Gems & Gemology

A bi-monthly periodical, without paid advertising, supported by subscriptions from Gemologists and other gem enthusiasts, aims to increase the gem merchant's knowledge and ability in order that he may protect more thoroughly his customers' best interests.

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In This Issue:

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EDITORIAL FORUM

ERROR CREPT IN

In our July-August editorials, we made some rather caustic comments regarding the proceedings of the International Jewelry Conference at the Hague. Particularly we complained of the indications that this Conference intended to set arbitrary rules concerning the physical and optical properties of gem stones.

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Evidently we misinterpreted their true intention. A letter from B. W. Anderson, director of the Laboratory of the Diamond, Pearl, and Precious Stone Section of the London Chamber of Commerce, chides us gently for our error.

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Says Mr. Anderson:

"I think you take a wrong attitude with regard to the suggested revision of the physical property data by the Laboratories. I myself have been pressing this keenly for some years, and for the very reason which you give as an argument *against* the idea—i. e., that I do *not* wish to see these data 'arbitrarily fixed' as they are at present by the standard textbooks, which copy from one another and give no freshly-determined data of their own.

"The annual submission of data actually determined in our laboratories will not *fix* these data—they will, on the contrary, leave them in a healthy state of readiness for further revision. A perfectly good comparison of this procedure is given by the tables of atomic weights, the values for which are periodically overhauled by an International Committee, which draws up a list of the best values to date, without any pretence of finality."

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It is also pointed out that we are wrong in assuming the figures considered by the International Jewelry Conference were those of Dr. Schlossmacher's revision of Bauer's *Edelsteinkunde*. It seems that a special committee has been appointed to prepare the list of properties and nomenclature. Also we withdraw our complaint against the lack of American representation upon the B.I.B.O.A. Since our editorial, the Gemological Institute of America has been asked to send a representative to the conferences. The Institute has also submitted upon request a list of proposed nomenclature of gem stones; this will be incorporated in future rulings of the B.I.B.O.A.

Gems & Gemology is the official organ of the American Gem Society and in it will appear the *Confidential Services* of the Gemological Institute of America. In harmony with its position of maintaining an unbiased and uninfluenced position in the jewelry trade, no advertising is accepted. *Gems & Gemology* does not intend to overlap the field of any other periodical in America or England.

Contributors are advised not to submit manuscripts without first assuring themselves that the information contained in them is of scientific accuracy. Manuscripts not accompanied by return postage will be held thirty days and destroyed.

Any opinions expressed in signed articles are understood to be the views of the author and not of the publishers.

Supplement to Continue

Our September-October issue incorporated the experiment of presenting news of the activities of the American Gem Society and its students along with those of the Gemological Institute of America. This innovation met with general approval of readers. Since then, the organization of the A.G.S. Guilds—briefly mentioned elsewhere in this issue—demands a medium through which instructions for organization, announcements of meeting places and dates, reports of each Guild's lectures and clinics, and news of members' lectures and other activities can be released. For this purpose a publication to be called *Guilds* will make its bow with one separate issue about February 1, 1935, after which it will appear in the nature of a supplement with the later issues of *Gems & Gemology.*

Announcement Extraordinary!

Publication of this magazine will henceforth be by the American Gem Society. The staff will remain the same. The nature of the articles and the form will remain the same. Also *Gems & Gemology* will continue to publish all articles and services of the Gemological Institute, *but* they will be distinguished from other material as contributions of the Institute.

NEW MEMBER APPOINTED TO EXAM BOARD

The Gemological Institute announces that Mr. Frank L. Spies has been appointed to the Examination Standards Board. He is associated with the firm of Handy and Harman. As he has had a great deal of experience in both manufacture and sale of precious metals, Mr. Spies will be a competent representative of the Precious Metals Trade on this board.

Do You Know . . .

When is a Spectroscope Used in Testing a Gem?

See *Precious Stones Tested in Laboratory,* page 188.

Duke of Kent Wears Wedding Ring

The Duke of Kent, according to the British *Goldsmiths' Journal,* accepted the custom of the native country of his bride, Princess Marina of Greece, and a double-ring ceremony was performed. The *Goldsmiths' Journal* sees in the Duke's decision an opportunity for the revival of the sale of men's wedding rings. Wholesalers, in the same issue, are advertising several styles of ring for the bridegroom.

The custom of the bridegroom's wearing a ring is by no means new. The Greek Catholic Church of the present day employs two rings in its marriage service—gold for the groom and silver for the bride. Until a couple of decades ago it was common practice in England for men to wear wedding rings, and there are a few Americans today who can remember the days when one's grandfather wore one. The custom has always been latent among us. Many rings are worn today and this recent news offers an opportunity to extend the custom. In a recent article, the *Manufacturing Jeweler* urges all American jewelers to adopt the custom of wearing wedding rings in order to set a style which will furnish added business.

Examination Results

The following men have successfully completed title examinations of the G.I.A. and of the A.G.S.

Qualifying Certified Gemologists

George C. Barclay, Barclay & Sons, Newport News, Va.

Harold D. Feuer, Jeweler, Worcester, Mass.

Leo J. Vogt, Hess & Culbertson, St. Louis, Mo.

Graduate Members American Gem Society

CALIFORNIA
F. R. Mathes, *Eureka*

FLORIDA
Julius Kadish, *Tampa*

OHIO
William O. Theis, *Cleveland*

RHODE ISLAND
A. Ronald Reed, *Providence*

WISCONSIN
William H. Schwanke, *Milwaukee*

PHILIPPINE ISLANDS
Leopold Kahn, Jr., *Manila*

Godfrey Eacret

AN APPRECIATION

With the passing of Godfrey Eacret on December 17, the entire jewelry trade, and especially the Gemological movement lost one of its most valuable and constructive forces and at a time when such constructive forces are needed to revive confidence in a trade suffering from the results of many destructive practices. Godfrey Eacret, more than any one man in the jewelry trade, was responsible for the successful establishment of the Gemological Institute of America. Without his vision and that of a handful of other retail jewelers who four years ago first investigated the work and plans of Robert M. Shipley, the G.I.A. would not have come into being and developed to a position where the value of its service is proving of assistance to thousands of jewelers on this continent, and to numerous organizations and associations among which is numbered the American Gem Society.

From the time he became a founder, Mr. Eacret gave unstintingly of his time and advice. Files of correspondence prove beyond question his rare executive and judicial ability and are now mute testimony to his unfailing desire to be of maximum assistance and to treat with most studied fairness every branch of the jewelry trade. He understood and appreciated the efforts of the scientist and educator. With a long and successful record of practical experience in the marketing of gems he also possessed the qualities of a true scientist, for he insisted upon ascertaining the facts and of revealing them to all, regardless of momentary disadvantage to any special group. At the same time he accepted no excuse for careless or unverified statements, which were met by him with forceful and unvarnished criticism. He frequently expressed himself as believing it useless to "call a spade a sugar spoon."

