	8,749	7,882	28,796	25,827

Prices.—American process lead-free zinc oxide was quoted at 14.5 cents per pound, and the 5- to 35-percent leaded variety was quoted at 15.375 cents per pound for carlots during 1960. Red-seal, green-seal and white-seal French process zinc oxides were 15.75, 16.25, and 16.75 cents per pound in carlots, respectively, throughout the year. Lithopone was quoted at 9.125 cents per pound in less than carlots for the year. Zinc chloride (50 percent solution), zinc sulfate (less than carlots), and zinc sulfide (carlots) were quoted at 5.15, 9.75, and 25.30 cents per pound, respectively, all year.

Foreign Trade.—Imports of zinc pigments and salts declined 17 percent in value and 19 percent in quantity below 1959. Of the 15,600 tons imported, 12,700 tons, or 81 percent, was zinc oxide.

Exports of zinc oxide and lithopone were down 15 percent and 65 percent, respectively.

TABLE 24.—U.S. imports for consumption of zinc pigments and salts

Kind	1959		1960	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Zinc oxide	16,510	$3,301	12,695	$2,632
Zinc sulfide	235	72	193	63
Lithopone	73	9	62	8
Zinc arsenate	------	------	(1)	(2)
Zinc chloride	766	127	889	151
Zinc sulfate	1,563	169	1,743	198
Total	19,147	3,678	15,582	3,052

[1] Less than 1 ton.
[2] Less than $1,000.

Source: Bureau of the Census.

TABLE 25.—U.S. exports of zinc pigments

Kind	1959		1960	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Zinc oxide	2,516	$765	2,137	$659
Lithopone	538	99	190	35
Total	3,054	864	2,327	694

Source: Bureau of the Census.

STOCKS

National Stockpile.—Inventories in the national stockpile at yearend approximately equaled or exceeded the basic and maximum objectives. No domestically produced zinc was reported by industry [8] to have been shipped to Government account. The total of such shipments reported by industry for 1945 through 1959 was 1,173,951 tons. GSA acquired 1,840 tons of foreign zinc in 1960, under surplus agricultural-product barter contracts, authorized under the Agricultural Trade Development and Assistance Act of 1954 and amendments. The 323,925 tons acquired from 1956 through 1960 under this program was placed in the supplemental stockpile.

Producer Stocks.—Smelter stocks of slab zinc began the year at 156,200 tons, rose to over 200,000 tons by the end of July, declined to 182,000 tons at the end of November, and increased to 188,000 tons by yearend.

[8] Kimberly, J. L., A Review of the Zinc Industry in the United States During 1960, Am. Zinc Inst., New York, N.Y., 16 pp.

TABLE 26.—Stocks of zinc at zinc-reduction plants in the United States, Dec. 31

(Short tons)

	1956	1957	1958	1959	1960
At primary reduction plants	64,794	153,338	182,111	[1] 152,410	180,308
At secondary distilling plants	2,081	2,495	1,909	[1] 3,800	7,673
Total	66,875	155,833	184,020	[1] 156,210	187,981

[1] Revised figure.

Consumer Stocks.—Stocks of slab zinc at consumers' plants were 102,400 tons at the beginning of the year but declined steadily during the year. In the first quarter, the stocks remained close to 100,000 tons, but by November they had declined to approximately 65,000 tons. On December 31, total stocks were 67,800 tons. An additional 4,000 tons of slab zinc was in transit to consumer plants. At the average monthly rate of consumption, total consumer stocks plus metal in transit represented about 4 weeks' supply.

TABLE 27.—Consumer stocks of slab zinc at plants Dec. 31, by industries

(Short tons)

	Galvanizers	Brass mills [1]	Zinc die-casters [2]	Zinc rolling mills	Oxide plants	Other	Total
Dec. 31, 1959 [3]	56,919	13,527	25,199	4,930	393	1,460	[4] 102,428
Dec. 31, 1960	36,269	7,825	18,052	3,771	689	1,154	[4] 67,760

[1] Includes brass mills, brass ingot makers, and foundries.
[2] Includes producers of zinc-base die castings, zinc-alloy dies, and zinc-alloy rods.
[3] Figures partly revised.
[4] Stocks on Dec. 31, 1959 and 1960, exclude 728 tons and 1,461 tons, respectively, of remelt spelter.

PRICES

The quoted price for Prime Western zinc at East St. Louis was 12.5 cents per pound at the beginning of the year. On January 8, the price increased to 13 cents, where it held until December 13, when it dropped 0.5 cent to 12.5 cents. On December 19, the price again dropped 0.5 cent to 12 cents where it remained for the rest of the year.

The average monthly zinc quotation on the London Metal Exchange was £88.412 a long ton (equivalent to 11.05 cents per pound computed at the exchange rate recorded by the Federal Reserve Board). The average price for January was £91.747 (11.47 cents per pound), and by March the average had declined to £88.899 (11.11 cents per pound). By May the price had increased to £91.452 (11.43 cents per pound) but thereafter an almost continual decrease brought the price to the low of £82.747 (10.34 cents per pound) in December.

Prices of new and old zinc scrap varied with market quotations for slab zinc. Sales of clean new zinc clippings, trimmings, and engravers' or lithographers' plates averaged slightly over 7 cents per pound through November. In December, the price dropped to 6.74 cents per pound but it averaged 7.08 cents for the year. Old zinc scrap ranged in price from 3.87 to 4.75 cents a pound, averaging 4.56 cents.

TABLE 29.—Price of zinc concentrate and zinc

	1956	1957	1958	1959	1960
Joplin 60-percent zinc concentrate:[1] Price per short ton..........dollars..	83.89	76.94	60.55	60.36	73.13
Average price common zinc at—					
St. Louis (spot)[1]..........cents per pound..	13.49	11.40	10.31	11.46	12.95
New York [1]..........do....	13.99	11.90	10.81	11.96	13.45
London [2]..........do....	12.19	10.18	8.24	10.27	11.05
Price indexes (1947–49 average—100): [3]					
Zinc (New York)	111	94	86	94	(4)
Lead (New York)	100	91	76	76	(4)
Copper (New York)	199	144	125	148	(4)
Straits tin (New York)	110	105	103	111	(4)
Nonferrous metals	156	137	128	136	139
All commodities	114	118	119	120	120

[1] Metal Statistics, 1961.
[2] E&MJ Metal and Mineral Markets English quotations converted into U.S. money on basis of average rates of exchange recorded by Federal Reserve Board.
[3] Based upon price indexes of U.S. Department of Labor.
[4] Data not available.

TABLE 30.—Average monthly quoted prices of 60-percent zinc concentrate at Joplin, and of common zinc (prompt delivery or spot), St. Louis and London [1]

Month	1959			1960		
	60 percent zinc concentrates in the Joplin region (per ton)	Metallic zinc (cents per pound)		60 percent zinc concentrates in the Joplin region (per ton)	Metallic zinc (cents per pound)	
		St. Louis	London [2 3]		St. Louis	London [2 3]
January	$68.00	11.50	9.36	$78.91	12.90	11.47
February	67.50	11.42	9.21	80.00	13.00	11.12
March	64.00	11.00	9.47	80.00	13.00	11.11
April	64.00	11.00	9.16	80.00	13.00	11.22
May	64.00	11.00	9.75	80.00	13.00	11.43
June	64.00	11.00	9.88	80.00	13.00	11.27
July	64.00	11.00	10.15	80.00	13.00	11.22
August	64.00	11.00	10.66	80.00	13.00	10.93
September	66.56	11.38	10.76	80.00	13.00	10.89
October	72.30	12.26	11.42	80.00	13.00	10.91
November	76.00	12.50	11.87	80.00	13.00	10.94
December	76.00	12.50	11.90	77.10	12.48	10.34
Average for year	60.36	11.46	10.27	73.13	12.95	11.05

[1] Joplin: Metal Statistics, 1961, p. 558. St. Louis: Metal Statistics, 1961, p. 555. London: E&MJ Metal and Mineral Markets.
[2] Conversion of English quotations into American money based on average rates of exchange recorded by Federal Reserve Board.
[3] Average of daily mean of bid and asked quotations at morning session of London Metal Exchange.

TABLE 31.—Average price received by producers of zinc, by grades

(Cents per pound)

Grade	1956	1957	1958	1959	1960
Special High Grade	14.26	12.13	10.45	11.78	13.69
High Grade	13.98	11.70	10.13	11.42	13.20
Intermediate	14.06	11.69	10.81	11.85	13.34
Brass Special	13.71	11.31	10.38	11.39	12.89
Select	13.41	10.56	10.48	10.93	12.64
Prime Western	13.13	11.24	9.98	11.18	12.15
All grades	13.73	11.64	10.22	11.47	12.86
Prime Western; spot quotation at St. Louis [1]	13.49	11.40	10.31	11.46	12.95

[1] Metal Statistics, 1961, p. 555.

FOREIGN TRADE

Imports.—Import quotas imposed October 1, 1958, by Presidential Proclamation 3257, dated September 22, 1958, remained in effect throughout 1960. The quotas limited annual competitive imports of unmanufactured zinc (not including zinc fume) to 379,840 tons in ores and concentrates and 141,120 tons as metal. The quotas established were 80 percent of the average dutiable imports into the United States during 1953–57. Specific quotas were assigned to those countries, supplying substantial quantities of U.S. imports, and an "all other" quota was established to cover the remaining eligible countries.

Imports for consumption (imports for immediate consumption plus withdrawals from bonded warehouses for consumption) given in table 34 give a close approximation of dutiable imports of unmanufactured zinc entering the United States. Imports of zinc fume, excluded from the quota restrictions, amounted to approximately 40,000 tons, averaging 77 percent zinc (57,000 tons in 1959). Mexico was the primary source; small quantities were supplied from Canada.

TABLE 32.—U.S. imports [1] of zinc, by countries

(Short tons)

Country	1951–55 (average)	1956	1957	1958	1959	1960
Ores (zinc content):						
North America:						
Canada	148,299	177,087	158,220	155,506	[2] 152,134	119,966
Cuba	777	1,155	1,209	223	188	78
Guatemala	6,974	11,433	9,313	6,483	8	6,063
Honduras	666	2,288	2,589	1,435	1,427	4,714
Mexico	175,139	193,007	192,519	158,609	[2] 182,409	190,069
Other North America	10	4	(3)	(3)	1	----------
Total	331,865	384,974	363,850	322,256	[2] 336,167	320,890
South America:						
Argentina	1,230	2	165	9	101	----------
Bolivia	11,651	7,294	7,633	7,328	[2] 2,530	1,215
Chile	2,205	346	1,400	977	479	30
Peru	66,994	98,541	119,004	102,990	[2] 86,672	80,016
Other South America	252	212	8	121	[2] 66	63
Total	82,332	106,395	128,210	111,425	[2] 89,848	81,324
Europe:						
Germany, West	----------	----------	----------	----------	5,756	2
Italy	1,748	----------	----------	----------	14,766	----------
Spain	5,931	----------	----------	----------	[2] 16,479	18,913
Other Europe	5,205	1,923	1,398	80	3,613	100
Total	12,884	1,923	1,398	80	[2] 40,614	19,015
Asia:						
Philippines	953	828	777	92	[2] 48	4,781
Other Asia	448	66	79	240	1	24
Total	1,401	894	856	332	[2] 49	4,805
Africa:						
Union of South Africa	6,032	13,400	21,048	21,700	7,957	12,300
Other Africa	601	----------	1,896	1,032	[2] 787	39
Total	6,633	13,400	22,944	22,732	[2] 8,744	12,339
Oceania: Australia	4,807	17,764	8,756	[4] 4,735	[2] 24,693	17,848
Grand total: Ores	439,922	525,350	526,014	461,560	[2] 500,115	456,221

See footnotes at end of table.

TABLE 32.—U.S. imports [1] of zinc, by countries—Continued

Country	1951-55 (average)	1956	1957	1958	1959	1960
Blocks, pigs, or slabs:						
North America:						
Canada	96,265	116,875	103,964	93,475	88,414	74,168
Mexico	16,506	17,153	23,536	23,256	9,338	8,950
Total	112,771	134,028	127,500	116,731	97,752	83,118
South America: Peru	5,311	6,590	22,947	9,736	12,337	7,517
Europe:						
Austria		2,296	1,020	110	220	
Belgium-Luxembourg	10,861	32,353	34,163	21,707	7,666	5,724
Germany [5]	6,255	15,285	8,772	2,673	55	2,680
Italy	7,902	13,486	10,010	6,166	7,459	3,517
Netherlands	2,222	5,965	2,504	2,520		
Norway	1,707			2,769	168	
United Kingdom	1,284	611	1,791	672	841	333
Yugoslavia	938	500	10,909	5,781	3,643	4,520
Other Europe	35	110				2,986
Total	31,204	70,606	69,169	42,398	20,052	19,760
Asia: Japan	44	4,883	2,887	2,039		
Africa:						
Congo, Republic of the, and Ruanda-Urundi [6]	6,001	17,782	33,007	20,991	12,790	9,307
Rhodesia and Nyasaland, Federation of	[7] 269	3,808	3,974	1,064	4,667	615
Other Africa	363					
Total	6,633	21,590	36,981	22,055	17,457	9,922
Oceania: Australia	2,213	7,281	9,523	2,240	9,365	450
Grand total: Blocks, pigs, or slabs	158,176	244,978	269,007	195,199	156,963	120,767

[1] Data include zinc imported for immediate consumption plus material entering country under bond.
[2] Revised figure.
[3] Less than 1 ton.
[4] Includes 52 tons imported from French Pacific Islands.
[5] West Germany, 1952–60.
[6] Effective July 1, 1960; formerly Belgian Congo.
[7] Northern Rhodesia.

Source: Bureau of the Census.

General imports (imports for immediate consumption plus entries into bonded warehouses) presented in table 32 show all physical entries of unmanfactured zinc into the United States. General imports declined 9 percent to 456,200 tons for ores and concentrates and decreased 23 percent to 120,800 tons for zinc metal.

Exports.—Exports of slab zinc increased to 75,100 tons in 1960. Most of the slab zinc was shipped to the United Kingdom, Japan, India, Sweden, West Germany, Netherlands, Brazil, and Mexico.

Tariff.—The duty on slab zinc remained at 0.7 cent a pound, that on zinc contained in ore and concentrate at 0.6 cent a pound, and that on zinc scrap at 0.75 cent a pound throughout 1960. The duties on zinc articles under the Tariff Act of 1930 were unchanged, remaining as shown on page 1290, Volume 1, 1953 Minerals Yearbook.

TABLE 33.—U.S. imports for consumption[1] of zinc, by classes

Year	Ore (zinc content) Short tons	Ore (zinc content) Value (thousands)	Blocks, pigs, slabs Short tons	Blocks, pigs, slabs Value (thousands)	Sheets Short tons	Sheets Value (thousands)	Old and worn out Short tons	Old and worn out Value (thousands)
1951-55 (average)	411,121	[2] $53,937	156,789	[2] $39,555	216	[2] $84	911	$118
1956	462,379	49,231	244,726	65,034	454	172	185	36
1957	679,416	88,516	268,824	[2] 64,129	732	245	227	32
1958	537,699	51,121	185,693	35,511	901	285	235	31
1959	[3] 424,134	[3] 37,475	164,462	33,996	951	311	183	26
1960	382,707	38,696	120,925	29,639	904	302	106	14

Year	Dross and skimmings Short tons	Dross and skimmings Value (thousands)	Zinc dust Short tons	Zinc dust Value (thousands)	Total value[4]
1951-55 (average)	2,565	$184	281	[2] $59	[2] $93,937
1956	417	61	72	18	[2] 114,552
1957	363	57	112	[2] 28	[2] 153,007
1958	737	77	96	14	[2] 87,039
1959	955	116	44	6	[3] 71,930
1960	1,099	175	19	7	68,833

[1] Excludes imports for manufacture in bond and export, which are classified as "imports for consumption" by Bureau of the Census.
[2] Data known to be not comparable with other years.
[3] Revised figure.
[4] In addition manufactures of zinc were imported as follows: [2] 1951-55 (average)—$60,161; [2] 1956—$287,361; [2] 1957—$264,348; 1958—$389,803; 1959—$811,916; 1960—$836,871.
Source: Bureau of the Census.

TABLE 34.—U.S. imports for consumption[1] of zinc, by countries

(Short tons)

Country	1951-55 (average)	1956	1957	1958	1959	1960
Ores (zinc content):						
North America:						
Canada	145,858	145,610	217,441	169,474	[2] 137,426	133,107
Cuba	122	1,103	1,247	52	[2] 72	17
Guatemala	6,573	13,209	10,337	6,093	10	1,811
Honduras	274	458	3,562	1,428	[2] 1,116	2,140
Mexico	161,439	187,305	261,265	208,202	[2] 147,877	142,216
Other North America	13	----------	2	111	1	----------
Total	314,279	347,685	493,854	385,360	[2] 286,502	279,291
South America:						
Argentina	882	----------	105	9	(3)	45
Bolivia	9,541	5,523	8,644	6,838	[2] 1,704	790
Chile	2,068	390	3,035	1,072	[2] 34	5
Peru	56,059	91,691	147,073	110,165	[2] 80,616	71,393
Other South America	298	11	70	121	(3)	49
Total	68,848	97,615	158,927	118,205	[2] 82,354	72,282
Europe:						
Germany, West	(3)	----------	8	----------	7,290	----------
Italy	2,443	----------	----------	----------	[2] 9,930	4,241
Spain	8,327	----------	----------	----------	[2] 13,476	10,405
Other Europe	5,085	861	215	11	2,344	982
Total	15,855	861	223	11	[2] 33,040	15,628
Asia:						
Philippines	953	816	942	92	29	679
Other Asia	446	----------	9	211	----------	1
Total	1,399	816	951	303	29	680

See footnotes at end of table.

TABLE 34.—U.S. imports for consumption[1] of zinc, by countries—Continued

(Short tons)

Country	1951–55 (average)	1956	1957	1958	1959	1960
Africa:						
Union of South Africa	6,444	407	19,751	27,190	[2] 4,331	5,333
Other Africa	588	----------	(3)	524	[2] 1,140	133
Total	7,032	407	19,751	27,714	[2] 5,471	5,466
Oceania: Australia	3,708	14,995	5,710	[4] 6,106	[2] 16,738	9,360
Grand total: Ores	411,121	462,379	679,416	537,699	[2] 424,134	382,707
Blocks, pigs, or slabs:						
North America:						
Canada	96,273	116,875	103,964	93,327	88,414	74,168
Mexico	15,144	16,929	23,690	22,804	9,718	8,675
Total	111,417	133,804	127,654	116,131	98,132	82,843
South America: Peru	5,307	6,590	22,947	9,736	12,337	7,517
Europe:						
Austria	----------	2,296	1,020	55	305	2
Belgium-Luxembourg	10,860	32,353	34,163	17,969	11,648	5,724
Germany [5]	6,255	15,257	8,772	2,035	662	1,619
Italy	7,874	13,486	10,010	5,816	7,173	4,237
Netherlands	2,222	5,965	2,504	730	1,705	----------
Norway	1,707	----------	----------	2,601	329	7
United Kingdom	1,284	611	1,791	112	1,363	373
Yugoslavia	938	500	10,572	5,009	3,384	5,640
Other Europe	35	110	----------	----------	----------	2,809
Total	31,175	70,578	68,832	34,327	26,569	20,411
Asia: Japan	44	4,883	2,887	1,708	355	----------
Africa:						
Congo, Rupublic of the and Ruanda-Urundi [6]	6,001	17,782	33,007	20,991	12,790	9,308
Rhodesia and Nyasaland, Federation of	[7] 269	3,808	3,974	560	4,840	396
Other Africa	363	----------	----------	----------	298	----------
Total	6,633	21,590	36,981	21,551	17,928	9,704
Oceania: Australia	2,213	7,281	9,523	2,240	9,141	450
Grand total: Blocks, pigs, or slabs	156,789	244,726	268,824	185,693	164,462	120,925

[1] Excludes imports for manufacture in bond and export, classified as "imports for consumption" by Bureau of the Census.
[2] Revised figure.
[3] Less than 1 ton.
[4] Includes 52 tons imported from French Pacific Islands.
[5] West Germany, 1952–59.
[6] Effective July 1, 1960; formerly Belgian Congo.
[7] Northern Rhodesia.

Source: Bureau of the Census.

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NORTH AMERICA

Canada.—Consolidated Mining & Smelting Co. continued as the leading Canadian zinc producer. According to the annual company report, the Sullivan silver-lead-zinc mine at Kimberly, British Columbia, produced 2,520,000 tons of crude ore. The 500-foot extension to the main shaft was completed during the year, and work was started on a new lower haulage level and crushing station. Production from the Bluebell lead-zinc mine at Riondel, British Columbia, was 255,600

TABLE 35—U.S. exports of slab and sheet zinc, by countries

(Short tons)

Destination	Slabs, pigs, and blocks				Sheets, plates, strips, or other forms, n.e.s.			
	1957	1958	1959	1960	1957	1958 [1]	1959 [1]	1960 [1]
North America:								
Canada	13	6	13	11	2,581	1,864	1,790	1,516
Cuba	31	31	114	105	123	132	76	64
Mexico	513	845	1,255	1,119	315	425	316	283
Other North America	58	46	55	1	40	57	71	42
Total	615	928	1,437	1,236	3,059	2,478	2,253	1,905
South America:								
Argentina	6	-------	43	-------	-------	-------	-------	17
Brazil	17	-------	135	2,414	69	87	26	28
Chile	40	36	523	10	37	-------	14	53
Colombia	55	14	37	1,045	408	195	134	55
Venezuela	-------	8	-------	10	72	86	105	75
Other South America	3	-------	-------	463	21	61	11	12
Total	121	58	738	3,942	607	429	290	240
Europe:								
Belgium-Luxembourg	1,064	-------	1,624	340	5	47	19	3
Denmark	-------	-------	-------	140	64	105	111	107
Germany, West	336	-------	56	3,364	34	73	174	121
Italy	-------	-------	-------	560	7	1	4	12
Netherlands	476	-------	280	2,522	22	122	60	42
Sweden	-------	-------	2,475	4,847	36	149	123	84
Switzerland	-------	-------	-------	336	26	87	133	142
United Kingdon	6,504	672	4,065	25,394	11	106	162	302
Other Europe	(2)	-------	-------	700	4	29	81	103
Total	8,380	672	8,500	38,203	209	719	867	916
Asia:								
India	672	-------	635	11,172	53	36	3	3
Japan	4	1	25	18,125	5	11	1	-------
Korea, Republic of	912	-------	-------	75	-------	-------	-------	-------
Philippines	8	5	-------	979	53	73	35	54
Other Asia	73	405	14	1,403	19	21	4	97
Total	1,669	411	674	31,754	130	141	43	154
Africa:								
Union of South Africa	-------	-------	-------	-------	51	42	50	74
Other Africa	-------	4	-------	9	-------	3	4	2
Total	-------	4	-------	9	51	45	54	76
Oceania	-------	-------	280	-------	-------	6	22	33
Grand total	10,785	2,073	11,629	75,144	4,056	3,818	3,529	3,324

[1] Owing to changes in classification by Bureau of the Census, data known to be not strictly comparable with earlier years.
[2] Less than 1 ton.

Source: Bureau of the Census.

tons; shaft sinking to lower levels continued under difficult water conditions. The H. B. zinc-lead mine near Salmo, British Columbia, produced 464,400 tons of ore. Exploration at the Duncan Lake lead-zinc property in the Lardeau district of British Columbia established the existence of ore in commercial quantities. Construction of a railroad to the zinc-lead property at Pine Point Mines, Ltd., near Great Slave Lake was being considered by the Canadian Government. Production of slab zinc at the Consolidated Minings' electrolytic plant at Trail, British Columbia, was 193,900 tons, 74 percent of total Canadian output. Approximately 81 percent was produced from concen-

TABLE 36.—U.S. exports of zinc ore and manufactures of zinc

	Zinc ore, concentrates (zinc content)		Slabs, pigs, or blocks		Sheets, plates, strips, or other forms, n.e.s.		Zinc scrap and dross (zinc content)		Zinc dust	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1951–55 (average)[1]	1,883	$490	31,051	$10,858	4,628	$2,867	8,977	$1,119	(2)	(2)
1956 [1]	854	162	8,813	2,465	4,444	3,031	14,921	1,540	372	$136
1957 [1]	7	(3)	10,785	2,553	4,056	2,950	5,469	822	595	195
1958 [1]	------	------	2,073	704	[4] 3,818	[4] 2,637	5,344	364	519	170
1959 [1]	1	(3)	11,629	2,673	[4] 3,529	[4] 2,708	11,332	1,053	521	182
1960 [1]	13	3	75,144	18,122	[4] 3,324	[4] 2,443	12,169	1,499	777	267

[1] Effective Jan. 1, 1952, zinc and zinc-alloy semifabricated forms, n.e.c., were exported as follows: 1952—$191,746 (quantity not available); 1953—286 tons ($151,496); 1954—543 tons ($257,316); 1955—651 tons ($295.685); 1956—582 tons ($301,230); 1957—485 tons ($246,527);[4] 1958—11,168 tons ($542,069);[4] 1959—1,071 tons ($612,388);[4] 1960—2,569 tons ($1,194,751).

[2] Not included in 1951-55 averages; 1951—723 tons ($400,656); 1952 included with "scrap"; 1953—502 tons ($181,055); 1954—509 tons ($150,756); 1955—445 tons ($161,956).

[3] Less than $1,000.

[4] Owing to changes in classification by the Bureau of the Census, data not strictly comparable to earlier years.

Source: Bureau of the Census.

trates from company-owned mines; 10 percent, from retreatment of stockpiles of zinc-plant residues and lead-blast furnace slag; and 9 percent, from purchased ores and concentrates.

According to the annual report of the Reeves McDonald Mines, Ltd., the company mined and milled 411,300 tons of ore at its Remac, British Columbia, mine, yielding concentrates containing 12,670 tons of zinc and 3,700 tons of lead plus values in silver and cadmium. Development consisted of 5,581 feet of drifts and raises, 145 feet of shaft sinking, and 1,738 feet of test drilling.

Sheep Creek Mines, Ltd., Windermere, British Columbia, reported production for the year ending May 31, 1960, to be 188,600 tons of ore grading 4.67 percent zinc and 2.79 percent lead, yielding concentrates containing 7,436 tons of zinc and 4,663 tons of lead. The millionth ton of ore since production began in 1954 was mined during the year from the Mineral King mine. The ore reserve increased from 408,000 to 416,000 tons in this time interval.[9]

Hudson Bay Mining & Smelting Co., Ltd., operated its zinc-copper-lead mines on the Manitoba-Saskatchewan boundary and ranked second as producer of zinc in Canada. The mill treated 1,682,000 tons of ore, an increase of 10,900 tons over 1959. Mill feed was 74.4 percent from the Flin Flon mine, 11.1 percent from the Coronation mine, 6.8 percent from the Chisel Lake mine, and 2.0 percent from the Birch Lake mine. The Coronation and Chisel Lake mines were brought into production on April 1 and September 1, respectively, and the Birch Lake mine was closed on April 14 when the ore body was mined out. Hudson Bay's ore reserve on December 31 was given as 15.8 million tons; zinc content averaged 5.2 percent. Slab-zinc production at the company electrolytic plant at Flin Flon (Manitoba) was 67,100 tons, 26 percent of the Canadian output.[10]

[9] Northern Miner, vol. 46, No. 21, Aug. 18, 1960, p. 187.
[10] Hudson Bay Mining & Smelting Co., Ltd., Annual Report, 1960, pp. 7–8.

The Manitouwadge (Ontario) mine of Willroy Mines, Ltd., ranked fourth as zinc producer in Canada. Production of ore was 429,300 tons, an increase of 58,000 tons over 1959. The average grade decreased from 9.93 to 7.39 percent zinc and yielded concentrates containing 27,000 tons of zinc plus quantities of copper, lead, silver, and gold. Exploration and development maintained the ore reserve at approximately a 6-year supply based on current operating tonnages.[11]

Geco Mines, Ltd., at Manitouwadge milled 1,290,000 tons of ore with a calculated grade of 2.74 percent zinc, 1.76 percent copper, and 1.36 ounces per ton of silver. The ore yielded 51,984 tons of zinc con-

TABLE 37.—World mine production of zinc (content of ore), by countries [1 2 3]

(Short tons)

Country [2]	1951-55 (average)	1956	1957	1958	1959	1960
North America:						
Canada [4]	384,905	422,633	413,741	425,099	396,008	405,620
Cuba	[5] 1,134	1,638	752	[6] 110	[7] 188	[7] 77
Greenland [6]	----------	6,050	9,350	6,700	8,350	11,000
Guatemala	7,562	12,000	10,300	5,278	----------	11,070
Honduras [7]	666	2,288	2,589	1,435	1,427	4,714
Mexico	248,449	274,351	267,891	247,033	290,938	289,274
United States [4]	576,552	542,340	531,735	412,005	425,303	435,427
Total	1,219,268	1,261,300	1,236,358	1,097,660	1,122,214	1,157,182
South America:						
Argentina	19,171	26,350	32,420	40,100	44,100	38,200
Bolivia (exports)	29,054	18,818	21,678	15,677	3,740	4,439
Chile	2,535	2,969	2,747	1,340	1,116	[6] 900
Peru	152,756	193,037	170,258	149,094	157,739	148,606
Total	203,516	241,174	227,103	206,211	206,695	192,145
Europe:						
Austria	4,989	5,868	6,334	6,463	6,522	7,250
Bulgaria [6]	27,700	39,400	50,000	55,000	61,300	64,800
Finland	8,566	43,000	47,400	51,800	59,600	46,328
France	13,841	13,870	13,640	13,800	15,500	18,900
Germany:						
East [6]	6,200	7,700	7,700	7,700	7,700	7,700
West	95,689	101,898	104,015	94,137	90,477	95,136
Greece	5,840	10,000	10,700	17,300	13,300	17,200
Ireland	1,917	1,798	1,792	463	1,424	1,429
Italy	122,874	137,600	143,400	150,800	145,200	141,400
Norway	6,236	7,007	7,735	10,016	10,907	10,869
Poland [6]	170,900	167,000	144,600	135,300	142,500	158,800
Spain	93,388	96,100	89,096	90,764	94,645	91,948
Sweden	52,704	72,797	74,528	77,808	86,548	77,492
U.S.S.R. [6 8]	228,900	310,000	330,000	360,000	370,000	380,000
United Kingdom	2,436	1,563	1,085	283	----------	----------
Yugoslavia	58,225	63,426	64,032	66,160	66,882	62,150
Total [2 6]	907,000	1,088,000	1,105,000	1,147,000	1,181,000	1,190,000
Asia:						
Burma	4,453	8,100	10,200	12,100	12,100	11,000
China [6]	16,800	39,000	44,000	50,000	72,000	88,000
India	2,458	4,200	4,500	4,300	6,000	5,800
Iran [9]	7,400	5,200	5,000	9,900	7,400	7,700
Japan	102,861	135,585	149,921	157,601	156,899	172,524
Korea:						
North [6]	[10] 23,900	55,000	55,000	66,000	66,000	66,000
Republic of	115	440	311	369	4	46
Philippines [11]	550	1,050	330	----------	6	5,487
Thailand	1,856	2,400	1,820	600	840	1,170
Turkey [6]	2,540	1,090	2,120	2,090	1,650	3,028
Total [2 6]	162,900	252,000	273,000	303,000	323,000	361,000

See footnotes at end of table.

[11] Willroy Mines, Ltd., Annual Report, 1960, 9 pp.

TABLE 37.—World mine production of zinc (content of ore), by countries [1 2 3]—Continued

(Short tons)

Country [2]	1951-55 (average)	1956	1957	1958	1959	1960
Africa:						
Algeria	22,408	35,703	32,743	36,725	39,969	43,320
Congo, Republic of the (formerly Belgian)	102,628	129,551	117,682	125,646	77,130	120,217
Morocco: Southern zone	35,437	46,549	53,864	54,257	71,285	56,106
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia	29,423	38,134	40,353	38,034	46,497	49,242
South-West Africa [4]	18,314	23,728	25,349	15,910	12,395	13,119
Tunisia	4,771	5,200	3,867	4,566	3,656	4,613
United Arab Republic (Egypt Region)	772	692				
Total	213,753	279,557	273,858	275,138	250,932	286,617
Oceania: Australia	254,095	311,452	326,573	294,609	278,631	325,468
World total (estimate)[2]	2,960,000	3,430,000	3,440,000	3,320,000	3,360,000	3,510,000

[1] Data derived in part from the Yearbook of the American Bureau of Metal Statistics, the United Nations Statistical Yearbook, and the Statistical Summary of the Mineral Industry (Overseas Geological Surveys, London).
[2] In addition to countries listed, Czechoslovakia and Rumania also produce zinc, but production data are not available; estimates for these countries are included in totals.
[3] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[4] Recoverable.
[5] One year only, as 1955 was first year of commercial production.
[6] Estimate.
[7] U.S. imports.
[8] Smelter production.
[9] Year ended March 21 of year following that stated.
[10] Average for 1953-55.
[11] Estimated metal content of the concentrates exported.