With the advent of the cultured pearl he spent much time and money—probably as much or more than anyone else in the American trade—to develop a satisfactory test, and his constructive efforts in this, as in all things to which he set his hand, never ceased. Only two weeks before his death he devoted several days in collaborating with a member of the staff of the Gemological Institute in experimentation with certain details of a possible pearl-testing method. To ferret out the truth was not a wholly selfish effort to assist himself in buying and to protect only the interests of his *own* customers. The results of successful research work for which he was responsible he was eager to pass on to all legitimate dealers.

His career throughout had been intimately associated with gems. He had seen and handled in its original form the great Cullinan. He had examined carefully the Hope Diamond before its importation to this country. He carried in his memory actual descriptions of these and many other important gems, and in the diamond department of Shreve & Company in San Francisco, he once recognized the fact that a blue stone, offered to him by a local lapidary as a sapphire, possessed slightly unusual properties. With the aid of the mineralogical department of the University of California, the stone was identified as a new gem and named benitoite. He investigated the deposit which has proven to be the only one known in the world, and for a time his firm exclusively controlled its output. His character is again exemplified by the fact that by far the largest and finest specimen of benitoite, which was for a time his personal property, he released to the gem collection of the Smithsonian Institute in an effort to further gemological education. His gifts of gem-testing equipment and gem specimens to the Gemological Institute have been the subject of numerous acknowledgments in *Gems & Gemology.*

Notwithstanding all this Godfrey Eacret gave generously of his time to other organizations. The December bulletin of the A.N.R.J.A. pays extraordinary tribute to the value of his work as regional vice-president of that organization. The members of the Retail Jewelers' Research Group will mourn the passing of one of their most beloved and respected colleagues. The many other organizations of which he was an officer will also know the loss of his strong character and his rare spirit.

As president of the world-famous Bohemian Club of San Francisco he succeeded against powerful opposition in releasing the money for the erection of its new building during the depression years when San Francisco business and labor were seriously in need of such stimulation. His thought was always for constructive progress and the good of the greatest number. His ideals will live after him as the soul of the gemological movement and prove an inspiration to thousands of jewelers and an untold number of their customers. One of the monuments to his memory will be the G.I.A., in the future service of which his spirit will be reflected, the organization which he repeatedly called "the first real plan which has been offered to the trade in order to make of our business the profession which the writer thinks it should be."

Godfrey Eacret was born in Englewood, N. J., on February 28, 1874. His first experience in the jewelry trade was as a boy with the formerly well-known firm of Randall, Baremore, and Billings in New York. In 1900, Shreve and Co., of San Francisco, asked him to become their diamond man. Mr. Eacret accepted and held the position until 1911, when he and Walter P. Treat, also of Shreve and Co., organized the retail firm of Treat and Eacret. In 1912, George R. Shreve, son of George C. Shreve who founded Shreve and Co., sold his interest in that corporation and joined the Treat and Eacret Co. The firm then adopted the name which it bears today—Shreve, Treat, and Eacret. The death, within a few years, of both his partners immediately placed a heavy responsibility upon Mr. Eacret.

For the three years preceding his death, Godfrey Eacret was Chairman of the Board of Governors of the Gemological Institute of America. He was also Chairman of the Local Retail Jewelry Code Authority for the district of San Francisco-Oakland, director and immediate past-president of the San Francisco Retail Jewelers' Association, and a director of the Jewelers' Security Alliance.

He is survived by his wife, Mrs. Clarissa B. Eacret, and his three daughters, Mrs. Barbara Irene Winter and Misses Bonnie Geraldine and Clarissa Beatrice Eacret.

NEW SCHOOL OF GEM-CUTTING TO OPEN

Max N. Felker, of the Felker Research Laboratories, will conduct classes of instruction in lapidation in quarters secured especially for this purpose at 9000 Sunset Boulevard in Los Angeles. Mr. Felker is known in this country for his successful attempt to apply the most modern methods to cutting gems and fashioning ornamental objects. The course will have three divisions: (1) Cutting en cabochon, (2) Fashioning of facet cut gems, and (3) Fashioning modern straight-line art objects. Special equipment, designed and constructed in the Felker laboratory, will be used, and rough material will be furnished as part of the tuition fee.

So far as we know, this is the first school of its kind ever planned. It has been customary for lapidaries to confine a knowledge of their methods to their assistants. In the older nations of Europe and Asia these assistants were most frequently confined to members of the lapidary's family. Mr. Felker has as an assistant instructor in his school a German who learned his trade in this manner, beginning while he was but a child.

Reminiscences of a South African Diamond Buyer

In 1921, the writer of this article bought diamonds in South Africa. His account of the country and of his experiences in the diamond fields presents a side of the diamond business unknown to the majority of readers.

by

JEAN P. SPITZEL

Diamond Importer, Los Angeles

I left Antwerp—my birthplace—on May 15th, 1921, reached Southampton two days later, and landed in Capetown after a very pleasant trip eighteen days after that. I entrained the same day for Johannesburg and arrived in forty-four hours.

Johannesburg is a very nice city. It is situated on a plateau 7000 feet high; climate semi-tropical. White population about 125,000; colored population about 300,000. Johannesburg is the largest city in the Union of South Africa. This Union consists of several states: The Cape Colony, Orange Free State, Transvaal and Rhodesia. Aggregate white population in the Union was then approximately 2,000,000 souls. By white population I mean both white native Dutch Colonials and European immigrants.

The first move I had to make to start any buying was to secure a diamond buyer's license. To get this I had to go to the Gold & Diamond Office and after being cross-examined by Mr. Brink—the official in charge of the office—I was granted the license. A bond of £1000 was required and I had to satisfy the authorities as to my knowledge of the diamond business and as to my integrity.

The next regulation I had to comply with was to have a small, portable sign painted (about 10x14 inches) with my full name and official title of "licensed diamond buyer." I also had to buy a little flag about 1½x2½ feet, with distinctive colors. I was then ready to set out to buy diamonds in Africa.

The Lure of the Diamond Fields

Diamonds in South Africa were bought from individuals. These men were really prospectors, but were commonly referred to as "diggers," although they, themselves, never turned a shovel; in South Africa all manual labor was done by negro natives. The diggers were a very colorful lot. They were men from all walks of life, young and old, sick and healthy, strong and feeble; mostly adventurers attracted by the diamond lure. Ex-convicts, who wanted a new start—men disappointed in love or business, lawyers and college professors — in short, everything and everybody was there. Looking them over and contacting them one could not but wonder where all these derelicts came from; there was drama behind every one of them and their behavior showed this plainly. They all turned to one of two lures—diamonds or whiskey.

Diggers also had to secure licenses to work their claims; a fee of 2/6 (the equivalent of 62c) a month was required by the South African government. In addition, several regulations had to be strictly observed. The most important one was that whenever a diamond was sold by the claim-holder he had to render a bill-of-sale and the buyer had to sign a receipt for the purchase. Both buyer and seller had to report the transaction to the Gold & Diamond Office.

Bloemhof was the main center of activity for alluvial diamond buying. It is about two hundred miles away from Johannesburg. The name Bloemhof is rather deceiving. Literally, it means "Garden of Flowers," but in reality the town is just an outpost in the heart of the desert, or, as it is called in South Africa—the veld. Bloemhof was then a town of three hundred inhabitants with hotels, general store, garage and bars. Kimberley, the center of the pipe-mining, is also situated in the heart of the veld, and both Kimberley and Bloemhof boast a very hot climate. I have worked at temperatures as high as 120° in the shade.

We discarded collars and coats and went to work in a small corrugated iron office. We called them offices because that is what the government called them, but they were just shacks one-quarter the size of a bungalow garage. No flooring, just gravel, and if you happened to drop a diamond you had to dig instead of sweeping the floor.

Offices stood in a row like cabins. When a buyer was in his office he hoisted his little flag to show the diggers he was open for business. When he was not in, or when he was in but not ready to buy, he pulled down his flag.

Each Purchase Recorded

There were two kinds of diamond buying—buying direct from the Syndicate, which we will neglect here for there was no use to go to South Africa and buy from the Syndicate. Their prices were supposed to be the same in London and in South Africa. The 10% export tax was not added in Africa, but to London prices. As soon as we shipped diamonds out of South Africa we had to pay the tax. We had to go to the Diamond & Gold Office and show whatever we had bought. Each stone was checked back exactly with buying records, then the whole packet was weighed and the man in charge sealed the package in front of us. With that sealed package we had to go to the Internal Revenue office, pay the 10% export tax and after obtaining both the receipted tax receipt and the officially sealed package, we could go to the post office to ship the diamonds. Otherwise, there was no earthly way of getting legitimate diamonds out of Africa. Some illicit buying existed. Natives stole and always tried to have the diamonds reach the buyer in some round-about way. Some of the natives cut the skin under their feet and hid diamonds in there. Some of them swallowed diamonds. Illicit buying and selling was very risky. There was only one sentence for buying or smuggling—seven years' hard labor and no parole.

Buying was not limited to the Bloemhof territory. Camps were scattered all over the veld and as it would have been a physical impossibility for the buyers to travel from camp to camp they only went to some of the more important ones. The days were pre-arranged and the diggers brought their finds to one of the more important camps; this often meant tramping through dust as much as ten or twelve miles. Sometimes women and children tramped along half stiff and frozen, for it is also cold in Africa. The fields are all located on high plateaux and in winter, before the sun comes up, the air is biting cold and penetrating.

Gate-Opening His Specialty

The roads in South Africa were not highways. They were just dirt roads running through farms. When we wanted to go somewhere we went through farms, thousands of acres. When we reached the other side of the farm we had to open the gate, pass and close it again. That was quite a tiresome job, so I hired a Kaffir boy for that sole purpose. When we approached a gate he jumped out and opened it. He closed it after the car passed and ran and jumped on the running-board.

Buying was done only three days a week—Thursday, Friday and Saturday. There was a gentlemen's agreement among the buyers—and that was the only one—not to buy on Monday, Tuesday or Wednesday. Those days were reserved for the diggers to find the diamonds. Usually they worked Monday, Tuesday and Wednesday. Thursday they went to a certain camp where the buyers were congregated. On those days all at once a flock of cars would arrive. Then the whole camp would come to life. Diggers rushed from one office to another.

Diggers seldom knew anything about diamonds. They just knew how to find them. Sometimes they offered us a pebble which they had mistaken for a diamond.

You may think diamond digging was a very profitable occupation. At the time I was on the fields only 300 diggers out 7000 there at that time made a living and I think the figure for the average earning was £250 a year (the equivalent of $1250). The cost of living in South Africa was about 25% higher than in England.

Buying the Rough Gems

Diggers often came to see the buyers in twos and threes. Usually they were partners working the same claim and sharing in the proceeds. Sometimes the escort was simply for moral support, or perhaps to impress the buyer. Invariably the same preliminary procedure occurred, one fellow would open his handkerchief and put a little stone on the table, look at us and wait. They never stated a price. They always wanted you to make them an offer. Sometimes offers did not work out so well. Suppose the digger had two or three little stones and we made him an offer of £10. The digger might have thought they were worth £75 and if we were the ones to disillusion him he might even go as far as to call us names. Sometimes it happened that one dealer had a grudge against another. Then he used the diggers as instruments. If I had a grudge against Mr. Blank, I would send the first tough digger who came along to see him. Before I did this I would make the digger an offer above the value of his merchandise and as the digger never sold at the first offer this would not be risky. Then I would tell him confidentially that his stone was really worth more than what I could afford to pay for it, but that Mr. Blank had just received a cable with instructions to buy that particular kind of stone. Then the digger would go over to see Mr. Blank. Usually a hot argument resulted. The joke worked—I was square with my competitor.

Another unpleasant experience was this: Suppose that an unnamed digger had been coming to me every week for several months. One week he had one stone and another week two stones and we had been getting along very well. Naturally he kept coming back. One day he came in with a piece of undesirable diamond. He would never admit it to be brown or undesirable—to him it was a "fancy" stone. He was usually under the impression that if I would put it in hydrochloric acid it would turn as white as snow. He would come in as usual, smiling, and say, "I have something nice today." I would look at the piece of brown. Finally I would say, "Well, I'll give you £3." He would think it worth £30. I would offer £4-0-0, £5-0-0, then £6-0-0, even if it actually were worth only £5. "I will give you £6-10—I will give you an open offer," which meant he could go to all the buyers (there were twenty or twenty-five always present) and if none of those offered him as much as £6-10 he was at liberty to return and take the offer. This procedure was supposed to show the man our good intentions, but actually we gambled that later on the man would come back and we would make up our loss. Unfortunately, nine times out of ten he did not come back—some other buyer had thought that if Spitzel could gamble £1-10, he could gamble £2 for the good will of this digger.

Crude Methods of Mining

The alluvial diamonds which I was buying were found in rivers or in old river beds. Through floods and volcanic eruptions those river beds had sometimes been covered by earth and dirt, and when a man started to work his claim he had to remove all the earth until he found a layer of gravel. Then he started to wash it in a special machine. It was done like gold washing. After the gravel was thoroughly washed a shovelful of it was dumped in a sieve and this sieve swirled steadily for three or four minutes. This motion has a centrifugal effect and draws the minerals of the highest specific gravity towards the center of the sieve and the bottom. Then, with a quick motion, the washer turned the contents of the sieve on a table like a child would a mold filled with wet sand. If there were any diamonds in that shovelful of gravel they were found right on top and in the center of the pile.

(To be Continued)

Precious Stones Tested in Laboratory

This is not an article by the G.I.A. but a "story" about the laboratory of the Institute written by a young author who has become familiar with the work and who prepared it at the request of a popular scientific magazine. While sticking closely to facts, it loses no opportunity to glorify the laboratory. For instance, your editor is also one of the members of the "staff" so heroically pictured.

by

BRUCE SUMNERS

The identification of precious stones is usually thought of as a comparatively simple job. The majority of us have the idea that any jeweler experienced in handling gems can recognize any stone at sight. Such is by no means the case.