Compiled by Augusta W. Jann, Division of Foreign Activities.

centrate assaying 54.56 percent zinc, an increase of 23 percent. The output made the mine Canada's third ranking zinc producer. Development and exploration consisted of drifts, raises, and diamond drilling. The ore reserve was calculated to be 17.4 million tons containing 4.18 percent zinc, 1.97 percent copper and 2.20 ounces per ton of silver.[12]

Sherbrooke Metallurgical Co., a subsidiary of Mathieson & Hegeler Zinc Co., began operating a new 400-ton-per-day capacity zinc concentrate roasting plant at Port Maitland, Ontario. The plant utilizes a pelletized, fluid-hearth process and it is planned to treat concentrates from zinc mines in eastern Canada for feed to the parent company's smelter near Clarksburg, W. Va.[13]

In Quebec, Quemont Mining Corp., Ltd., milled 856,600 tons of ore, containing 2.60 percent zinc plus values in copper, gold, and silver. Production was 31,778 tons of zinc concentrate, containing 52.2 percent zinc.[14] Other Quebec producers of zinc concentrate included Normetal Mining Corp., Ltd., which milled 347,200 tons of a copper-zinc-gold-silver ore, yielding 20,024 tons of zinc concentrate containing 51.50 percent zinc; Waite Amulet Mines, Ltd., which treated 297,000 tons of ore of 3.48 percent zinc and produced 14,432 tons of concentrate with

[12] Geco Mines, Ltd., Annual Report, 1960, pp. 3–5.
[13] Northern Miner, vol. 46, No. 39, Dec. 22, 1960, p. 1.
[14] Quemont Mining Corp., Ltd., Annual Report, 1960, p. 3.

50.8 percent contained zinc; East Sullivan Mines, Ltd., which for the first 7 months of 1960 milled 563,800 tons of a zinc-copper ore, containing 1.04 percent zinc and yielding zinc concentrate containing 4,948 tons of zinc.

Several mining companies announced plans for developing properties in the new Mattagami Lake mining district of northwestern

TABLE 38.—World smelter production of zinc, by countries [1] [2] [3]

(Short tons)

Country	1951-55 (average)	1956	1957	1958	1959	1960
North America:						
Canada	240,329	255,564	247,316	252,093	255,306	260,968
Mexico [4]	60,228	62,136	62,353	63,329	61,362	58,318
United States	893,629	983,610	985,796	781,246	798,666	803,720
Total	1,194,186	1,301,310	1,295,465	1,096,668	1,115,334	1,123,006
South America:						
Argentina	12,507	16,200	16,150	17,400	14,100	[5] 19,700
Peru	10,453	10,419	32,483	32,034	29,595	35,406
Total	22,960	26,619	48,633	49,434	43,695	55,106
Europe:						
Austria	[6] 1,493	7,932	10,291	11,698	12,608	12,700
Belgium [7]	221,818	254,289	259,755	236,730	247,250	272,888
Bulgaria	[6] 1,497	6,435	8,282	9,000	9,900	18,700
France	101,106	124,106	143,905	165,190	162,306	165,471
Germany, West	172,514	204,964	202,548	146,816	152,046	156,299
Italy	65,255	79,817	82,107	78,656	83,499	87,518
Netherlands	28,261	31,980	33,085	29,285	35,445	39,771
Norway	46,040	53,762	53,299	50,180	53,767	48,024
Poland	147,864	169,000	175,013	179,252	185,263	193,501
Spain	24,902	25,381	24,138	27,239	27,039	30,883
U.S.S.R. [5]	229,000	310,000	330,000	360,000	370,000	380,000
United Kingdom	83,723	91,247	86,111	83,537	81,722	83,219
Yugoslavia	15,354	21,890	32,473	34,445	35,220	39,612
Total [1] [5]	1,146,000	1,386,000	1,447,000	1,418,000	1,465,000	1,537,000
Asia:						
China (refined) [5]	16,000	38,000	41,000	45,000	66,000	77,000
Japan	92,586	150,169	152,152	155,401	175,642	198,921
Total [5]	108,600	188,000	193,000	200,000	242,000	276,000
Africa:						
Congo, Republic of the (formerly Belgian)	[8] 27,106	46,390	54,227	58,905	60,418	58,817
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia	28,058	32,396	33,040	33,880	33,483	33,368
Total	55,164	78,786	87,267	92,785	93,901	92,185
Oceania: Australia	103,094	117,592	123,589	128,547	130,436	134,656
World total (estimate)	2,630,000	3,100,000	3,190,000	2,990,000	3,090,000	3,220,000

[1] In addition to countries listed, Czechoslovakia and Rumania also produce zinc, but production data are not available; estimates are included in the total.
[2] Data derived in part from the Yearbook of the American Bureau of Metal Statistics, the United Nations Monthly Bulletin and the Statistical Yearbook, and the Statistical Summary of the Mineral Industry (Overseas Geological Surveys, London).
[3] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[4] In addition, other zinc-bearing materials totaling 30,288 short tons in 1953; 18,545 in 1954; 37,442 in 1955; 39,554 in 1956; 30,504 in 1957; 19,572 in 1958; 314 in 1959; and 1,246 in 1960.
[5] Estimate.
[6] One year only, as 1955 was first year of production reported.
[7] Includes production from reclaimed scrap.
[8] Average for 1953-55.

Compiled by Augusta W. Jann Division of Foreign Activities.

Quebec.[15] Orchan Mines with an indicated reserve of over 4 million tons of 12.7 percent zinc and 1.3 percent copper intended to build a mill of 1,000 tons daily capacity to be in operation in 1962. Mattagami Lake Mines, Ltd. (a partnership controlled by Noranda Mines, Ltd.), McIntyre Porcupine Mines, Ltd., and Canadian Exploration, Ltd., completed shaft sinking and planned a mill of at least 2,000 tons daily capacity for the fall of 1962 to exploit estimated reserves of 22 million tons, averaging over 12 percent zinc plus values in copper and precious metals. The same company also planned to build eastern Canada's first zinc refinery, a 165,000-ton-per-year facility, south of Montreal at Valleyfield, to process zinc concentrates from Mattagami Lake district and other area mines.[16]

In New Brunswick, Heath Steele Mines, Ltd., resumed underground development, but no decision was made as to when the unit would be brought back into production.[17]

In Newfoundland, Buchans Mining Co., Ltd., operated its lead-zinc-copper property near Red Indian Lake at a normal rate. Sinking of a new concrete-lined McLean shaft was suspended at a depth of 3,526 feet, pending the results of future drilling from the 20th level to determine if the ore body continues beyond the presently proven depth of 3,265 feet.[18]

Mexico.—Reports continued that the Mexican Government had selected a site and would construct a 30,000-ton-per-year zinc refinery at Saltillo, Coahuila.

In December, the Mexican Congress passed a new mining law, which provided substantial tax advantages to Mexican-controlled mining and smelting operations. Most of the non-Mexican companies were arranging to transfer a substantial part of their assets to Mexico-incorporated companies and to encourage Mexican investors to purchase 51 percent or more of the ownership.

American Smelting and Refining Co. continued operating its extensive zinc-producing units in Mexico.

American Metal Climax, Inc., through its Mexican subsidiary, Cia. Minera de Penoles, S.A., mined 257,000 tons of lead-zinc ore. A new 3.5-miles haulage tunnel at the Avalos mine, placed in operation in May, increased the mine capacity.

San Francisco Mines of Mexico, Ltd., at the San Francisco and Clarines mines, Chihuahua, during the year that ended on September 30, milled 905,000 tons of crude ore yielding 104,000 tons of 57.43 percent zinc concentrate, 58,400 tons of 65.39 percent lead concentrate, and 10,700 tons of 28.29 percent copper concentrate. The company reported that despite increasing cost of supplies, the operating cost per ton of ore milled was reduced over the preceding year and was comparable with that of 1950.

Fresnillo Co. operated its lead-zinc mining and milling units at Fresnillo in Zacatecas and at Naica in Chihuahua. In the year ending June 30, 1960, the company milled 629,900 tons of ore, including 68,400 tons of custom ore, at the Fresnillo mill and 379,100 tons of ore at the Naica mill. The Fresnillo mill yielded 38,658 tons of 51.6 per-

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[15] Northern Miner, vol. 46, No. 38, Dec. 15, 1960, p. 1.
[16] Mining Congress Journal, vol. 47, No. 4, April 1961, p. 102.
[17] American Metal Climax, Inc., Annual Report, 1960, p. 22.
[18] American Smelting and Refining Company, Annual Report, 1960, p. 12.

cent zinc concentrate; the Naica mill yielded 33,927 tons of 53.9 percent zinc concentrate. Use of de-slimed mill tailing for stope filling at the Fresnillo mine made it possible for about one-fourth of the current production to be mined from sandfilled stopes.[19]

El Potosi Mining Co. (subsidiary of Howe Sound Co.) operated its El Potosi mine in the Santa Eulalia district, Chihuahua.

SOUTH AMERICA

Argentina.—Cia. Minera Aguilar, S.A., a subsidiary of St. Joseph Lead Co., operated its lead-zinc-silver mine in the Province of Jujuy. The mill produced 57,600 tons of zinc concentrate compared with 66,500 tons in 1959. Cia. Metalurgica Austral-Argentine, S.A., smelted the concentrate at its electrothermic zinc smelter and reported sales of 7,000 tons of slab zinc compared with 7,700 tons in 1959.[20]

Production at National Lead Co. operations was reported to be 13,000 tons of zinc concentrate, containing 7,650 tons of zinc.

Bolivia.—The leading mine was Animas Telamayu. Total production for Bolivia was reported as 3,800 tons of zinc concentrate containing 64 percent zinc.

Peru.—Cerro de Pasco Corp. produced 35,156 tons of slab zinc at its La Oroya electrolytic zinc plant from concentrates produced at corporation-owned mines. An additional 110,901 tons of zinc concentrate was sold for export. Company officials authorized an increase in the capacity of the zinc plant from 31,500 to 52,500 tons per year.[21] Production of the copper-lead-zinc mines of Compañía de Minas Buensventura, S.A., increased 20 percent. The open-pit zinc-lead Santander mine of Cia. Minerales Santander, Inc., produced 32,720 tons of zinc concentrate, an increase of 39 percent. Among other significant zinc producers in Peru were Volcan Mines Co., Cia. Minera Atacocha, Cia. des Mines de Huaron, and Northern Peru Mining Corp.

EUROPE

Austria.—The lead-zinc mines of Austria produced 212,000 tons of crude ore, yielding 14,400 tons of zinc concentrates containing 7,250 tons of recoverable zinc.

Bulgaria.—The lead-zinc mines of Bulgaria mined 3,058,600 tons of ore to produce the estimated 64,800 tons of contained zinc in concentrates. Enlargements and improvements to the mines and flotation plants in the Rhodope Mountains were in progress.[22]

Norway.—Norske Sing og Blygruber A/S announced that mining of Mofjellet ore would begin at an annual 70,000-ton rate in 1960 and would be increased to a 92,000-ton rate by 1962. Production from the Bleivassli mine was estimated to be 107,000 tons of ore.[23]

Germany, West.—Output of lead and zinc concentrates from the Rammelsberg mine in the Harz Mountains contributed about 40 percent of the combined lead-zinc production in West Germany. After

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[19] The Fresnillo Co., Annual Report, 1960, pp. 10–13.
[20] St. Joseph Lead Co., Annual Report, 1960, pp. 10–11.
[21] Cerro Corp., Annual Report, 1960, pp. 11–12.
[22] Mining Journal (London), vol. 256, No. 6552, Mar. 17, 1961, p. 308.
[23] Canadian Mining Journal, vol. 81, No. 8, August 1960, p. 119.

nearly 1,000 years of continuous mining, reserves were estimated at 5 million tons of high-grade ore and 4 to 5 million tons of low-grade ore.[24]

Poland.—Zinc continued to be the major nonferrous metal produced in Poland; output increased about 4 percent. Planned expansion for 1965 will increase production 30 percent. Mines were operated at Marchlewski, Olkusz-Chrzanow, Orzel Bialy, and Trzelionka; zinc refineries were at Liping, Trzebinia, Bolslaw, Welnowice, Szopienice, and Kunegunde. A plant near Katowice, to operate largely from zinc in slag dumps, was scheduled to begin production in 1964 and reach full capacity in 1966.[25]

Spain.—Two new smelters with an annual capacity of approximately 20,000 tons of slab zinc and a second with about 16,000 tons of capacity were placed in operation. The new smelter capacity will make Spain an exporter of zinc metal, and exports of zinc ores will decrease.[26]

United Kingdom.—The British Government, through the Board of Trade, announced that it was offering for sale about 1,100 tons of Special High grade and 700 tons of High grade zinc for delivery and pricing between October 1960 and March 1961.[27]

A new furnace of the Imperial Smelting process design was placed in operation in the second quarter of the year at the Swansea plant. This is a larger unit than the one previously installed at the Avonmouth plant.[28]

Yugoslavia.—Production from the new lead-zinc mine of Suplia Stijena in northern Montenegro increased zinc output from this district. A number of new mines were scheduled to begin production in northern Macedonia; the ores were to be treated at the nearby Trepca smelters.[29]

ASIA

Burma.—Burma Corp., Ltd., continued to operate the Bawdwin lead-zinc-silver mine in the Shan States of northern Burma. The hoist servicing the lower levels of the mine required rebuilding, and its use was restricted during the latter part of the year, thus reducing mine capacity.

India.—A license was granted to the Metal Corporation of India, Ltd., to construct an electrolytic zinc plant with a capacity of 15,000 tons of slab zinc annually. The plans were to build the plant at Udaipur (Rajasthan) based upon the lead-zinc-silver deposits of the Zawar mines. An agreement was made for technical and financial assistance from Société Miniere et Metallurgique de Penarroya of Paris.[30]

Japan.—Expansion projects underway or planned by Japanese zinc mine producers will approximately double the existing slab-zinc capacity. The new facilities were expected to be completed in 1965.

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[24] Huttle, J. B., Nearly 1,000 Years of Mining at Rammelsberg: Eng. Min. Jour., vol. 161, No. 10, October 1960, pp. 97–103.
[25] Mining Journal (London), Annual Review, May 1961, p. 257.
[26] Metal Bulletin (London), No. 4493, May 6, 1960, p. 15.
[27] Metal Industry (London), vol. 97, No. 11, Sept. 9, 1960, p. 214.
[28] Mining World, vol. 22, No. 12, November 1960, p. 74.
[29] Mining Journal (London), Annual Review, May 1961, p. 265.
[30] Journal of Mines, Metals, and Fuels (Calcutta), vol. 8, No. 9, September 1960, pp. 22–23.

Korea, North.—An electrolytic zinc plant having an annual slab-zinc capacity of 40,000 tons was completed at the Munpchen Metal Works in North Korea and placed in operation.[31]

Philippines.—Surigao Consolidated Mining Co., Inc., exported 1,206 tons of 51-percent zinc concentrate to the United States, the first consignment of some 15,000 tons contracted to be delivered.[32]

AFRICA

Algeria.—Société Algérienne du Zinc [33] reported that its mine across the border from Bou Beker, Morroco, operated with only minor interruptions throughout the year. The ore reserve continued to decrease by about the quantity mined, and about 2 years' reserve at the current rate remained. Exploration beyond the mining area disclosed some encouraging mineralization.

Congo, Republic of the.—The Price Leopold copper-zinc mine of the Union Minière du Haut Katanga near Elisabethville supplied 1,038,000 tons of ore for milling at the Kipushi concentrator to produce 193,000 tons of zinc concentrate, containing 56.57 percent zinc. A subsidiary of the company roasted 138,900 tons of the concentrate, producing sulfuric acid for ore treatment and 114,100 tons of sintered concentrate. During the year, 93,000 tons of roasted concentrate was sold to Societe Metallurgique du Katanga (Metalkat) for electrolytic processing, and 96,400 tons of crude and sintered concentrate was shipped to Belgium.

Rhodesia and Nyasaland, Federation of.—At Broken Hill, the Rhodesia Broken Hill Development Co., Ltd.,[34] mined 221,300 tons of crude ore. The heavy-medium separation plant treated 150,900 tons of ore to recover 115,600 tons of sink product that was part of the 183,400 tons of feed for the sulfide flotation plant. The flotation plant produced 52,400 tons of zinc concentrate containing 56.1 percent zinc. The leach plant treated 106,200 tons of feed material composed of calcines, flotation plant tailings, and zinc silicate ore, averaging 38.2 percent zinc. Leach solution and calcined concentrate were processed in the company electrolytic plant to yield 32,370 tons of slab zinc. An additional 618 tons of slab zinc was recovered from 1,800 tons of treated smelter dross. Zinc concentrate stockpiling continued, pending completion of the new Imperial vertical-furnace smelter expected to be in operation early in 1962.

South-West Africa.—Tsumeb Corp., Ltd., mined and milled 614,000 tons of ore, averaging 24 percent combined copper, lead, and zinc during the year ending June 30, 1960. The company sold zinc concentrate containing 24,900 tons of zinc during the year. Tsumeb's ore reserve above the 30th level was 7.9 million tons, averaging 4.47 percent zinc. Probable ore in the next 500 feet below the 30th level was estimated at 3 million tons, averaging 2.3 percent zinc.[35]

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[31] Metal Bulletin (London), No. 4580, July 1, 1960, p. 21.
[32] Mining News Letter (Philippines), vol. 11, No. 5, May–June 1960, p. 242.
[33] Newmont Mining Corp., Annual Report, 1960, p. 16.
[34] The Rhodesia Broken Hill Development Co., Ltd., Annual Report, 1960, 19 pp.
[35] American Metal Climax, Inc., 1960 Annual Report, p. 27.

OCEANIA

Australia.—The Broken Hill district of New South Wales continued to be the leading Australian zinc-producing area. Mining companies operating were New Broken Hill Consolidated, Ltd.; Consolidated Zinc Corp., Ltd.; Broken Hill South, Ltd.; and North Broken Hill, Ltd. Estimated output in the district was 2,200,000 tons of crude ore, yielding about 455,000 tons of concentrate averaging 52 percent zinc plus some lead and silver.

During the fiscal year ending June 30, 1960, Mount Isa Mines, Ltd., milled 3,011,000 tons of silver-lead-zinc ores from its properties in the Cloncurry district of Queensland. Production of zinc concentrate amounted to 37,698 tons, containing 19,604 tons of zinc.[36] Equipment was acquired for planned additions to the mill and for sinking a new 24-foot diameter shaft. The Queensland Government progressed with studies for rehabilitating the Townsville Mount Isa Railway, and construction was to start in 1961.

Lake George Mines, Pty., Ltd., during the fiscal year ended June 30, 1960, mined and milled 220,000 tons of zinc-lead-copper ore in the Captain's Flat district of New South Wales and produced 33,200 tons of zinc concentrate containing 18,800 tons of zinc.[37] The exploration program, virtually concluded by the end of the fiscal year, failed to disclose economic extensions of existing ore bodies or new ore bodies. Future operations were to be limited to mining the remaining reserve estimated at 590,000 tons.

For the fiscal year ended June 30, 1960, the Electrolytic Zinc Co. of Australasia, Ltd., milled 220,000 tons of ore from its mines in the Read-Rosebery district. The ore yielded 66,000 tons of zinc concentrate containing 55 percent zinc and lesser quantities of lead and copper concentrates. The zinc concentrates from this district and the Broken Hill district were treated at the company Risdon electrolytic plant to produce 132,000 tons of slab zinc, the largest recorded output. Construction proceeded to increase slab-zinc capacity. Part of the expansion was for treating zinc plant residues to produce the required additional feed to the zinc plant.[38]

TECHNOLOGY

The American Zinc Institute sponsored an expanded research program to promote the utilization of zinc. Included in the program were studies on the use of powder metallurgy for improved wrought zinc alloys, galvanizing behavior on commercially produced steel sheet materials, resistance spot welding of galvanized sheets, and effectiveness of zinc anodes for cathodic protection of steel under marine conditions.

Several papers reported research by the Federal Bureau of Mines[39] and Geological Survey.[40]

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[36] American Smelting and Refining Company, Annual Report, 1960, pp. 14–15.
[37] Lake George Mining Corp., Ltd., Annual Report, 1960, 16 pp.
[38] E Z Industries, Ltd., Annual Report, 1960, 24 pp.
[39] Powell, H. E., Beneficiating a Complex Sulfide-Oxide Lead-Zinc Ore From Missouri: Bureau of Mines Rept. of Investigations 5564, 1960, 10 pp.
Engel, A. L., and Heinen, H. J., Experimental Treatment of Base-Metal Ores From California and Nevada: Bureau of Mines Rept. of Investigations 5566, 1960, 9 pp.
McWilliams, John R., and Erickson, Eric G., Methods and Costs of Shaft Sinking in the

The Exide Industrial Division of Electric Storage Battery Co. announced that they had developed an advanced type of fuel cell in which zinc is oxidized in a potassium hydroxide electrolyte as oxygen is admitted under low pressure. The use of economical materials, simplicity of design, and ability to be recharged were expected to overcome the major shortcomings of previously announced experimental devices of this type, and the company entered into agreements with 12 equipment manufacturers to develop jointly an adaptation of this fuel cell to power electric industrial trucks.

The U.S. Naval Research Laboratory in Washington, D.C., reported that a liquid layer of zinc on columbium is effective in preventing oxidation of the columbium at temperatures above 2,000° F.

Patents issued included a zinc nitrate-chromic acid treatment for corrosion resistance of zinc; [41] use of zinc mercaptides in preparing a lubricating grease; [42] a process to produce zinc selenide; [43] a process to prepare a zinc brightening agent; [44] and two processes for recovering zinc metal from zinc residues, skimmings, and drosses.[45] [46]

General Telephone and Electronics Laboratories determined a relationship [47] between zinc sulfide luminescence emission under ultraviolet light and the newly formed surface in ball milling and also reported research [48] on utilization of zinc compounds in luminescent materials.

Webb & Knapp Strategic Corporation was developing [49] and testing the Strategic-Udy process to recover iron, copper, and zinc from copper smelter slag at Anaconda, Mont. The proposed 1,000 ton-per-day steel plant would yield 150 pounds of zinc oxide for each ton of steel produced.

(Footnotes Continued)

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[41] Francis, Howard T., and Roebuck, Frank H. (assigned to National Steel Corp.), Process for Treating Metals and Product: U.S. Patent 2,964,432, Dec. 13, 1960.

[42] Millikan, Allen F., and Franczak, Ernest T. (assigned to the Pure Oil Co.), Method of Preparing Zinc Mercaptides and Methods of Preparing a Grease Containing Zinc Mercaptides: U.S. Patent 2,963,434, Dec. 6, 1960.

[43] Zalm, Pieter (assigned to American Philips Co., Inc.), Method of Producing Zinc Selenide: U.S. Patent 2,929,678, Mar. 22, 1960.

[44] Wernlund, Christian J. (assigned to E. I. du Pont de Nemours & Co., Inc.), Zinc Plating: U.S. Patent 2,928,800, Mar. 15, 1960.

[45] Wainer, Eugene (assigned to Horizons, Inc.), Zinc Recovery: U.S. Patent 2,936,233, May 10, 1960.

[46] Wainer, Eugene (assigned to Horizons, Inc.), Metallurgy of Zinc: U.S. Patent 2,936,234, May 10, 1960.

[47] Kremheller, A., Faria, S., and Levine, A. K., Study of Ball Milling and the Determination of Lattice Chloride in Zinc Sulfide: Jour. of Electrochem. Soc., vol. 107, No. 9, September 1960, p. 753-758.

[48] Harrison, D. E., Relation of Some Surface Chemical Properties of Zinc Silicate Phosphor to Its Behavior in Fluorescent Lamps: Jour. of Electrochem. Soc., vol. 107, No. 3, March 1960, pp. 210-217.

[49] Steel, vol. 147, No. 23, Dec. 5, 1960, p. 63.

Zirconium and Hafnium

By F. W. Wessel[1]

ZIRCONIUM SPONGE production reached a record high in 1960. The Australian zircon surplus remained untouched during the year, while the Union of South Africa acquired a larger portion of the United States market. Hafnium production increased, but the metal was still in tight supply. Refractories required a larger share of the available zircon.

LEGISLATION AND GOVERNMENT PROGRAMS

The General Services Administration sold 1,797 tons of zircon from the national stockpile during the year.

The Atomic Energy Commission (AEC) renewed its contract for hafnium conversion with the Wah Chang Corp. and placed a second contract with that company for direct production of hafnium. The AEC also contracted with Nuclear Materials and Equipment Corp., Apollo, Pa., for production of hafnium crystal bar.

DOMESTIC PRODUCTION

Mine output of zircon, entirely from Florida, was about the same as in 1959. Zircon was produced by E. I. du Pont de Nemours & Co., Inc., Humphreys Gold Corp., and The Florida Minerals Co. at properties in Trail Ridge, South Jacksonville, and Vero Beach, respectively.

In the last half of 1960, Metal & Thermit Corp. purchased Orefraction Minerals, Inc., which milled and sized zircon for foundry

TABLE 1.—Salient zirconium and hafnium statistics in the United States

	1956	1957	1958	1959	1960
Zircon:					
Production .... short tons..	44,174	[1] 56,802	30,443	([2])	([2])
Price: Dec. 31 .... per short ton..	([2])	$55.00	$41.00	$47.25	$47.25
Imports .... short tons..	31,140	41,692	19,225	54,878	34,280
Price: Dec. 31 .... per short ton..	$58.90	$45.10	$42.00	$44.60	$44.60
Zirconium sponge:					
Production .... short tons..	238	([2])	1,265	1,404	1,423
Price: Dec. 31 .... per pound..	([2])	$7.50	$6.25	$6.25	$6.25
Hafnium: Production .... short tons..	([2])	([2])	[3] 31	[4] 17	[4] 35

[1] Florida only.
[2] Data not available.
[3] Includes metal content of oxide.
[4] Sponge only, estimated.

[1] Commodity specialist, Division of Minerals.

and ceramic uses at Andrews, S.C., and also acted as broker for much of du Pont's production at Trail Ridge.

Production of zirconium sponge amounted to 1,423 short tons, a small increase from the 1,404 tons in 1959. This production was supplied by Reactive Metals, Inc., Carborundum Metals Co., Columbia-National Corp., and Wah Chang Corp.

Columbia-National Corp. resumed production about mid-year, its zirconium metal having satisfactorily met corrosion tests.

The Mallory-Sharon Metals Corp. was placed under management of Bridgeport Brass Co. in January. In May, National Distillers & Chemical Corp. and Sharon Steel Corp., each of which had a one-third interest in Mallory-Sharon, increased their holdings to 60 and 40 percent, respectively; P. R. Mallory & Co., Inc., former holder of the remaining one-third, exchanged its common stock for preferred stock and notes. The company was renamed Reactive Metals, Inc. Its assets included a sponge plant at Ashtabula, Ohio, a melting and fabricating plant at Niles, Ohio, and a fabricating plant at Huntsville, Ala., formerly owned by Johnston & Funk Metallurgical Corp. The Huntsville plant was sold to Wah Chang Corp. later in the year. Bridgeport Brass Co. retained its management functions and its option to purchase Reactive Metals shares.

Production of zirconium ingot was estimated at 2,690,000 pounds, a 62-percent increase from 1959. Leading producers were Harvey Aluminum, Inc., Torrance, Calif.; Reactive Metals, Inc., Niles, Ohio; and Westinghouse Electric Corp., Pittsburgh, Pa.

The Wolverine Tube Division of Calumet & Hecla, Inc., completed construction of its fabricating facility in Inkster, Mich., and scheduled initial operation for January 1961.

Chase Brass & Copper Co. (Waterbury, Conn.), Harvey Aluminum, Inc. (Torrance, Calif.), and Superior Tube Co. (Norristown, Pa.) also produced zirconium tubing during the year.

Union Carbide Metals Co. and Vanadium Corporation of America continued production of zirconium ferroalloys. Reflecting a low steel-production rate, ferroalloy production declined 10 percent in 1960.

The four zirconium sponge producers also produced 125,691 pounds of hafnium oxide. An estimated 70,000 pounds of hafnium sponge was made and shipped for refining. Nuclear Materials and Equipment Corp. contracted with AEC to produce crystal-bar hafnium. The AEC also allotted 7,000 pounds of sponge hafnium to Wah Chang and Reactive Metals for melting and purification in the electron-beam furnace on a trial basis.

Various melters and fabricators generated an estimated 400,000 pounds of scrap zirconium and drew from inventory to return 550,000 pounds to ingot production.

Norton Co. and Titanium Alloy Manufacturing Division, National Lead Co., major producers of zirconium oxide, were joined by the Harbison-Carborundum Corp., Falconer, N.Y. Total domestic oxide produced was 13,813,000 pounds.

Production of zircon and zirconia refractories totaled 24,862 short tons. Major producers were Corhart Refractories Co., at Corning, N.Y., and Louisville, Ky.; Harbison-Carborundum Corp.; and The Chas. Taylor Sons Co., Cincinnati, Ohio.

Stauffer Chemical Co. produced raw zirconium tetrachloride in the Niagara Falls, N.Y., area; Kawecki Chemical Co. produced potassium zirconium fluoride at Boyertown, Pa.; and Titanium, Zirconium Co. made various zirconium chemicals at Flemington, N.J.

CONSUMPTION AND USES

Apparent consumption of zircon in the United States in 1960 was about 89,000 tons. This quantity was distributed approximately as follows:

	Percent
Ceramic and foundry zircon, crude or milled	52.0
Refractories	20.5
Metal and alloys	11.0
Chemical and ceramic compounds, and abrasives	9.0
Oxide	7.5
	100.0

Consumption of zirconium ingot was 1,529,000 pounds; Reactive Metals, Inc., Jessop Steel Co., and Westinghouse Electric Corp. were the principal fabricators.

Nuclear energy reactor construction remained essentially the sole use for both zirconium and hafnium. A nuclear-powered submarine fleet accounted for the major portion of the metals consumed, and a significant quantity went into components for reactors at Hanford, Wash., and Hallam, Nebr.

Atomics International Division, North American Aviation Corp. designed a zirconium-uranium hydride fuel element into the Systems for Nuclear Auxiliary Power (SNAP–II) reactor, intended for use in space vehicles. The company also initiated studies of the applicability of zirconium hydride-moderated reactors to large-scale power generation. A 300,000-kilowatt reactor is estimated to need 35,000 pounds of zirconium hydride.

Minor uses of zirconium as laboratory ware and in chemical processing were also introduced during the year.

STOCKS

Dealer stocks of zircon concentrate increased again to about 4,474 tons, but consumer inventories decreased to 15,554 tons from 21,480 tons (revised figure) in 1959. Inventories of zirconium sponge and ingot were 2,916,000 and 1,167,000 pounds, respectively.

PRICES AND SPECIFICATIONS

There was no price change for any major zirconium commodity during 1960. Domestic zircon sold at $47.25 per short ton f.o.b. mines at Starke, Fla.; imported zircon at $50 per long ton, c.i.f. Atlantic ports. The Nigerian high-hafnium zircon, containing 3.20 percent HfO_2 and 53.02 percent ZrO_2, continued to bring $150 per short ton. Australian zircon sold for £15 15s. per long ton on the London market at yearend.

Reactor-grade zirconium sponge remained at $6.25 to $6.50 per pound. Prices of other forms of metal and of ferroalloys remained unchanged.

FOREIGN TRADE[2]

Imports.—Imports of zircon decreased 38 percent to 34,280 short tons in 1960. The decrease was entirely in Australian shipments, as imports from Nigeria and the Union of South Africa increased sharply.

Imports of 107 short tons of zircon from Denmark early in the year were unofficially but credibly reported. This material may have originated at Denmark's new black-sand operation.

TABLE 2.—U.S. imports for consumption of zircon, by countries

(Short tons)

Country	1951–55 (average)	1956	1957	1958	1959	1960
Australia [1]	23,079	30,351	41,659	19,175	53,650	29,183
Brazil [2]	1,644	331	-----	-----	-----	-----
Canada [3]	-----	303	14	-----	24	2
Nigeria	-----	-----	-----	50	868	1,850
Union of South Africa	-----	-----	-----	-----	280	3,133
United Kingdom [3]	-----	155	19	-----	56	112
Total: Quantity	24,723	31,140	41,692	19,225	54,878	34,280
Value	[4] $633,355	$791,612	$1,142,472	$467,391	$1,517,485	$1,233,815

[1] Imports from Australia through 1954 were partly in the form of mixed concentrate containing small quantities of rutile and ilmenite.
[2] Concentrate from Brazil includes some baddeleyite.
[3] Believed to be country of shipment rather than country of origin.
[4] 1954 data known to be not comparable with other years.

Source: Bureau of the Census.