In Los Angeles, California, there is a completely equipped laboratory, devoted exclusively to testing jewels of all kinds. This laboratory is one of the departments of the Gemological Institute of America. Gem stones from cities large and small on this continent, and in fact from every corner of the world, are sent here for a final authoritative decision. These are gems which have defied local jewelers with only limited gem testing equipment at their command. Every instrument in the G.I.A. laboratory is either made especially for the testing of gems or has been altered by expert technicians to serve this exclusive purpose. Several pieces of apparatus already have been designed and built by members of the Institute's research department and are available in no other laboratory in the world, and others are in the course of experimentation and development.

A visit to the Gemological Institute while a batch of determinations is being run presents a fascinating new angle on what is probably the oldest business in the world—that of bartering jewels. It is an amazing experience to watch these scientists fix a costly jewel on the stage of a microscope and study it as intently as a bacteriologist studies a smear preparation.

Accurate Grading of Diamonds

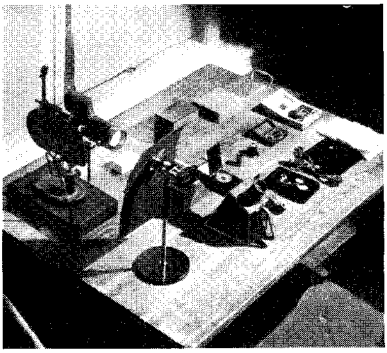
The diamond—best known of the gems to the average buyer—rarely, if ever, requires a scientific test for its identification. However, the majority of jewelers agree that one of the greatest problems of their trade today is a lack of standardization in the grading of diamonds. The often-heard term "Blue-White Perfect Diamond" has been used to describe so many grades of diamonds (some of them actually quite yellowish and not at all perfect) that it has come to mean nothing at all. The term *perfect* should mean that a stone is free from flaws under a certain magnification. The N.R.A. has specified that the magnifier used in examining diamonds must be at least seven power. To insure maximum efficiency in grading diamonds, the Gemological Institute has prepared for the jewelry trade a ten power magnifier corrected to true focus and freed from color defects. The technicians connected with the Institute have developed a special holder for the Zeiss aplanatic triplet lens system. The whole assembly is so lightly constructed that it can be used as an "loupe," which is the jeweler's term for a magnifier designed to be held in the eyesocket of the user. This new instrument weighs less than the average low power loupe formerly used for the purpose. Yet the Institute's loupe can be dropped on a stone floor without damage; its case is constructed of the very strong aircraft alloy duralumin.

The distinction of color in a given diamond is a more difficult matter than classifying its perfection. Experiments in the G.I.A. laboratory are being carried out toward the perfection of a special colorimeter to grade and record the exact hue of a diamond.

Diamonds Easily Distinguished

Because of their great hardness, their brilliancy, and their "fire" or power of breaking light into the colors of the spectrum, diamonds are easily recognized at sight by any expert. Distinguishing between other gems is not so easy. In the Institute laboratory, a battery of instruments is used to classify these stones.

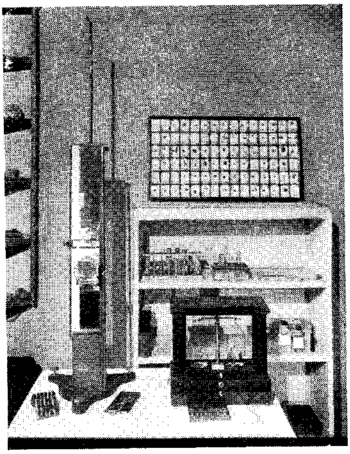
The most important instrument used here for determination, and the easiest to operate, is the *refractometer*. It measures the relative amount which a gem bends the light rays which enter it. The stone to be tested is placed on a hemisphere of dense glass and the refractive index is read by viewing a transparent scale through an eyepiece. Two types of refractometers are shown in the accompanying illustrations. Other tests are used when the refractometer fails to give a reading. The microscope especially seems to be an important aid in such a case. As each gem species has its own particular power of refraction, this index when secured serves to make a first separation. It is never enough to make an absolute determination.


PHOTOGRAPH BY HERBERT LYMAN EMERSON, JR.

Reading from foreground: Zeiss Spectroscope, Tully Refractometer, Smith Refractometer, Loupes and Dichroscopes.

A little instrument called a *dichroscope* also finds important application in gem testing. Many stones which appear to be a solid color actually owe their hue to the blending of two or three distinct colors. When the gemologist looks through a dichroscope, he sees two lighted squares side by side. These are really two images of the same opening, produced by a prism of Iceland spar. If a dichoric (twin-colored) gem is viewed through this instrument, the squares will appear as two distinct colors. It is the blending of these colors which causes the apparent hue of the gems. Many imitation gems are detected by the use of this instrument. Three dichroscopes are shown in the upper left-hand photograph of the page of illustrations.

A colorless stone, of course, can have no dichrosim. In the case of such a gem, a microscope which is fitted with attachments for polarized light is often applied. Two monocular (single eyepiece) instruments illustrated are of this type. Through a series of complex optical tests dependent upon the observation of the interference of light as it passes through a crystalline substance, the workers in this laboratory can determine the nature of the gem being tested. While the stone is still in focus these scientists study the tiny inclusions which are made visible by the microscope, and from them draw an indication of the gem's identity.



PHOTOGRAPH BY HERBERT LYMAN EMERSON, JR.
The Jolly Balance and Diamond Balance for Specific Gravity Determinations. Dense Liquids and Acids for Metal Testing.

Few Physical Tests Are Possible

Very few physical or chemical tests can be applied to precious stones. As some of these gems are worth many hundreds of dollars, bits of them cannot be chipped off for use in blowpipe and acid tests. However, two properties — hardness and specific gravity—are often used to advantage. As these tests are simply applied, they are also the mainstays of the smaller laboratories in jewelry stores throughout the country. Gems vary in hardness from diamond at 10 down to soapstone, which is sometimes substituted for jade, at 1. Through the use of sharp points of minerals of various hardnesses or of polished plates of the same substances, the laboratory staff at the Institute are able to determine the approximate hardness of a particular gem.

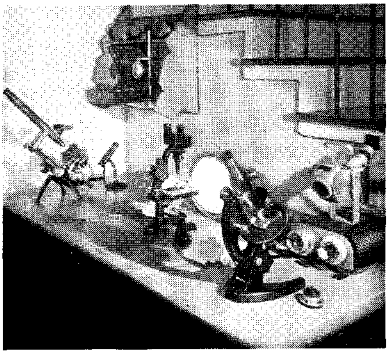
The use of specific gravity tests is known to every student of physics. Several types of balance are used by the G.I.A. to determine the specific gravity of a gem. The most accurate of these is an adaptation of the very sensitive diamond-weighing balance. The lanky *Jolly balance,* well known to mineralogists, also finds an occasional application. For very small stones, with which an accurate determination of specific gravity by weighing methods is not possible, a graded series of very dense liquids is employed.

Often a cut gem will defy all the above efforts on the part of the laboratory to determine its identity. Most of the determinations performed at the Institute are those of gems whose identity could not be agreed upon by smaller laboratories. This is a serious business, acting as final arbiter on the identity of a gem. Upon the strength of the determination made at the G.I.A., the gem may be valued at $5 or $5000. And if the gem proves to be worth only $5, it may mean financial tragedy for its owner.