Exports.—Exports of zircon in 1960 totaled 1,382 short tons; 724 tons went to Canada, 173 tons to Mexico, 169 tons to Colombia, and 316 tons to other countries. Total value of these shipments was $316,663, or about $229 per ton. Zircon reexported (all to Canada and Mexico) totaled 648 short tons.

Exports of 498 tons of crude metal, alloy, and scrap, valued from $0.85 to $44 per pound, were reported, principally to the United Kingdom. Total value of these was $1,679,362. Semifabricated forms weighing 35 tons and valued at $928,006 were exported principally to Canada and the United Kingdom.

WORLD REVIEW

Australia.—The Australian Mineral Sands Producers' Association met several times during the year, seeking to raise the price of rutile and zircon by about 20 percent. Voluntary output restrictions were proposed, but the conferences reportedly came to no uniformly satisfactory conclusion.

Important quantities of zircon remained unsold in stockpiles at the beginning of the year. Producers of ilmenite in Western Australia stockpiled semifinished rutile and zircon.

Brazil.—A uraniferous zircon deposit at Poços de Caldas was drilled and sampled; the ore was intended for a sodium uranite plant soon to be built.

[2] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 3.—Free world production of zirconium ores and concentrates by countries [1]

(Short tons)

Country	1951-55 (average)	1956	1957	1958	1959	1960
Australia	42,393	81,153	99,188	66,381	127,015	[2] 114,000
Brazil [3]	3,825	2,863	1,799	10,471	[4] 50	(5)
Egypt	127	402	45	[2] 45	3,000	(5)
India	1	3	10	10	[2] 10	[2] 10
Malagasy Republic (Madagascar)	[6] 1		1	58	50	[2] 100
Malaya, Federation of		[4] 51	[4] 47	[4] 28	130	63
Nigeria (U.S. imports)				50	868	1,850
Senegal, Republic of	418	1,268	3,197	6,057	9,557	11,408
Union of South Africa				1,129	5,924	[2] 7,000
United States	24,461	44,174	[7] 56,802	[8] 30,443	(9)	(9)

[1] This table incorporates some revisions.
[2] Estimate.
[3] Chiefly baddeleyite.
[4] Exports.
[5] Data not available.
[6] Average for 1952-55.
[7] Includes Florida only.
[8] Excludes Idaho.
[9] Figure withheld to avoid disclosing individual company confidential data.

Compiled by Augusta W. Jann, Division of Foreign Activities.

Malagasy Republic.—A company formed late in 1959 to exploit sand deposits prepared to treat 100,000 tons of sand annually, producing 1,500 tons of zircon in addition to monazite and ilmenite. Pilot-plant operations began in March.

U.S.S.R.—A mineral containing 30 percent zirconium and named vlassovite, reportedly a new species, was discovered on the Kola Peninsula, presumably in the lovozerite formation.

United Kingdom.—Vickers-Armstrongs, Ltd., will manufacture and sell the General Dynamics TRIGA reactor in the British Isles. The uranium-zirconium hydride fuel elements will continue to be supplied by General Dynamics Corp.

By special exception to a previous Treasury order, zirconium sponge was admitted duty free during the year.

A new company, Upsil, Ltd., was organized to distribute to the British market various Pechiney products, including zirconium.

TECHNOLOGY

A method for flotation of zircon was developed in Australia.[3] A recovery of 81 percent was achieved by using a saturated soap in an alkaline circuit.

A hafnium-zirconium separation method developed by the AEC at Oak Ridge, Tenn., was patented;[4] methyl isobutyl ketone was the organic solvent used.

A discussion of recovery of various forms of zirconium scrap, an economic necessity as long as the 5:1 conversion ratio exists, was published.[5] Reclaiming light scrap, however, remained a problem.

[3] Subramanya, G. V., Selective Flotation of Zircon From Beach Sands: Jour. of Mines, Metals, and Fuels, vol. 8, No. 7, July 1960, pp. 47–48.
[4] Overholser, L. G., Barton, C. J., Sr., and Ramsey, J. W. (assigned to the United States as represented by the Chairman of the AEC), Separation of Hafnium from Zirconium: U.S. Patent 2,938,269, May 31, 1960.
[5] Rubin, B. F., and Gessner, R. F., Recycling Zircaloy Scrap: Metal Prog. vol. 77, No. 4, April 1960, pp. 97–100.

Some results of research on hafnium reduction by the Federal Bureau of Mines were presented.[6] Reduction of hafnium with a combination of sodium and magnesium, was found to be superior to the use of magnesium alone. The Bureau also published a comprehensive bibliography of hafnium, which contained 670 references.[7]

Research at Pennsylvania State University led to publication of a study of equilibria in the system zirconia-thoria-uranium dioxide.[8]

Research by Wah Chang Corp. personnel resulted in development of a fused-salt purification method for crude hafnium tetrachloride.[9]

In addition, much research effort was expended in the field of evaluation of alloys of zirconium and hafnium, with particular stress on corrosion.

Ceramic engineers at the University of Illinois developed a zircon coating for application as an oxidation shield to tungsten at temperatures up to 3,000° F.

Hafnium carbide, developed as a high-temperature ceramic material, was shaped by the hot-press method to 98-percent theoretical density.

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[6] Elger, G. W., Bimetallic Reduction of Hafnium Tetrachloride: Bureau of Mines Rept. of Investigations 5633, 1960, 17 pp.

[7] Abshire, E., and Notestine, S., Bibliography of Hafnium: Bureau of Mines Inf. Cir. 7928, 1960, 30 pp.

[8] Mumpton, F. A., and Roy R., Low-Temperature Equilibria Among ZrO_2, ThO_2, and UO_2: Jour. Am. Ceram, Soc., vol. 43, No. 5, May 1, 1960, pp. 234–240.

[9] Fairgrieve, D. S., and Fortner, J. W., Production and Purification of High-Purity Hafnium: Jour. Metals, vol. 12, No. 1, January 1960, pp. 25–26.

Minor Metals

By F. W. Wessel,[1] Donald E. Eilertsen,[1] Frank L. Fisher,[2] Don H. Baker,[1] John G. Parker[1]

Contents

CESIUM AND RUBIDIUM[3]

THE pegmatite deposit at Bernic Lake, Manitoba, Canada, is a major source of cesium. The deposits are adequate to meet North American needs in the foreseeable future. U.S. imports of pollucite and the production of cesium, rubidium, and compounds containing these metals sharply increased.

Domestic Production.—No ores were mined for cesium and rubidium in the United States during 1960. San Antonio Chemicals, Inc., San Antonio, Tex., continued to produce Alkarb from a diminishing stockpile of residues accumulated from the treatment of African ores for lithium. The stockpile was expected to be exhausted early in 1961.

American Potash & Chemical Corp., Trona, Calif.; Penn Rare Metals, Inc., Revere, Pa.; Fairmount Chemical Co., Inc., Newark, N.J.; and U.S. Industrial Chemicals Co., Cincinnati, Ohio, produced a total of 175 pounds of cesium and rubidium metal. American Potash & Chemical Corp., Penn Rare Metals, The Dow Chemical Co., Midland, Mich., and Maywood Chemical Works, Maywood, N.J., produced 5,922 pounds of cesium and rubidium compounds.

In mid-1960, Penn Rare Metals, Inc., was purchased by Kawecki Chemical Co. Two companies announced their entry into the cesium-rubidium market as suppliers; they were Trionics Corp., a subsidiary of Motor Products Corp., Detroit, Mich., and MSA Research Corp., Callery, Pa.

Consumption an Uses.—The glass and ceramic industries, by their use of Alkarb, continued to use most of the cesium and rubidium.

Research on using cesium in plasma thermocouples for the direct generation of alternating current, sponsored by several western electric

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[3] Prepared by F. W. Wessel.

power companies, was conducted throughout the year by General Atomics Division, General Dynamics Corp., San Diego, Calif. Laboratories of the National Aeronautics and Space Agency (NASA) continued development of an ion engine in which cesium ions are ejected to produce thrust. The Rocketdyne Division of North American Aviation, Inc., was doing similar work under contract with the U.S. Navy Department.

Prices.—Pollucite ores from Canada and the Federation of Rhodesia and Nyasaland sold at $360 to $420 per short ton, delivered.

Small quantities of cesium and rubidium were priced at $4 to $5 per gram for chemically pure material, and $1.40 and $1.10, respectively, for 99+ percent metal. Ten-pound lots were sold for $540 per pound for cesium, and $390 for rubidium.

Chemically pure compounds of both metals were priced at from $0.40 to $1.00 per gram. Technical grade compounds sold at $13 to $17 per pound for rubidium salts and $27.50 to $36 for cesium salts. Alkarb closed the year at $126.50 per ton in bulk carlots.

Foreign Trade.—During 1960, domestic consumers imported 29,000 pounds of pollucite in almost equal amounts from Canada and Rhodesia.

World Review.—Chemalloy Minerals, Ltd., formerly Montgary Explorations, Ltd., continued developing its mine at Bernic Lake, Manitoba, Canada, and began shipping pollucite. The ore was expected to average 27 percent Cs_2O.

Lithium Corporation of Canada announced plans to conduct further exploration of its property in the Bernic Lake area.

Bikita Minerals, Ltd., explored and developed a beryl-spodumene-pollucite deposit in Southern Rhodesia. Products were to be marketed in the United States by American Potash & Chemical Corp.

Technology.—An article on an operation at Bernic Lake, Manitoba, Canada, described the geology of the pegmatite deposit, gave the history of its development, and discussed cesium's uses.[4]

Results of laboratory studies showed the possibility of extracting radioactive cesium by first complexing it with heavy-metal ferrocyanides and then separating it by foam flotation.[5]

Additional research on extraction and control of cesium 137 was published; extraction was said to be improved by the use of ethyl alcohol.[6]

In connection with studies of oxide films on metals, research at Oak Ridge National Laboratory developed some physical chemistry data on rubidium.[7]

A method of determining the presence of cesium and rubidium in rocks was developed by the Federal Bureau of Mines[8] and can be used in the field. The method, based on reactions with molybdenum salts, is sensitive enough to detect these metals in concentrations as low as 60 parts per million.

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[4] Brinsmead, R., Manitoba Mine: Precambrian—Mining in Canada, vol 33, No. 8, August 1960, pp. 18-35.

[5] Pushkarev, V. V., Skrylev, L. D., and Bagrestsov, V. F., (Extraction of Radioactive Cesium with Mixed Heavy Metal Ferrocyanides): Jour. Appl. Chem. USSR, vol. 33, No. 1, January 1960, pp. 78-81.

[6] Lima, F. A., Abrao, A., and Pagano, C., Removal and Recovery of Cesium-137 from Swimming Pool Reactor Water: Ind. Eng. Chem., vol. 52, No. 2, February 1960, pp. 147-148.

[7] Cathcart, J. V., and Smith, G. P., Oxidation Rates of K and Rb between—79° C and —20° C: Jour. Electrochem. Soc., vol. 107, No. 2, February 1960, pp. 141-142.

[8] Dean, K. C., and Nichols, I. L., Field Test for Cesium and Rubidium: Bureau of Mines Rept. of Investigations 5675, 1960, 9 pp.

GALLIUM[9]

Domestic Production.—Aluminum Company of America, East St. Louis, Ill., produced gallium metal, and The Eagle-Picher Co., Miami, Okla., produced gallium metal, gallium sesquioxide, and gallium arsenide. Domestic gallium production and shipments for the year were the largest ever reported. Production and shipments each continued to be measurable in hundreds of pounds.

Uses.—Small uses existed for gallium, such as sealant material for glass joints and valves in vacuum equipment, backing material for optical mirrors, and material in thermometers and low melting alloys. Interest increased in potential new electronic uses for certain gallium compounds. Gallium arsenide was used for optical work, infrared devices, transducers, and tunnel diodes. Gallium arsenide tunnel diodes, which can be operated at frequencies above 4,000 megacycles, and can withstand high temperatures and much more nuclear radiations than transistors, were made available for many possible uses including space-vehicle communication systems, fast computers, and radar receivers. Gallium phosphide was also available for small rugged electronic devices for possible uses in missiles, satellites, and space vehicles. Gallium garnets were available for application in low frequencies of the microwave region.

Prices.—Market prices per gram of standard, intermediate, and high-purity gallium were as follows:

Quantity	99.99 percent	99.999 percent	99.9999 percent
Up to 100 grams	$2.25	$2.50	$3.00
100 gram lots	1.80	2.00	2.75
1,000 gram lots	1.60	1.85	2.60

Technology.—Fabrication techniques, electrical properties, and uses for gallium arsenide diffused diodes were described.[10] Techniques consisting of relatively low-temperature vapor phase reaction between phosphorus and gallium suboxide (Ga_2O) were developed to produce gallium phosphide crystals or whiskers of greater purity than crystals made by earlier methods.[11] Arsenides and phosphides of gallium or indium were produced by the following chemical methods: By continuous-flow vapor phase reaction in the presence of unreactive carrier gas; by direct reaction in the liquid phase; by passing AsH_3 or PH_3 into the molten chlorides; and by replacement reaction starting with $AsCl_3$ or PCl_3 and the metal.[12] Processes were patented for purifying gallium by bringing impure molten gallium in contact with ammonia and nitrogen[13] or with hydrochloric acid and

[9] Prepared by Donald E. Eilertsen.
[10] Lowen, J., and Rediker, R. H., Gallium-Arsenide Diffused Diodes (Lincoln Laboratory, Mass. Institute of Tech.): Jour. Electrochem. Soc., vol. 107, No. 1, January 1960, pp. 26–29.
[11] Chemical and Engineering News, Vapor Reaction Makes Gallium Phosphide: Vol. 38, No. 16, Apr. 18, 1960, p. 72.
[12] Effer, D., and Antell, G. R., Preparation of InAs, InP, GaAs, and GaP by Chemical Methods: Jour. Electrochem. Soc., vol. 107, No. 3, March 1960, pp. 252–253.
[13] Merkel, Hans, Erlangen, Germany (assigned to Siemens-Schuckertwerke Aktiengesellschaft, Berlin-Siemensstadt, Germany), Method and Apparatus for Producing Spectrally Pure Gallium: U.S. Patent No. 2,927,853, Mar. 8, 1960.

chlorine.[14] A comprehensive bibliography on gallium was published.[15]

GERMANIUM[16]

Germanium production and consumption continued to increase as more widespread and diverse applications for the element were adopted by the expanding electronic industry.

Domestic Production.—Production of germanium was geared to consumption, and an estimated 54,000 pounds of germanium from raw material was produced and consumed. An additional unknown quantity was available to the electronic industry from scrap metal sources. A significant quantity of the germanium produced in the United States is derived from germanium-bearing base metal concentrates imported from South-West Africa. Refinements in processing continued to extend the germanium supply. Although the substitution of silicon for germanium in the manufacture of transistors, diodes, and rectifiers continued to increase, a strong demand for germanium still existed.

One new producer, American Metal Climax, Inc., at Carteret, N.J., came into operation to join the Eagle-Picher Co., Miami, Okla.; American Zinc Co., Fairmont, Ill.; and Sylvania Electric Products, Inc., Towanda, Pa. The latter company expanded facilities during the year. Sylvania and American Metal Climax relied on purchased raw material, primarily from foreign sources of supply, and scrap. Eagle-Picher and American Zinc produced germanium as a byproduct of their zinc operations. Each of these companies produced germanium dioxide and several electronic grades of both polycrystalline and single crystal germanium.

Consumption and Uses.—Germanium consumption continued to increase, paralleling the expanding electronic industry. Although the number of transistors, diodes, and rectifiers increased, the quantity of germanium per semiconductor device dropped because of improvements and refinements in processing and manufacturing techniques. Several companies offered germanium tunnel diodes in commercial quantities for the first time. The only significant use of germanium outside the electronic industry was as a color modifier in the manufacture of fluorescent lights.

Prices.—The prices for germanium as quoted in E&MJ Metal and Mineral Markets were unchanged during 1960. This was the first time in several years that the quoted prices for germanium did not decline. The price quotations were:

Grade and quantity:		Price: Cents per gram delivered	Price: Cents per gram f.o.b. shipping point
First reduction	1,000 gram lots	29.5	30.15
Intrinsic quality	do	29.95	31.95
First reduction	10,000 gram lots	29.5	28.15
Intrinsic quality	do	29.95	29.95

[14] Gebauhr, Werner, Erlangen, Germany (assigned to Siemens-Schuckertwerke Aktiengesellschaft, Berlin-Siemensstadt and Erlangen, Germany), Continuous Process for Purifying Gallium: U.S. Patent No. 2,928,731, Mar. 15, 1960.

[15] Bretèque, Pierre, Gallium Bulletin Bibliographique (in French): Aluminum Industrie Aktiengesellschaft, September 1960, 76 pp.