Difficulties Must Be Overcome

When a gem defies the simpler tests, the Institute's staff must use more difficult methods to identify it. More complex instruments, requiring even greater skill in handling are taken from their cases. Delicate adjustments are made. Sometimes hours are required to obtain a single focus to the satisfaction of the operator. One of these instruments is the *spectroscope* which appears in two of the above illustrations. Also the fluorescence or glowing of gem stones when exposed to ultra-violet light is used as a guide. Filters are used to screen out visible light. In the dark, gems under the influence of these rays seem to shine with a self-produced light. The ultra-violet apparatus employed in this laboratory is seen in use as an illuminator for the Zeiss microscope.

For detection of synthetic jewels this laboratory is especially prepared. Several gem species have been produced synthetically; that is, stones exactly like the genuine in physical and optical properties have been manufactured by man. Corundum (which includes ruby and sapphire) and spinel are made in commercial quantities. They appear everywhere in the jewelry trade, and as they are much less valuable than the naturally-occurring gems which they reproduce, their detection is imperative. The minute bubbles in synthetics differ widely from the angular inclusions in genuine gems, and most synthetics can be detected by simple tests. The inclusions in especially difficult specimens are studied through the use of powerful microscopes and a determination made on this basis. In case the microscope test is not entirely satisfactory, the gem is examined through the spectroscope and under ultra-violet rays.



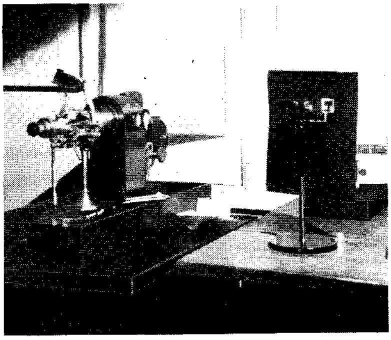
PHOTOGRAPH BY HERBERT LYMAN EMERSON, JR.

Left to right: Powell and Lealand Microscope, Bausch and Lomb Binocular Microscope, Zeiss Microscope, Hanovia-Kromayer Ultra-Violet Lamp.

The Problem of the Pearl

Cultured pearls are produced which are difficult to detect from the genuine. A mother-of-pearl ball is inserted in an oyster, which is then returned to the sea in a cage and allowed to coat the ball with a layer of true pearl. Many of these cultured pearls have exactly the same external appearance as true pearls. The endoscope is used to test pearls which have a hole drilled through them. This instrument — it is imported from France — throws an intense beam of light through a

Left: The Endoscope Used for Testing Pearls. Right: The Spectroscope.



PHOTOGRAPH BY HERBERT LYMAN EMERSON, JR.

hollow needle which is inserted in the drill-hole. A pair of tiny mirrors mounted on the end of the needle are designed to reflect the light around to the eyepiece if the pearl is genuine. If the pearl is cultured, the light is trapped between the parallel layers of the mother-of-pearl core and strong beam cannot reach the second mirror. Therefore, only a faint glow is visible in the eyepiece. Other modifications of the endoscope principle are incorporated in some instruments, but as the G.I.A. staff can adapt the endoscope to perform the same tests, these other instruments are not used in the laboratory. A delicate specific gravity determination employing a dense liquid can be used occasionally as a supplimentary test.

Other tests have to be applied if the pearl has no drill-hole through which to insert one of the special types of mirror-needle. The research workers at the Institute, however, are not satisfied with any of the existing instruments designed for this purpose. They are working along what are considered new and untried lines in an effort to develop an instrument which will determine the true nature of an undrilled pearl. If such a test is discovered it will almost entirely supersede the instruments which require a drilled pearl for their operation.

Question:

Why are Metals Generally Used as Alloys Rather Than in Their Pure State?

See *Metals and Alloys*, page 195.

BOOK REVIEWS

An Introduction to Physical Geology, **Second Edition, 1927.** ***Price $3.00.***

An Introduction to Historical Geology, **Third Edition, 1928.** ***Price $2.75.***

Elements of Geology,* 1931. *Price $3.00.

All by Dr. William J. Miller, published by Van Nostrand, New York. May be secured from any book store or from G.I.A. Book Dept.

These books reflect the lecture-room personality of Dr. Miller—smoothly expressed, brief and clear. He inclines, even in his books, a bit to the chatty side. The result is reading matter which is not cold, factual dissertation, but an interesting account of geological processes and results.

Physical Geology is an excellent elementary volume which is recommended by the Gemological Institute as supplementary general reading with the geological sections of its course No. 2.

Good Illustrations

This volume is profusely illustrated with pertinent sketches and photographs; a large number of both were personally prepared by the author. The illustrations are a valuable aid to visualizing the processes and land formations described in the text.

Much of the life of this book is derived from the originality with which Dr. Miller expresses himself. An unusual order of subject matter, which is claimed to eliminate much repetition and anticipation, is but one example. The author draws upon other sources only when absolutely necessary; otherwise he talks from his own knowledge and experience.

Historical Geology is of practical interest only to those gemologists concerned with prospecting for gems or metals. However, it is a fascinating subject for any who have time and inclination for earth history. One especially interesting part of this text is *paleogeography* (ancient geography). The evolution of the continents, particularly North America, is clearly traced, accompanied by a number of sketch maps.

Theories of Evolution Expounded

The evolution of plant and animal life, as their history is recorded in the fossils, is also told. The author presents clearly the history of the ancient fish and animals which inhabited this planet long ago, and outlines their evolution up to the present day.

Elements of Geology is an abridged combination of the two above volumes. It is necessarily very brief, inclining toward sketchiness. However, it is readable and forms a fairly complete reference book on the general subject of geology. It is recommended by the American Gem Society to those of its *Graduate Members* who are unable to continue an organized course in gemology.

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(To be Continued)

Metals and Alloys*

Can you define a metal? It is not easy. This is the first of several articles intended to give you some elementary facts about the precious metals and their alloys as they are used in jewelry.

The average person, if asked to define a metal, would find difficulty in doing so. Everyone is familiar with metal, yet the exact properties which must be distinguished in an element in order for it to fit the scientific definition are not generally known. A popular usage of the term means any substance which is composed principally of an aggregation of crystals of the metallic elements, such as copper or iron, whether or not they are combined with other elements. By a scientific definition, metals are those chemical elements which usually form solids at ordinary temperatures and which when heated and allowed to cool solidify in an opaque mass of closely interlocking crystals. The most distinguishing feature of a metal is its luster. All metals have—in greater or lesser degree—an unusual ability to reflect light. The principal reason for this is that little or no light is refracted and enters the material. The whole of the light falling on the surface is reflected. This brilliant reflection produces the high or *metallic* luster of these substances.

Other important properties of metals are their ability to conduct heat and electricity. And most metals, when pure and in compact form, may be hammered out or shaped, or drawn into wire without breaking—properties known respectively as malleability and ductility. Pure gold possesses the last two properties to a greater degree than any other metal.