[16] Prepared by Frank L. Fisher.

Germanium dioxide was 16.5 cents per gram in 1960; single crystal germanium was 60.5 cents per gram in 10,000 gram lots, and 68.5 cents per gram in 1,000 gram lots.

Foreign Trade.—Imports of germanium metal and germanium dioxide totaled 24,872 pounds valued at $1,864,010. Of this quantity, 20,568 pounds was imported from Belgium, 4,062 pounds from West Germany, and the remainder from the United Kingdom and Canada. The total did not include 27,326 pounds of low-grade germanium-bearing concentrate from West Germany nor a significant quantity of germanium in germanium-bearing base-metal concentrate imported from South-West Africa.

World Review.—*Belgium.*—The Société Générale Métallurgique at Hoboken and the Sociéte Vielle Montagne at Balen again made Belgium the largest producer of germanium. Raw material for the Belgian industry was obtained from the Republic of the Congo and South-West Africa.

Germany, East.—Production of germanium on a commercial scale was started by VEB Spurnemetalle, Freiburg. Annual capacity of the plant was 2,500 pounds. The germanium was contained in flue dust obtained from the Wilhelm Pieck metallurgical combine at Mansfeld.

Japan.—Germanium consumption in Japan was estimated at 80,000 pounds.

Technology.—The highlight of germanium research was the development of epitaxially grown germanium crystals by vapor-growth techniques. This iodide dissocation process was a major technological break-through because it provided a simplified method of producing transistors having more accurate and predictable characteristics. The Union Minière du Haut-Katanga installed a Franz ferrofilter for the magnetic recovery of germanium sulfide at its plant at Kipushi, in the republic of the Congo.[17]

INDIUM[18]

Domestic Production.—Indium metal was produced by American Smelting and Refining Company, Perth Amboy, N.J. and by The Anaconda Company, Great Falls, Mont. The first-mentioned firm also produced indium chloride and indium sulfate. In 1960 indium production increased and shipments decreased.

Uses.—The three largest uses for indium were in electronics, bearing alloys, and low-melting alloys. Indium salts were used for plating, and there was continued interest in developing applications for indium arsenide and indium antimonide in electronic devices.

Prices.—The price of indium metal was $2.25 per troy ounce up to 100 troy ounces, $1.65 to $2.25 per troy ounce in 100-troy-ounce lots, $1.55 to $2.25 per troy ounce in 1,000-troy-ounce lots, and $1.25 to $2.25 per troy ounce in lots over 5,000 troy ounces.

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[17] Bouchat, M. A., Detiege, A., and Robert, D., Magnetic Recovery of Germanium Sulfide With The Franz Ferrofilter. AIME Trans. 1960, Preprint No. 60B38, 17 pp.
[18] Prepared by Donald E. Eilertsen.

World Review.—The potential annual indium production of Consolidated Mining & Smelting Co. of Canada, Ltd., Trail, British Columbia was reported to be 1 million troy ounces, or about 35 tons.[19]

Technology.—Indium continued to be one of several metals used in Federal Bureau of Mines research to obtain fundamental information on magnesium-base alloys to develop improved structural compositions.

Purified indium phosphide was produced by first vaporizing indium and phosphoris to produce an impure product that was subsequently revaporized with additional indium.[20] Indium oxide was prepared by controlled evaporation of indium under pressure in the presence of air.[21] The electrical characteristics of high-purity indium antimonide were described.[22]

RADIUM[23]

Domestic radium consumption declined in 1960, and imports of radium and radium salts were about 80 percent of the 1959 imports.

Domestic Production.—Radium was not produced in the United States, and requirements were met by imports of the element and its salts or radioactive substitutes. Principal domestic distributor for radium, its derivatives, and related compounds was Radium Chemical Co., Inc., New York, N.Y. Other firms in the radium industry were Canadian Radium & Uranium Corp., New York, N.Y.; United States Radium Corp., Morristown, N.J.; and A. Bruce Edwards, Philadelphia, Pa. Radium Chemical was sales representative for the Union Minière du Haut Katanga, the world's leading radium producer, and A. Bruce Edwards was sales representative for the Atomic Energy of Canada, Ltd.

Consumption and Uses.—Radium and radium salts were used primarily by industry. The electronic industry used a form of radium-beryllium mixtures as a source of neutrons. The medical profession, in telecuritherapy, used radium's radioactive emissive properties. Radium also was used in industrial radiograph for nondestructive testing of materials; in zinc-sulfide compounds to make self-activated luminous paint; and in radium foil, which was used as an ionizing agent and in static-elimination equipment.

Prices.—Throughout 1960, the price of radium was quoted by E&MJ Metal and Mineral Market at \$16 to \$21.50 per milligram of radium content, depending on the quantity.

Foreign Trade.—Radium and radium salts were imported from Belgium, Canada, and the United Kingdom. The principal source of radium was Belgium, where high-grade uranium ores and slimes from the Republic of the Congo uranium deposits were processed by Union Minière du Haut Katanga.

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[19] Fraser, D. B., Indium: Review 11, Canadian Mineral Industry—1959 (Preliminary), Dept. of Mine and Tech. Surveys, Ottawa, Canada, May 1960, 3 pp.

[20] Weiser, Kurt, (assigned to Radio Corporation of America), Method of Preparing Pure Indium Phosphide: U.S. Patent 2,937,075, May 17, 1960.

[21] Barrett, Robert E., Olson, Earl R., and Schall, Jr., Paul, (assigned to Battelle Development Corporation, Columbus, Ohio) Indium Oxide Coatings: U.S. Patent 2,932,590, Apr. 12, 1960.

[22] Mirgalovskaya, M. S., and Matkova, L. I., Production of High-Purity Indium Antimonide: Zhurnal neorganicheskoy khimii, vol. 5, No. 7, 1960, pp. 1551–54. In: Current Review of Soviet Technical Press, Aug. 26, 1960, p. 4.

[23] Prepared by Don H. Baker, Jr.

TABLE 1.—U.S. imports for consumption of radium salts and radioactive substitutes

Year	Radium salts		Radioactive substitutes, value [1] (thousands)
	Milligrams	Value (thousands)	
1951–55 (average)	94,399	$1,481	$120
1956	43,221	633	[2] 514
1957	76,206	1,061	844
1958	38,419	538	908
1959	32,967	518	1,145
1960	23,333	364	1,394

[1] Includes artificial radioactive isotopes that are not substitutes for radium.
[2] Due to changed tabulating procedures by the Bureau of the Census, data are known not to be comparable with other years.

Source: Bureau of the Census.

RHENIUM [24]

Domestic Production.—Rhenium was produced in the United States by Chase Brass & Copper Co., Inc., Waterbury, Conn., subsidiary of Kenncott Copper Corp., and the Department of Chemistry, University of Tennessee, Knoxville, Tenn. Production and consumption of rhenium was substantially larger than in 1959.

Uses.—Uses for rhenium and rhenium alloys were in the following major categories: Electronic components, including filaments, heaters, and structural components; electrical contacts; thermocouples; filler materials for welding molybdenum and tungsten; and coatings such as those for exhaust nozzles. A significant new use for rhenium-molybdenum alloys was in magnet wire.

Prices.—At the close of the year Chase Brass & Copper Co. quoted the following prices for various materials, minimum order $50: Ammonium perrhenate, $425 a pound up to 5 pounds, and $400 a pound for larger quantities; potassium perrhenate $395 a pound up to 5 pounds, and $370 a pound for larger quantities; first grade rhenium powder, $650 a pound up to 1 pound, and decreasing prices to $580 a pound for lots of 20 or more pounds; rhenium sintered bar (melting stock) $800 a pound up to 1 pound and decreasing prices to $750 a pound for lots of 5 or more pounds. Rhenium strip and wire and molybdenum-rhenium alloy rod and wire (50 percent Mo–50 percent Re and 60 percent Mo–40 percent Re by weight) were also available.

Technology.—The Federal Bureau of Mines at Salt Lake City, Utah, continued research on developing methods to extract rhenium from various molybdenite concentrate and molybdenite roaster fumes. In connection with this work, a laboratory quantitative method to determine less than 1 part per million of rhenium in ores and various metallurgical products was being developed.

Experiments showed that rhenium could be dissolved in tantalum to 48 weight–percent and that the maximum solubility of tantalum in rhenium was 5 weight–percent.[25]

[24] Prepared by Donald E. Eilertsen.
[25] Brophy, J. H., Schwarzkopf, P., and Wulff, J., The Tantalum-Rhenium System: Trans. Met. Soc., AIME, vol. 218, No. 5, October 1960, pp. 910–914.

A few occurrences of rhenium were reported in the U.S.S.R. Observations indicated that molybdenite from high-temperature deposits contained less rhenium than molybdenite from medium-temperature deposits.[26]

SCANDIUM[27]

Emphasis during 1960 was on marketing scandium oxide for research purposes.

Domestic Production.—Union Carbide Metals Co., Niagara Falls, N.Y. produced no scandium in 1960 and apparently the company's hopes for scandium metal had not been borne out by experimental work. The availability of scandium from uranium mill waste liquors appeared to minimize the need for thortveitite as a scandium ore-mineral.

Research Chemicals Division, Nuclear Corporation of America, continued to produce scandium metal. American Scandium Corp., Cincinnati, Ohio, announced in September that it could supply scandium, yttrium and rare-earth metals, alloys, and other compounds. Vitro Chemical Co. continued to produce scandium oxide from concentrate obtained as a byproduct of uranium milling. King Products sold a very small amount of scandium metal, Fairmont Chemical Co., Inc., ceased operation as a supplier of scandium separated from thortveitite, and St. Eloi Corp. was reported to have gone out of business. Motor Products Corp., Detroit, Mich. announced that they would have available high-purity materials, including scandium, yttrium, and rare-earth compounds, for use in electronic devices and advanced electronic research.

Uses.—No commercial market for scandium or its compounds developed during 1960. The metal is comparable in some respects to aluminum, but it is much more like yttrium and the rare-earth metals. It is easily contaminated and loses its desirable properties, such as ductility. High prices restricted its uses exclusively to research projects.

Prices.—Improved process techniques and expanded production facilities led Vitro Chemical Co. to cut the price of scandium oxide by almost 50 percent. The high grade material—99.9 percent pure—sold for $2,850 per pound (reduced from $5,500 per pound) and 99 percent pure scandium oxide sold for $2,700 per pound (formerly $4,995 per pound). Smaller lots were quoted at prices ranging from $6.00 to $8.60 per gram, depending upon lot size and purity of material. Scandium metal prices were relatively unchanged from 1959, ranging from $30 to $60 per gram depending upon purity and lot sizes.

World Review.—It was reported that 2 pounds of scandium had been extracted from waste liquors discarded by Canadian uranium mills and that the pulp concentrate was sold to a United States company for conversion to metal.[28]

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[26] Fleischer, Michael, The Geochemistry of Rhenium-Addendum: Econ. Geol., vol. 55, No. 3, May 1960, pp. 607-609.
[27] Prepared by John G. Parker.
[28] Mining Journal (London), vol. 254, June 3, 1960, p. 651.

Technology.—Two papers published during 1960 described a new method for determining scandium in rocks and meteorites.[29] Scandium and yttrium have been used as internal standards in the spectrographic determination of elements in mixtures of the rare-earth elements.[30]

The research on scandium extraction from organic waste liquids from uranium mills conducted by the Federal Bureau of Mines was similar to that being done at the Port Pirie chemical treatment plant in Australia [31] and to processing methods used by Rio Tinto Dow on waste liquors discarded after extraction of thorium from uranium ores in Ontario, Canada.[32] Bureau of Mines research indicated that several pounds a day of scandium could be recovered from the domestic uranium mills that employ acid leach circuits.

At the Ames Laboratory of the U.S. Atomic Energy Commission, pure scandium metal was produced by calcium reduction of the fluoride by two methods—a low-temperature alloy process and a direct-reduction process with subsequent distillation of the product. Among the properties of the metal determined were: Atomic structure, hexagonal; atomic volume, 15.03$\pm$4 cc.; calculated density at room temperature, 2.990$\pm$0.007 g. cc.; electrical resistivity at room temperature, 66.6$\pm$0.2 x 10^{-6} ohm-cm.; thermal coefficient at room temperature, 5.4 x 10^{-8} ohm-cm. degree; and melting point, 1,539° C. $\pm$2°.[33]

Scandium diboride, supposedly a good substitute for chromium diboride as a component of light heat-resistant alloys, was made in the U.S.S.R. using powder metallurgy methods.[34]

SELENIUM[35]

Production, consumption, and imports of selenium dropped sharply in 1960, to a level slightly lower than the 1951–55 average. The decrease in demand was partly attributed to a shift away from selenium's use in the manufacture of dry-plate rectifiers. This important use had accounted for half the annual production in recent years. Producers' stocks of selenium-bearing slimes and residues generated by electrolytic copper separation showed a marked increase.

Selenium was designated by the President as eligible for acquisition under the 1960 barter program of the U.S. Department of Agriculture, Commodity Credit Corporation (CCC).

Domestic Production.—Primary selenium production dropped 179,000 pounds to 620,000 pounds, the lowest production in 9 years. Part of the decrease resulted from an attempt to adjust production to the drop in demand from 1959. The supply from secondary sources was about 5 percent.

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29 Bate, George L., Potratz, Herbert August, and Huizenga, John R., Scandium, Chomium, and Europium in Stone Meteorites by Simultaneous Neutron Activation Analysis: Geochimica et Cosmochimica Acta, vol. 18, January 1960, pp. 101–107.
Kemp, D. M., and Smales, A. A., The Determination of Scandium in Rocks and Meteorites by Neutron-Activation Analysis: Analytica Chimica Acta (Amsterdam) vol. 23, No. 5, November 1960, pp. 410–418.

30 Melamed, Sh. G., Polyakov, S. N ., and Zemskova, M. G., [The Spectral Analysis of Rare-earth Elements]: Zavodskaia Laboratoriia, vol. 26, 1960, pp. 554-556; Nuclear Sci. Abs., vol. 14, No. 19, Oct. 15, 1960, p. 2423.

31 Chemical Age (London), vol. 83, No. 2122, Mar. 12, 1960, p. 458.

32 World Mining, vol. 13, No. 9, August 1960, p. 66.

33 Spedding, F. H., Daane, A. H., Wakefield, G., and Dennison, D. H., Preparation and Properties of High Purity Scandium Metal: Trans. Met. Soc., AIME, vol. 218, No. 4, August 1960, pp. 608–611.

34 Samonsov, G. V., Akademiia nauk SSSR Doklady, vol. 133, No. 6, 1960, pp. 1344-1346; Current Rev. of Soviet Tech. Press, Nov. 4, 1960, p. 12.

35 Prepared by Frank L. Fisher.

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TABLE 2.—Salient selenium statistics

(Thousand pounds contained selenium)

	1951–55 (average)	1956	1957	1958	1959	1960
United States:						
Production [1]	704	[2] 928	1,077	727	799	620
Shipments	790	1,035	625	737	1,011	650
Imports for consumption	170	235	148	184	224	160
Consumption, apparent	950	1,270	773	920	1,234	810
Stocks: Producers'	96	191	651	551	339	290
Price per pound, commercial grade	$3.65–$5.25	$9.00–$15.00	$7.50–$12.00	$7.00–$7.50	$7.00	$6.50–$7.00
World: Production	1,353	1,923	1,940	1,507	1,719	1,777

[1] Includes small quantities of secondary selenium in 1954–59.
[2] Revised figure.

Allied Chemical Corp., Marcus Hook, Pa., and Kawecki Chemical Co., Boyertown, Pa., recovered selenium from sulfides used in chemical processing. American Metal Climax, Inc., Carteret, N.J.; American Smelting and Refining Company, Baltimore, Md.; International Smelting & Refining Co., Perth Amboy, N.J.; and Kennecott Copper Corp., Garfield, Utah, produced selenium as a byproduct of the electrolytic refining of copper.

Consumption and Uses.—Shipments from producers to consumers dropped to 650,000 pounds from more than 1 million pounds in 1959. Most of this sharp decline resulted from inroads made by substitutes. The growing trend toward the use of silicon and, to a lesser extent, germanium dry-plate rectifiers in a market formerly dominated by selenium was of particular significance. Consumption of selenium by the chemical, rubber, metallurgical, ceramic, and glass industries also declined.

Consumption of commercial-grade and high-purity selenium, in approximately equal quantities, accounted for 93 percent of the total. Ferroselenium accounted for most of the remainder.

High-purity selenium was used in electronic applications. New uses developed in recent years, such as xerography and photoluminescence, did not require large quantities of selenium. Despite sharp inroads by substitutes, there was promise in 1960 of new important electronic applications for selenium that were in the research and development stage. The heavy-metal selenides, especially those of silver, bismuth, cadmium, lead, and zinc, have distinct and favorable properties for use in thermoelectric and photoelectric applications.

Stocks.—Producers' stocks of marketable selenium at yearend were 290,000 pounds, less than a 6-month supply at the 1960 rate of consumption. Stocks of selenium-bearing slimes and residues at producers' plants continued to increase as the quantity generated at electrolytic refineries was far in excess of the consumption rate.

Prices.—The price quoted for commercial-grade selenium was adjusted to $6.50–$7.00 a pound in July 1960 to reflect market conditions more realistically. This was the first change since February 1958. High-purity and ultra-high purity (99.999 percent Se) selenium were quoted at $9.50 and $20.00 per pound, respectively, throughout the year. Ferroselenium was unchanged at $7.00 per pound of selenium content.

Foreign Trade.—Imports of selenium and selenium salts for consumption totaled 158,126 pounds, a decrease of 29 percent from 1959. Imports from Canada were 141,592 pounds valued at US$740,521. Other countries exporting selenium to the United States were Belgium-Luxembourg, 10,367 pounds; Japan, 4,800 pounds, Sweden, 1,343 pounds; and West Germany, 24 pounds. The total did not include 13,448 pounds of selenium in selenium-bearing residues imported from the Federation of Rhodesia and Nyasaland.

TABLE 3.—Free world production of selenium by countries [1]

(Pounds)

Country	1951-55 (average)	1956	1957	1958	1959	1960
North America:						
Canada	327,523	330,389	321,392	306,990	368,107	562,272
Mexico	30,052	201,864	175,475	107,576	8,891	6,944
United States	703,760	928,400	1,077,000	727,400	799,100	620,000
South America:						
Argentina	[2] 331	2,205	(3)	(3)	(3)	(3)
Peru	[4] 5,741	3,944	6,865	8,419	8,155	10,681
Europe:						
Belgium-Luxembourg (exports)	49,913	81,571	24,471	48,942	124,560	72,531
Finland	5,858	8,390	9,219	13,051	13,196	11,358
Sweden	128,929	168,532	143,300	84,135	132,276	[5] 165,345
Asia:						
Japan	77,532	162,916	154,335	182,406	229,486	278,234
Africa: Rhodesia and Nyasaland, Federation of: Northern Rhodesia	20,490	32,055	25,137	24,805	32,587	46,827
Oceania: Australia	2,722	2,581	3,002	[6] 3,000	[6] 3,000	[6] 3,000
World total [1]	1,353,000	1,923,000	1,940,000	1,507,000	1,719,000	1,777,000

[1] This table incorporates a number of revisions of data published in previous Minor Metals Chapters. Data do not add to exact totals shown because of rounding.
[2] One year only, as 1955 was first year of production reported.
[3] Data not available; no estimate included in world total.
[4] Average for 1954-55.
[5] Exports.
[6] Estimate.

Compiled by Augusta W. Jann, Division of Foreign Activities.

World Review.—*Canada.*—The preliminary estimate of Canadian selenium production in 1960 was 562,300 pounds, worth Can$3,487,800. This selenium was a byproduct of the electrolytic copper refineries of The International Nickel Company of Canada, Ltd., at Copper Cliff, Ontario, and Canadian Copper Refiners, Ltd., Montreal East, Quebec.

Belgium.—Production of selenium was 72,500 pounds. It was obtained as a byproduct of electrolytic copper operations in the Republic of the Congo and the Federation of Rodesia and Nyasaland.

Finland.—Selenium output of Outokumpu Oy at Pori was 11,400 pounds.

Japan.—Japanese selenium producers reported 278,200 pounds of selenium from their copper, gold, and sulfur operations.

Mexico.—Production of selenium was 6,900 pounds, most of it as a byproduct of lead flue dusts.

Peru.—Cerro Corp. at Oroya reported 10,700 pounds of selenium produced during the year as a byproduct of its electrolytic copper refinery.

Rhodesia and Nyasaland, Federation of.—Production of selenium contained in copper slimes totaled 46,800 pounds.

Technology.—Research and technology emphasized new applications during the year. The continued generation of selenium-bearing slimes and residues in excess of demand was not conducive to a search for new sources. Where a search for selenium was undertaken, it was primarily as an indicator for tellurium or some other metal. The U.S. Geological Survey published a report on its occurrence.[36]

Research and development in 1960 indicated that selenium had promise as a thermoelectric material. It was used with tellurium as a component of ternary and quaternary thermoelectric compounds. Silver selenide and selenides of other heavy metals were the object of intensive research that has had encouraging results.

TELLURIUM [37]

The tellurium industry continued to grow in 1960, as tellurium's wider application in thermoelectricity became more apparent through new avenues of research and development.

TABLE 4.—Salient tellurium statistics

(Thousand pounds of contained tellurium)

	1951–55 (average)	1956	1957	1958	1959	1960
United States:						
Production	145	233	255	171	196	260
Shipments	141	[1] 255	[1] 214	[1] 182	316	320
Stocks, Dec. 31, Producer	123	126	167	134	63	40
Imports for consumption	(2)	(2)	2	6	16	20
Price per pound	1.75	$1.50–$1.75	$1.50–$1.75	$1.65–$1.75	$1.65–$3.00	$3.00–$4.00
World: Production	153	241	287	224	357	390

[1] Revised figure.
[2] Data not available.

Domestic Production.—Production of tellurium increased to 260,000 pounds, a new record, obtained solely as a byproduct of the electrolytic refining of copper and the refining of lead. Producers were American Metal Climax, Inc.; American Smelting and Refining Company; International Smelting & Refining Co.; Phelps Dodge Refining Corp.; and United States Smelting, Refining, and Mining Co. An intensive search for commercial tellurium from new sources of supply was not successful.

Consumption and Uses.—Shipment of tellurium to consumers reached a record 320,000 pounds. The increased volume of consumption was attributed in part to buying arising from the prevalent upward price trend. The extensive use of tellurium in the metallurgical,

[36] Davidson, D. F., Selenium in Some Epithermal Deposits of Antimony, Mercury, and Silver and Gold; Geol. Survey Bull. 1112-A, 1960, 17 pp.
[37] Prepared by Frank L. Fisher.

chemical, rubber, and ceramic industries continued. The quantity of tellurium consumed in thermoelectricity increased, but it was used mostly for research and development. Thermoelectric devices available on a commercial scale did not use significant quantities of tellurium; purchases for this purpose were estimated at less than 10 percent of consumption.

Many tellurium thermoelectric materials were introduced in addition to the standbys, lead telluride and bismuth telluride. One alloy, Neelium, is composed of bismuth, tellurium, selenium, and antimony. Several companies offered thermoelectric modules on a commercial scale for the first time for spot-cooling electronic components. The use of tellurium to improve the physical properties of structural steels increased, but the quantity of tellurium needed was small.

A new use for tellurium was as the raw material for producing iodine 131 for use in radioactive pharmaceuticals. Tellurium is bombarded with neutrons to yield tellurium 131, which decays to iodine 131.

Stocks.—Tellurium-bearing slimes and residues stored by producers decreased slightly but still contained more than 1 million pounds of recoverable tellurium. Producers' stocks of marketable tellurium continued to decrease and were only 40,000 pounds at yearend.

Prices.—The price of commercial-grade tellurium was advanced 50¢ per pound to $3.00 per pound on January 1. In May it was raised to $3.50 and in September to $4.00 per pound. The quoted price for high-purity tellurium was unchanged at $25.00 per pound.

Foreign Trade.—Imports of tellurium compounds amounted to 20,000 pounds valued at $40,000. Peru supplied 11,006 pounds and Australia 4,164 pounds. The remainder came from the United Kingdom and Japan. Imports of tellurium metal and exports of tellurium were not reported.

World Review.—*Canada.*—A preliminary estimate of tellurium production was 56,000 pounds valued at Can$197,000. This compared with 1959 production of 13,000 pounds valued at Can$30,000. The Canadian production was recovered as a byproduct by the International Nickel Company of Canada, Ltd., Copper Cliff, Ontario, and Canadian Copper Refiners, Ltd., Montreal East, Quebec.

TABLE 5.—Free world production of tellurium by countries [1]

(Pounds)

Country	1951–55 (average)	1956	1957	1958	1959	1960
North America:						
Canada	7,365	7,867	31,524	38,250	13,023	56,352
United States	144,700	232,600	254,900	170,500	196,000	260,000
South America: Peru	468	88	----------	14,868	62,600	59,343
Asia: Japan	[2] 772	331	716	110	2,761	13,825
Free world total [1]	153,300	240,900	286,600	223,700	356,900	389,500

[1] This table incorporates a number of revisions of data published in previous Minor Metals chapters. Data do not add to exact world total shown because of rounding.
[2] Average for 1953–55.

Compiled by Augusta W. Jann, Division of Foreign Activities.

Japan.—Tellurium was produced as a byproduct at copper refineries in Japan. Production in 1960 was 13,800 pounds.

Peru.—The production of tellurium was 59,000 pounds, all obtained as a byproduct of copper production at the Oroya refinery of the Cerro Corp.

Technology.—Tellurium research was concentrated in three areas. First, the search was intensified for new sources of supply as research in tellurium geochemistry was advanced, and improved methods of detection and analysis were investigated. An important contribution to geochemistry was published.[38] Second, the possibilities of improving recovery of tellurium from present operations and of finding new byproduct sources of supply were investigated. Third, research and development toward improving the quality and performance characteristics of the thermoelectric properties of tellurium compounds were carried out on a large scale. Investigators focused their attention on tellurium binary compounds with the high atomic weight metals and several ternary and quaternary compounds that contain tellurium as a major component. Successful efforts to obtain consistently a material with a thermoelectric figure of merit Z greater than 3.0×10^{-3} were not reported. Increasing the Z value is the key to the widespread use of thermoelectric devices. A Z value greater than 5.0×10^{-3} would be most desirable and was the unattained objective of tellurium thermoelectric research and development in 1960.

THALLIUM[39]

Domestic Production.—Thallium was produced in the United States only by the American Smelting and Refining Company, Denver, Colo. Shipments of thallium metal and thallium compounds decreased.

Uses.—Thallium sulfate, an odorless, tasteless, and very poisonous material, was used to exterminate rodents and ants. Thallium-activated sodium iodide crystals mounted on photomultiplier tubes were used as the heart of certain portable scintillation counters for detecting gamma radiation.

Price.—The price of thallium metal was $7.50 per pound.

Technology.—The physical and electronic design of a hand-portable scintillation counter using thallium-activated sodium iodide crystals, containing about 1 percent thallium, was described.[40] The electrical properties of thallium selenide monocrystals prepared by melting thallium and selenium were reported.[41]

YTTRIUM[42]

The future of yttrium depends to a great extent on the discovery and development of a large deposit, easily minable and amenable to low-cost extractive processes. With sufficient raw material available, technology and new uses could evolve faster.

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[38] Sindeeva, N. D. [Mineralogy, Types of Deposits, and Principal Features of the Geochemistry of Selenium and Tellurium], Acad. Sci., Moscow, 1959, 257 pp.

[39] Prepared by Donald E. Eilertsen.

[40] Vaughn, W. W., Rhoden, V. C., Wilson, E. E., and Faul, Henry, Scintillation Counters for Geologic Uses: Geol. Survey Bull. 1052-F, 1959, pp. 213-240.

[41] Akhundov, G. A., Abdullaev, G. B., and Guseinov, G. D., Certain Properties of Thallium Selenide Monocrystals: Soviet Physical: Solid State, vol. 2, No. 7, January 1961, pp. 1378-1380. (Published Originally in Fizika Tverdogo Dela, vol. 2, No. 7, July 1960, pp. 1518-1521.)

[42] Prepared by John G. Parker.

Domestic Production.—Although it is associated with the rare-earth elements in such minerals as gadolinite, xenotime, apatite, bastnasite, doverite, euxenite, and monazite, yttrium was recovered almost entirely as a coproduct with rare-earth metals and thorium from industrial stocks of monazite concentrate. A small amount of yttrium-bearing residue from Idaho euxenite was sold by the General Services Administration (GSA) for experimental purposes. An actively worked iron-ore deposit in New Jersey was investigated as a potential producer of yttrium and rare-earth elements contained in minerals such as doverite, xenotime, and bastnasite.

American Potash & Chemical Corp., West Chicago, Ill.; Michigan Chemical Corp., St. Louis, Mich.; Research Chemicals Division, Nuclear Corporation of America, Burbank, Calif.; and Vitro Chemical Co., Chattanooga, Tenn., processed rare-earth concentrates for yttrium and its compounds.

By midyear, Mallinckrodt Chemical Works made final shipments to GSA of residues containing yttrium, rare-earth elements, and thorium obtained from euxenite processing.

Commercial producers of yttrium metal included American Potash & Chemical Corp.; American Scandium Corp., Cincinnati, Ohio; Lunex Co., Pleasant Valley, Iowa; Michigan Chemical Corp., and Research Chemicals. Ames Laboratory of the Atomic Energy Commission (AEC), Ames, Iowa, the pioneer producer of yttrium metal for experimental use, opened a new metals process development building.[43] The Federal Bureau of Mines laboratories at Reno, Nev. and Albany, Oreg., and the Oak Ridge National Laboratory, AEC, Oak Ridge, Tenn. continued to produce yttrium metal for experimental use.

Uses.—Yttrium was employed in various forms by the ceramics, chemical, electronics, metallurgical, and nucleonics industries and in the field of medicine.

Although most of the industrial demand for yttrium iron garnet was for polycrystalline material, single crystals have the advantages of homogeneity, higher purity, and magnetic anisotropism. Yttrium-iron-garnet crystals were used for various microwave applications because of their extremely narrow line width and low insertion loss. The electronic industry needed larger crystals than were available to provide more interaction with the microwave field in many systems.

Yttrium was used in ferrites for gyromagnetic effects, in special optical glasses, electrically conducting ceramics, and refractories. Because of its high melting point (2,410° C.), it might be used in crucibles. It has been added to thorium oxide to produce high-temperature resistors. Yttrium hydride was mentioned as a potential moderator material because of certain features such as its short-time tensil properties, hardness, and conductivity.[44]

Colloidal radioactive yttrium silicate was used instead of radioactive gold to treat malignant fluids in lung and abdominal cavities. The advantages over radioactive gold were the absence of penetrating gamma radiation and superior surface penetration of the beta particles.[45]

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[43] Iron Age, vol. 186, No. 20, Nov. 17, 1960, p. 124.
[44] Parker, D. S., Properties of Hydrided Yttrium: AEC Rept. APEX-558, General Electric Co., Aircraft Nuclear Propulsion Dept., May 1960. Reviewed in Reactor Core Materials, A Quarterly Technical Progress Review, prepared for AEC by Battelle Memorial Institute, vol. 3, No. 4, November 1960, pp. 23-25.
[45] Science Newsletter, vol. 78, No. 20, Nov. 12, 1960, p. 313.

Prices.—Vitro Chemical Co. sold 99 percent yttrium oxide for $60 per pound and 99.9 percent yttrium oxide for $65 per pound. The highest price for highest purity material in the smallest gram-size lots was 24 cents per gram.

In a price schedule issued November 1, 1960, American Potash & Chemical Corp. listed production chemical yttrium oxide (60–85 percent pure), in 50- to 99-pound lots, at $22 per pound of yttrium oxide. Actual prices were based on analysis. Highest purity yttrium oxide (99.9999 percent) was available at $1.50 per gram to $295 per pound depending on quantity.

According to quotations in American Metal Market throughout 1960, yttrium metal prices were as follows: 80 percent purity metal, 63 cents per gram in 10- to 99-gram lots and 42 cents per gram in 100- to 450-gram lots; 99.9 percent purity, 81 cents per gram and 54 cents per gram in the same size lots as indicated above.