The Occurrence of Metals

Metals usually occur in nature combined with other elements in mineral compounds known as ores. Only occasionally are these elements found in the uncombined or native state. Gold, because of its slight affinity (combining power) with other elements, is almost always found as a native metal. Silver is frequently found in a native state, but a principal ore of silver is the mineral argentite Ag_2S. Native copper and iron are found only occasionally.

Metals are extracted from ores by several methods. Chemical reactions in which the metal in a mineral compound is precipitated in a free state are often employed for this process. The method of smelting is well known; many ores thus brought to a temperature exceeding the melting point of the metals contained in them release their holds upon the metals and allow them to run off in the molten state. Smelting and chemical reactions are the two principal modes of recovery. Other processes are sometimes employed. For instance, magnesium is recovered from the mineral magnesite

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*A.G.S. Research Service.

($MgCO_3$) by heating this ore to a temperature considerably below the melting point of the magnesium which it contains and thereby driving off the CO_3. This leaves fairly pure magnesium.

Alloys

According to correct scientific terminology, a combination of two or more metallic elements is not a metal but an alloy. The majority of substances which are commonly spoken of as metals are really alloys. Steel (iron and carbon), brass (copper and zinc), and "German silver" (copper, nickel, and zinc) are commonly-used alloys. Any combination of a metallic element with one or more other elements, whether or not the latter are metals, is correctly called an alloy.

There are two principal types of alloy. The first of these is an intimate combination in which one of the constituents is dissolved in the other as salt dissolves in water. A less intimate combination of the constituents produces a purely mechanical mixture. Often the addition of but a small per cent of foreign elements to a metal forms an alloy whose strength and durability greatly exceed those of the pure metal. As gold is much too soft and malleable for use in its pure form, all gold jewelry is made from an alloy in which some foreign element or elements (usually silver or copper, and sometimes zinc or nickel) have been added in order to increase the strength.

Classification of Metals

Metals can be divided into three general classes:

1. *The noble or precious metals.* Osmium, iridium, platinum, rhodium, ruthenium, palladium, gold, and silver.

2. *The common metals.* Iron, copper, lead, tin, zinc, nickel, aluminum, chromium, tungsten, antimony, cobalt, bismuth, magnesium, etc.

3. *The lesser-known metals.* Such as beryllium, sodium, zirconium, and lithium.

Of these groups, gemology is especially concerned only with the first two. Common metals are used in alloying the precious metals, particularly gold. The lesser-known metals, although they are finding ever-increasing use in tool and machinery alloys, have not yet been applied in jewelry alloys.

"BLUE EAGLE" CHALCEDONY

During his Eastern trip Robert M. Shipley, president of the Institute, inspected the unusual cut chalcedony owned by Adrian Reiter of Indianapolis, Indiana. This stone, which has been featured because of its natural resemblance to the blue eagle emblem of the N.R.A., is a blue chalcedony containing a large amount of red inclusions. The inclusions surround a patch of the blue background in such a manner as to form an almost perfect eagle. This unusual cut stone was exhibited at one of the meetings of the American Gem Society which immediately preceded the A.N.R.J.A. Convention in Cincinnati last Fall.

GEMOLOGICAL GLOSSARY

(Continued from last issue)

(The key to pronunciation will be found in the January, 1934, issue.)

Commercial White. Term applied to very slightly yellow diamonds, about the same as Top Cape. See also Top Cape.

Common Opal. Translucent, only slightly colored opal without fire or play of colors, not gem material.

Compact. Consisting of a firm, closely united aggregate.

Complex Crystals. Those having many crystal forms and faces.

Compound. Enclosures at the South African diamond mines in which the natives are held under contract while they work.

Concentrates (kon'sen-trates or kon-sen'trates). Minerals or ground reduced by mechanical or chemical processes to a minimum bulk.

Concentric (kon-sen'trik). Consisting of spherical layers about a common center, like an onion.

Conch. (Pronounced konk. Formerly and still by some pronounced konch or konsh.) Any of the various marine shells, originally of various bivalve shells, now of various large spiral univalve shells.

Conch Pearls. Pearls, often pink in color from the univalves Strombus and Cassis, commonly known as Conch.

Conch Shells. Univalves of the species Strombus and Cassis employed for making cameos.

Conchoidal Fracture (kon-koi'dal). Shell-like or conchoidal fracture are terms used to describe breakage which produces curved ridges like the outside markings on a shell, or the ripple marks in water.

Conchiolin or Conchyolin (kon-kie'oe-lin). A constituent of the pearl oyster's shell.

Concretions (kon-kree'shuns). Mechanical aggregation, or chemical union of particles of mineral forming balls or nodules in strata of a different material.

Confused. Irregular, indistinct aggregate.

Conglomerate (kon-glom'er-ate). Rock composed of gravel embedded in sand which acts as a cement.

"Congo Emerald" (kon'goe). Dioptase from the Belgian Congo.

Contact Twins (kon'takt). Twins joined on a common plane.

Copal (koe'pal). A natural resin obtained direct from living trees or from "fossil resin." Kraus states that "It occurs in rounded amorphous masses generally with 'goose skin' surface and a conchoidal fracture. Hardest varieties are used for gem purposes and used especially in imitation of amber."

Copaline or Copalite (koe'pal-in or koe'pal-ite). A resinous substance, first found in blue clay at Highgate, near London, and apparently a vegetable resin, partly changed by remaining in the earth. Like resin copal in hardness, color, transparency and difficult solubility in alcohol. Color clear, pale yellow to dirty gray and dirty brown. Emits a resinous aromatic odor when broken (Dana).

"Copper Emerald" (kop'er). Dioptase.

Coral (kor'al). Hard limestone-like structure secreted by the tissues of various sea animals called zoophytes. When fossilized, the limestone-like matter is often replaced by silica.

Cordierite (kor'di-er-ite). A gem mineral species. See Iolite.

Corean (koe-ree'an). See Korean.

Cornelian (kor-neel'yan). See Carnelian.

"Cornish Diamond" (kor'nish). Rock crystal.

Corundum (koe-run'dum). Oxide of aluminum. Hexagonal system. Hardness 9; R.I. 1.76-1.77; Specific Gravity 3.95-4.10. Gem varieties, Ruby and Sapphire.

Cotterite (kot'er-ite). Quartz having a metallic pearly luster.

Cracks. Cleavage cracks which are separations "along the grain," i. e., between atomic planes in gems, and which show smooth reflective surfaces.

Cradle (krae'd'l). A trough in which placer miners wash or "rock" gem gravels. See Baby.

Crested. Consisting of groups of tabular crystals forming ridges.

Creolite (kree'oe-lite). Banded jasper.

Critical Angle (krit'i-kal). Angle which determines amount of total internal reflection.

Crocidolite (kroe-sid'oe-lite). Fibrous hornblende of a bluish or greenish color. The altered form consists of silica colored yellow, brown or red and is called tiger-eye.

Crocoite (kroe'koe-ite). A lead chromate mineral, red in color. Hardness 2½-3; specific gravity 6.0; refractive index 2.45.

Cross Stone. Chiastolite; also, staurolite.

Crown. That part of a cut stone above the girdle.

Crown Glass. The most inferior and cheapest variety of paste from which gem imitations are made.