Technology.—A book was published on the history of yttrium and its occurrences. The physicochemical properties of yttrium metal and compounds, methods of separation, purification, and determination were given, and analyses in the presence of interfering ions were described.[46]

A report on yttrium presented at the National Western Mining and Energy Conference in Denver discussed yttrium minerals and mineral deposits, extraction of concentrates and separation of the oxide, preparation of yttrium metal, and its fabrication, properties, and uses.[47]

A comprehensive review contained valuable information and a bibliography pertaining to yttrium, and the rare-earth metals, and scandium. Melting points and transition temperatures of rare-earth, yttrium, and scandium halides were given.[48]

The low thermal neutron cross section, high melting point, and high ultimate tensile strength of yttrium and its ability to absorb hydrogen indicated its potential use as a structural material for certain atomic energy components.[49]

Yttrium shows good corrosion resistance to nuclear reactor coolants at high temperatures in static isothermal systems.[50]

A new series of binary alloys was suggested based on the relatively high tensile properties and high strength-to-weight ratio of yttrium that are comparable to those of aluminum, magnesium, and titanium. The solid solution of yttrium-zirconium added strength to alloys of these metals. Small amounts of titanium acted as grain refiners in yttrium alloys; and some hard-particle strengthening and grain refinement occurred with up to several percent copper in yttrium. Yttrium acted as a purifier of vanadium and chromium. This was shown by crystallization in quite pure state of the latter metals from

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[46] Vickery, R. C., The Chemistry of Yttrium and Scandium, International Series of Monographs on Inorganic Chemistry: Vol. 2, New York, Pergamon Press, 1960, 128 pp.; Nuclear Sci. Abs., vol. 15, No. 1, Jan. 15, 1961, p. 17.

[47] McGurty, J. A., and Simmons, C. R., The Metal Yttrium, Aircraft Nuclear Propulsion Dept., General Electric Co., Cincinnati, Ohio, 1960, 35 pp.

[48] Spedding, F. H., and Daane, A. H., The Rare-Earth Metals, Met. Rev., (London), vol. 5, No. 19, 1960, pp. 297–341.

[49] Gardner, Annesta R., The Rare-Earth Elements: Product Eng., vol. 31, No. 17, Apr. 25, 1960, pp. 39–43. American Metal Market, vol. 67, No. 230, Dec. 2, 1960, p. 5.

[50] Hoffman, E. E., Corrosion of Materials by Lithium at Elevated Temperatures, Oak Ridge National Laboratory, ORNL-2924, Oct. 27, 1960.

the two liquid regions of both yttrium-vanadium and yttrium-chromium binary systems.[51]

The endurance limits of yttrium are in the same order of magnitude as those of many structural metals. Cold-working, especially after initial hot- or warm-working at less than the recrystallization temperature, improved the hardness, tensile strength, and ductility of as-cast yttrium.[52]

A new process for recovering yttrium from scrap featured low cost and high purity of the final product. Scrap material was converted to crude yttrium oxide by heating it in an open fireplace and then in silica trays at 800° C., followed by solution, removal of impurities, precipitation of yttrium oxalate, and again heating it to form yttrium oxide.[53] Yttrium metal was prepared from a low-melting yttrium-magnesium intermediate alloy. In this process, yttrium triflouride was first reduced with calcium in the presence of magnesium to form the alloy, the magnesium was removed by sublimation, and oxygen and fluorine were removed from the resultant molten yttrium metal sponge by extraction with fused yttrium salts.[54]

Yttrium was used as an internal standard in the analysis of minuscule quantities of rare-earth elements by spectrographic techniques. It was said that concentrations of only 0.07 part per million can be detected.[55]

Yttrium 90, an easily prepared and relatively short-lived radioisotope, was used as a radiation source in intralymphatic therapy.[56] At the Ames Laboratory, yttrium was shown to be of potential value as a fuel-container material for reactors.[57] Its oxygen content was lowered to about 150 parts per million, and interstitial impurities were dissolved by immersion in a salt bath. Electron beam melting removed fluorine from yttrium sponge, and the inherent ductility of yttrium was shown by cold extrusion of the metal into complex shapes.

Ferrites of garnet structure, with yttrium and heavier rare-earth metals as components, were measured between the Curie point and 1,500° K. Curves were plotted from which temperature and molecular field coefficients could be determined.[58]

Vapor pressure and temperature data for yttrium and scandium were graphically presented.[59]

A simple, rapid, and precise method to determine oxygen in yttrium was developed. The method uses a magnesium oxide reagent to eliminate interaction of fluoride with glass apparatus.[60]

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51 Love, Bernard, The Metallurgy of Yttrium and the Rare Earth Metals, Pt. I, Phase Relationships; Wright Air Development Division Tech. Rept. 60–74, May 1960, 226 pp.

52 Love, Bernard, The Metallurgy of Yttrium and the Rare Earth Metals, Pt. II, Mechanical Properties: Wright Air Development Division Tech. Rept. 60–74, June 1960, 64 pp.

53 Provow, Douglas M., and Fisher, Ray W., Chemical Processing of Yttrium Scrap, Ind. and Eng. Chem., vol. 52, No. 8, August 1960, pp. 681–682.

54 Carlson, O. N., Haefling, J. A., Schmidt, F. A., and Spedding, F. H., Preparation and Refining of Yttrium Metal by Y–Mg Alloy Process, Jour. Electrochem. Soc., vol. 107, No. 6, June 1960, pp. 540–545.

55 Steel, vol. 147, No. 21, Nov. 21, 1960, p. 97.

56 Atomic Energy Commission, Atomic Energy Research in the Life and Physical Sciences 1960: Special Rept., January 1961, p. 13.

57 Work cited in footnote 56, p. 109.

58 Aléonard, Roland, [Paramagnitic Study of Yttrium and Rare-Earth Ferrites of the Formula $5Fe_2O_3.3M_2O_3$]: Physics and Chemistry of Solids, vol. 15, August 1960, pp. 167–182; Nuclear Sci. Abs., vol. 15, No. 3, Feb. 15, 1961, p. 421 No. 3260.

59 Beavis, L. C., Vapor Pressure of the Rare Earth: Sandia Corp., Albuquerque, N. Mex., Aug. 2, 1960 14 pp.; Nuclear Sci. Abs., vol. 15, No. 3, Feb. 15, 1960, p. 343, No. 2619.

60 Banks, Charles V., O'Laughlin, Jerome W., and Kamin, George J., Determination of Oxygen in Yttrium and Yttrium Fluoride by the Inert Gas Fusion Method: Anal. Chem., Vol. 32, No. 12, November 1960, pp. 1613–1616.

Reports published during 1960 described the extraction of yttrium from euxenite concentrate and the preparation of high-purity yttrium. It was determined that high-purity yttrium was ductile enough to show promise as a structural metal.[61]

Studies using metallographic, thermal, and X-ray methods indicated that two intermetallic compounds present in the yttrium-nickel system melt congruently and seven undergo peritectic decomposition.[62]

A number of papers in the Russian scientific press indicated a continuing interest in yttrium. Some described research on complexes formed by yttrium; one showed how yttrium could be determined colorimetrically in the presence or absence of lanthanum.[63]

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[61] Shaw, Van E., Extraction of Yttrium and Rare-Earth Elements from Arizona Euxenite Concentrate: Bureau of Mines Rept. of Investigations 5544, 1960, 9 pp.

Block, F. E., Campbell, T. T., Mussler, R. E., and Robidart, G. B., Preparation of High-Purity Yttrium by Metallic Reduction of Yttrium Trichloride: Bureau of Mines Rept. of Investigations 5588, 1960, 22 pp.

[62] Beaudry, B. J., and Daane, A. H., Yttrium-Nickel System, Trans. Met. Soc. AIME, vol. 218, No. 5, October 1960, pp. 854–859.

[63] Panova, M. G., Levin, V. I., and Brezhneva, N. E., [Investigation of Complexes Formed by Yttrium; Pt. I, Yttrium Oxinates], Radiokhimiya, Leningrad, vol. 2, No. 2, April 1960, pp. 197–207.

Panova, M. G., Brezhneva, N. E., and Levin, V. I., [Investigation of Complexes Formed by Yttrium; Pt. 2, Sulfate, Nitrate, and Chloride Complexes], Radiokhimiya, Leningrad, vol. 2, No. 2, April 1960, pp. 208–214.

Serdyuk, L. S. and Federova, G. P., [Photometric Determination of Yttrium with Stilbazo], Zhur. Anal. Khim., 15, May–June 1960, pp. 287–290; Nuclear sci. Abs., vol. 14, No. 20, Oct. 31, 1960, p. 2596.

Minor Nonmetals

By Albert E. Schreck [1]

THIS chapter contains data on the minor nonmetallic mineral commodities—greensand, meerschaum, mineral wool, staurolite, and wollastonite.

GREENSAND

Domestic output of greensand (glauconite) in 1960 was 13 percent lower than in 1959. Average output for the 5-year period 1956–60 was about 5,000 tons valued at $189,000. The open-pit operations of Kaylorite Corp. (Calvert County, Md.), National Soil Conservation, Inc. (Burlington County, N.J.), and Inversand Co. (Gloucester County, N.J.) accounted for the entire output.

Of the total quantity sold, 69 percent was used as a soil conditioning agent and the remainder was used for water softening.

Prices of greensand ranged from $13.26 to $78.95 per short ton f.o.b. mine.

MEERSCHAUM

The principal use for meerschaum, the mineral sepiolite, continued to be smokers' accessories, such as pipe bowls and cigar and cigarette holders. There was no domestic production of this mineral commodity and consumers had to rely on imports.

Imports in 1960 increased substantially over 1959, with Turkey the major supplier and France contributing the remainder.

The Tanganyika Meerschaum Corp. produced meerschaum at its mine on the Kenya-Tanganyika border. The material was made into pipes at the firm's Nairobi, Kenya, factory.[2] Output of meerschaum

TABLE 1.—U.S. imports for consumption of meerschaum [1]

Year	Pounds	Value	Year	Pounds	Value
1951-55 (average)	9,501	$15,994	1958	17,392	$15,432
1956	13,140	[2] 21,770	1959	7,323	16,333
1957	10,538	20,046	1960	41,564	29,460

[1] 1951-55: Turkey 9,418 pounds, $15,848; Austria, 3 pounds, $8; Union of South Africa, 80 pounds, $138; 1956: All from Turkey; 1957: Turkey, 10,426 pounds, $19,649; Union of South Africa, 112 pounds, $397; 1958: All from Turkey; 1959: Turkey, 6,304 pounds, $15,862; France, 1,019 pounds, $471; 1960: France, 2,566 pounds, $1,186; Turkey, 38,998 pounds, $28,274.
[2] Data known to be not comparable with other years.

Source: Bureau of the Census.

[1] Commodity specialist, Division of Minerals.
[2] Mining Journal (London), vol. 255, No. 6529, Oct. 7, 1960, p. 391.

in Tanganyika in 1960 totaled 25,000 pounds, about 6,000 pounds less than in 1959.

MINERAL WOOL

Statistical data on production and sales of mineral wool for 1959 and 1960 are not available. The value of mineral wool produced from rock, slag, and glass increased 153 percent during the period 1949 to 1958 from $93 million to $235 million. The output was primarily used in industrial and equipment insulation and structural insulation.

Employment in the mineral-wool producing industry increased from 7,544 workers in 1949 to about 12,000 in 1958.

The Kansas Geological Survey investigated the possible use of volcanic ash for manufacturing mineral wool. A satisfactory product can be made by adding limestone to reduce the SiO_2 content.[3]

STAUROLITE

Production and value of staurolite increased in 1960, continuing the upward trend that began in 1953. The rate of increase was not as large as in several previous years, but it was substantial. Staurolite, used in the manufacture of cement, was recovered as a byproduct of titanium minerals mining operations in Clay County, Fla., by E. I. du Pont de Nemours & Co., Inc., at its Highland and Trail Ridge plants.

WOLLASTONITE

Domestic output of wollastonite in 1960 increased about 17 percent over 1959 to establish a new high for the industry.

Cabot Minerals Division of Cabot Corp., from the Willsboro mine, Essex County, N.Y., accounted for most of the production. Two firms in Riverside County, Calif., Lawrence Johnson and Mineral Exploit Co., supplied the remainder.

Adirondack Development Corp., Keeseville, N.Y., conducted exploration and development work on a wollastonite deposit near Lewis, N.Y.

The principal use for wollastonite was in ceramics such as wall and floor tile, porcelain fixtures, and electrical insulators; as a filler in asphalt tile and plastics; and as a paint extender. Wollastonite produced in California was used as ornamental and building stone.

From January 1960 through mid-October 1960, Oil, Paint & Drug Reporter quoted the following prices on wollastonite: Fine, bags, carlots, works, $39.50 per ton; less than carlots, ex warehouse, $56 per ton; medium, bags, carlots, works, $27 per ton; less than carlots, ex warehouse, $44 per ton. On October 17, the quotations and prices were changed as follows: Fine, paint grade, bags, carlots, works, $41 per ton; less than carlots, ex warehouse, $51 per ton; medium, paint grade, bags, carlots, works, $29 per ton; less than carlots, ex warehouse, $39 per ton.

[3] Bauleke, Maynard P., Mineral Wool from Volcanic Ash: Rock Products, vol. 63, June 1960, pp. 110, 112.

INDEX

BY KATHLEEN J. D'AMICO[1]

The index consists of three parts: A commodity index, company index, and a world review index.

Because nearly all commodity chapters in Minerals Yearbook, volume I, follow a standard outline (Introductory Summary, Domestic Production, Consumption and uses, Stocks, Prices (and specifications), Foreign Trade, World Review, World Reserves, and Technology), references to such data have been omitted under the various headings.

Readers seeking information on mine production for States, Territories, or possessions should refer to tables in the Statistical Summary chapter, starting on page 87. These tables show the commodities produced in each area, thus guiding the reader to the appropriate commodity chapters. The reader should refer to volume III, however, for complete area information.

COMMODITY INDEX

[1] Publications editor.

Company Index

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World Review Index

At the beginning of the 1950's there were only four independent countries in Africa—Egypt, Ethiopia, Liberia, and the Union of South Africa, comprising about 12 percent of the continental area.[3] By the end of 1960, 22 new African countries and the Malagasy Republic (formerly Madagascar), occupying more than two-thirds of Africa's total area, had come into existence. Nearly three-fourths of the population was living in independent countries. These new States, their dates of independence and their former names are as follows:

New States of Atrica and Madagascar, 1950–1960

Name: Long form	Name: Short form	Date of independence	Former name or names
Cameroun, Republic of	Cameroun	Jan. 1, 1960	French Cameroun (or French Cameroons).
Central African Republic		Aug. 13, 1960	Central African Republic (also Ubangi Shari).
Chad, Republic of	Chad	Aug. 11, 1960	Chad.
Congo, Republic of	Congo [1]	Aug. 15, 1960	Congo (also Middle Congo).
Congo, Republic of the	do	June 30, 1960	Belgian Congo.
Dahomey, Republic of	Dahomey	Aug. 1, 1960	Dahomey.
Gabon Republic	Gabon	Aug. 17, 1960	Gabon.
Ghana, Republic of	Ghana	Mar. 6, 1957	Gold Coast Colony and British Togoland.
Guinea, Republic of	Guinea	Oct. 2, 1958	French Guinea.
Islamic Republic of Mauritania	Mauritania	Nov. 28, 1960	Mauritania.
Ivory Coast, Republic of	Ivory Coast	Aug. 7, 1960	Ivory Coast.
Libya, United Kingdom of	Libya	Dec. 24, 1951	Libya.
Malagasy Republic		June 26, 1960	Madagascar and dependencies.[2]
Mali, Republic of	Mali	Sept. 24, 1960	Soudan (as part of the Federation of Mali).
Morocco, Kingdom of	Morocco	Mar. 2, 1956	French Morocco, Spanish Morocco, and Tangier International Zone.
Niger, Republic of	Niger	Aug. 3, 1960	Niger.
Nigeria, Federation of	Nigeria	Oct. 1, 1960	Nigeria (colony and protectorate).
Senegal, Republic of	Senegal	Sept. 24, 1960	Senegal (as part of the Federation of Mali).
Somali Republic	Somalia	July 1, 1960	Somalia and British Somaliland.
Sudan, Republic of the	Sudan	Jan. 1, 1956	Anglo-Egyptian Sudan.
Togo, Republic of	Togo	Apr. 27, 1960	French Togo.
Tunisia, Republic of	Tunisia	Mar. 20, 1956	Tunisia.
Upper Volta, Republic of	Upper Volta	Aug. 5, 1960	Upper Volta (Volta).

[1] Congo is presently acceptable as the short form for both the Republic of Congo (formerly part of French Equatorial Africa) and the Republic of the Congo (formerly Belgian Congo). For use on maps showing both countries the Office of the Geographer recommends that the former be identified by the short form and the latter by the long form.

[2] Although Madagascar is frequently associated with the continent of Africa it is, strictly speaking, not a part of it. In this article Madagascar is considered as part of the African complex in the general discussion, but the Malagasy Republic occupying the island of Madagascar and its dependencies should not be construed as an African state.

[3] Pearcy, G. Etzel, Africa: Names and Concepts: Dept. of State Pub. 7129, Africa Series 9, January 1961, 9 pp.

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