Crypto-Crystalline (krip'toe-kris'tal-in). Indistinctly crystalline, in which the crystalline grains are not discernible even under magnification, although an indistinct crystalline structure can be proven by the polarizing microscope.

Crystal (kris'tal). A crystalline solid bounded by natural plane surfaces.

Crystal. A trade term for diamonds of a particular nuance of color. See Diamond Glossary.

Crystal Aggregate or Crystal Group. A number of crystals grown together so that each crystal in the group is large enough to be seen by the unaided eye and each crystal is more or less perfect. Differs in a gemological sense from a *crystalline* aggregate in that a gem cut from the crystal aggregate cannot be polished with a smooth surface, although such a gem might be cut from an individual crystal.

Crystal Group. Same as Crystal Aggregate.

Crystal Material. Crystal structure which does not result in a definite geometric form visible to the unaided eye is known as crystal material or crystalline material.

Crystal, Rock. Uncolored transparent quartz.

Crystalline (kris'tal-in). Having crystal structure, but without definite geometrical external form.

(To be Continued)

Modern Methods of Fashioning Gem Materials

An American company has developed a process by which they believe they can fashion gem stones in competition with the large cutting plants in Germany. Their secret lies in performing every operation with maximum efficiency. In this article, Mr. Felker tells how the cutting is done.

by

MAX N. FELKER

Felker Research Laboratory, Torrance, California

It is difficult to prepare an article dealing—as I was requested to do—with methods of gem-cutting "in general." Gem materials vary considerably in the methods best applied to cutting them. We should not expect to apply the same process to fashioning the 9-hard sapphire, and to the opal whose hardness is less than that of steel. Lapidaries, too, have their favorite methods of working and no two of these methods are the same in every detail. In general, though, the procedures favored by various gem cutters do not differ greatly.

In our shop, we handle material varying in hardness from 4 to 9. As a rule the softer substances are fashioned into ornamental boxes, desk sets, and similar objects. Facetted gems are seldom cut from minerals less than 6 in hardness and usually they are formed from stones whose hardness is between 7 and 9. As the same process which we apply to cutting quartz is applied with equal efficiency if with considerably less speed to facetting corundum, I shall explain it in detail.

The ancient lapidaries' first step in the fashioning of a gem was to "soften" the stone so that it might be cut more easily. Serpent's blood was considered an excellent softening agent to use on a rough diamond, for instance. Today we omit this step, and begin by planning as nearly as possible the exact size and form of cutting of each stone which we expect to obtain from a certain piece of rough.

Planning before Cutting

First of all, we study the material, usually holding it against a strong light, to find what flaws are present. In almost every case, it is planned to eliminate any flaws present, even though several small stones rather than one large one may result. A stone of one carat which is free from flaws is more valuable than an exactly similar gem of six carats, which has its beauty spoiled by a conspicuous blemish. By "free from flaws" is not meant, however, *perfection* in the sense that the term seems usually to be applied to diamonds—that is, clean under ten magnifications.

If the rough material is waterworn so that the exterior is nearly opaque, or if it is covered with matrix, several small patches on the surface will be polished so that the interior can be studied. If a gem crystal is perfect throughout, which it almost never is, plans can be made to cut it into one large stone.

Finest Color Sought

Color in a gem stone is even more important than freedom from flaws. It should be neither too light nor too dark, and should be evenly distributed throughout. Many stones cut in the Orient owe their hue to a small, deeply-colored spot near the culet. Often the base of the gem is placed greatly off-center, or cut deeper than it should be, in order to pick up the spot of color. In America, material which must be treated in this fashion is avoided. Rough with its color evenly distributed throughout is sought. Sometimes a gem crystal will have a fine color on one end and a poor one or none at all on the other. In such a case, we plan to fashion a gem from the good part and either abandon the other half of the crysstal or cut it as inferior material.

Most colored gems must be "lined up" or oriented in order to secure the best possible color. The reason for this is the very strong dichroism (property of being two-colored) possessed by some of these stones. A tourmaline, for instance, may be a fine green when viewed from end to end, but show an unattractive yellowish green through the crystal. To bring out the better color, it is necessary to cut the finished gem with its table parallel to the base of the crystal.

Deeper of Dichroic Colors More Desirable

In most cases, the deeper color of a dichroic gem is the finer. Especially is this true of ruby and sapphire. Sometimes, however, a rough gem crystal is of a too-dark color, or even opaque, viewed from end to end. In this case, the gem must be cut with its table parallel to the length of the original crystal. This method of lightening the color is never very successful—the resulting stone shows two distinct colors which seldom produce a pleasing effect.

In fashioning gems such as zircon and the transparent quartz varieties, where the dichroism is not pronounced, the orientation of the gem is disregarded. This is also true in the case of the singly refractive and, therefore, non-dichroic stones garnet and spinel.

Orientation by Instinct

Lapidaries who have been long at the work do not consciously orient a crystal before cutting it. They seem to have an ability acquired through years of experience, and from their fathers and grandfathers in many cases, of sensing the most beautiful gem possible from a given piece of rough. A gem cutter of this school heats the wax on his lapidary stick and begins to set the stone in it. He often is dissatisfied with its first position, melts the wax, and rearranges the stone. Once it is placed to his satisfaction, it is ready to go on the wheel. In almost every case, the finished gem proves to be the finest it is possible to secure from that crystal.

A large part of the rough material received at our factory is in pieces too big to be fashioned into single gems. A few lapidaries use a hammer to reduce the size of these pieces—especially when little or nothing has been paid for the rough. The fragments are then fashioned according to their shapes. We wish to preserve as much as possible of the rough. Also, we almost always work toward a particular finished shape. Therefore, we cannot handle our rough material in this manner. The diamond saw is used to reduce the size of large pieces of rough.

The same is true in the use of cleavage. Although many gem minerals have perfect or nearly perfect cleavages which may be used to split the rough along parallel planes, the material wasted in the application of this process more than offsets the time saved over sawing.

The diamond saw cuts quickly and in any desired direction. The saws which we use do not employ the small, three or four-inch diameter blades used in actually sawing diamonds. Our blades range from six to thirty inches and will cut through great slabs of material.

"Mud Saw" Not Favored

Some lapidaries use what is called a "mud saw." This employs the same bronze or auto-steel blade as the diamond saw, but it is charged with carborundum rather than with diamond. The charge on a diamond saw consists of finely-crushed bort. The saw blade is hacked and the bort fed into the fissures. Then a steel roller is used to embed the diamond powder firmly into the edge of the blade. Thus a rotary saw whose teeth are minute grains of diamond is produced. Owing to the greatly superior hardness of diamond over any other material, the saw cuts through rough material easily and very rapidly. A tank of kerosene, through which the saw turns, is employed to clean and lubricate the blade while it is cutting.

The mud saw does not have its charge forced into the metal. A mixture of carborundum powder and light oil or water is fed to the blade from a tank through which it turns. The saw picks up enough of this mixture as it rotates to give it cutting power. The mud saw is much slower than the diamond saw. We have also found it to be much less economical, one of our most important requirements being that of speed. For this reason, we use the diamond saw exclusively.

The Correct "Touch"

The stone being cut on the diamond saw, if small, is held against the blade by hand. It is imperative that a sharp point of mineral does not come against the blade first. This point will often strip the diamand charge from the rim of the saw and make recharging necessary. Larger pieces of material are clamped into a special holder on a swinging arm which guides them through the saw. The "touch," or pressure of the material being cut against the saw, must never be heavy. If the stone is pressed heavily against the blade, it will cause the very thin metal to bend slightly and the resulting cut will be badly out-of-line. No large saw cuts an absolutely straight line; but after using a blade a few times, we are able to predict its course with fair accuracy, place the material being cut slightly out of position, and thus cut almost as we please. A small, comparatively thick blade will yield a straight cut.

The sound which the saw makes as it cuts is an important guide. Experience teaches us the exact note which the saw "sings" as it cuts with maximum efficiency into a certain piece of rough. This note is higher or lower depending upon the hardness of the material being cut. Always, it is a whirring rasp. Visitors to a lapidary shop are usually made very nervous by the piercing sound of the working saws.

Preventing Breakage in Sawing

As the saw approaches the end of a cut, that is, as it forces its way almost to the far edge of a piece of rough, the stone very often breaks through to finish the cut. This leaves a jagged fracture and wastes a considerable amount of material. To prevent this loss, we fuse a large mass of wax to the back of the material. Even after the stone is cut through, the wax holds the two halves in position. The rough is thereby given less opportunity to aid the saw by fracturing.

Even with these precautions, no little material is wasted in sawing. The loss, however, is due largely to the necessity of removing flawed or poorly colored portions and not to actual mechanical breakage. In Kunzite, whose crystals are commonly full of both internal and external fractures and cleavage lines, the loss necessary before pieces suitable for polishing may be secured is sometimes as great as eighty or ninety per cent. Of all stones, garnet probably shows the least waste in fashioning. The rough material is usually very evenly colored and relatively free from flaws. The loss is seldom as much as forty per cent. The average loss for all rough stones between seven and nine in hardness I should judge to be about fifty per cent, even with the careful and efficient handling applied in our shop.

(To be Continued)

A. G. S. GUILDS ORGANIZED

The most important new development resulting from the numerous meetings and conferences during Mr. Shipley's 100-day tour was the perfection of a plan to re-establish the old guild system and adapt it to the retail jewelry business in this country. Immediate membership in guilds will be open to those meeting ethical requirements and having had actual trade experience. Full membership will eventually require passing of scientific examinations covering principally material which will be presented at guild meetings. Eight guilds were organized. Full details of this new plan will be published in the first issue of the new magazine *Guilds*, which will appear about February 1st.

A GEMOLOGICAL ENCYCLOPEDIA

(Continued from last issue)

HENRY E. BRIGGS, Ph.D.

Total Reflection

We will remember that when light passes from a rare to a dense medium, it is refracted toward the perpendicular, hence in that case the angle of refraction will be less than the angle of incidence. Now if the ray is passing from the dense to the rare medium, it will be refracted away from the perpendicular, hence the angle of refraction in this case will be greater than the angle of incidence. When the angle of refraction becomes so great as to be a right angle, the immergent ray will just graze the surface between the two media. When the angle reaches this point it is called the critical angle for if it is further increased, the ray will not be able to immerge from the dense medium, but will be reflected back from the surface of it according to the laws of reflection. This then is called total reflection for in this case no part of the ray is lost by absorption but all of it is reflected back into the dense medium.

Total reflection plays an important part in the beautiful effect we see in a fine faceted gem. A gem which is properly cut should confine the light which enters it by total reflection for a short period. While the light will actually be in the gem only a very short time, so short, in fact, that man could not appreciate it, yet since it travels several times as far in the gem the brilliancy will be greatly increased. It must be remembered that in use light enters a gem from all angles and this must be kept in mind when cutting a gem.

The critical angle is determined easily from the index of refraction. In this measurement air is the standard and its index is taken as 1; the sine of the critical angle is always equal to 1/n. In this we see that 1 is the standard or index of air while n is the index of refraction of the specimen in question, or that is to say the ratio between its refraction and that of the standard air. Thus the index of refraction for diamond 2.42 would be divided into 1. This will give us .4132 which is the sine of the critical angle of diamond. Now refer to a table of values of trigonometric values (in any trigonometry text-book) find this sine and the angle opposite it will be 24° 25′, the critical angle of diamond. (See table of critical angles.)

Dispersion

Dispersion is the power of separating whole light into spectrum of which it is composed. It is always accompanied by refraction although the two are independent of each other. That is, a mineral may be highly refractive and yet weakly dispersive and vice versa. Dispersion is due to unequal refraction of the spectrum which makes up whole light. A certain mineral may have the power to bend a ray of light considerably and yet it may be weakly dispersive because it bends all the spectrum almost equally. Again a certain mineral may not have a very great refractive power and yet be highly dispersive for the reason that it does not bend the spectrum evenly. Some of the spectrum may pass through, being bent just a little and then the balance may be each one bent more and more until the last is bent until it immerges from the crystal with quite a distance between it and the first portion of the spectrum. Thus we see that dispersion is directly due to refraction in one way and yet in another way it is independent of it. Dispersion is the refraction of spectrum which makes up light while refraction as we studied it before is the bending of light in a whole state.

Dispersion is measured and expressed by the difference in the indices of refraction of red and violet light of a given mineral. As in diamond the index for red light is 2.407, and for violet light 2.465, the difference 0.058 is the dispersion for diamond between red and violet. Sometimes dispersion is read between red and blue.

Systems of Crystallography

While there are thousands of different crystals, yet all of the many forms may be divided into six groups, defined by the lengths and angular relationship of imaginary lines, called crystal axes, passing through the center of the crystal. These groups are called systems.

> *Cubic System.* This system includes all crystals which have three axes of the same length, which are all at right angles to each other.
>
> *Hexagonal System.* This system includes all crystals which have four axes. The axes are arranged thus: three horizontal and equal intersect each other at 60 degrees. The fourth is either longer or shorter and is perpendicular to the other axes.
>
> *Tetragonal System.* This system includes all crystals having three axes all at right angles to each other and with the vertical axis longer than the two equal horizontal axes.
>
> *Orthorhombic System.* This system includes all crystals which have three axes all at right angles to each other, but all of different lengths.
>
> *Monoclinic System.* This system includes all crystals which have three axes arranged thus: two in the horizontal plane intersecting at an oblique angle and unequal in length, one perpendicular to the other axes and which is also unequal to the others.
>
> *Triclinic System.* This system includes all crystals which have three axes all unequal and all inclined to each other at angles other than right angles.

Occasionally we find two or more crystals which have grown together. Also we find compound crystals. These are all termed "twins" or "twin crystals."

(To be continued)

Gemological Microscopy

(Continued from last issue)

III. MEASUREMENTS OF REFRACTIVE INDEX

Two methods of measuring refractive indices, developed by mineralogists for use with the microscope, are applicable to cut gem stones. The first of these is the Duc de Schaulnes method; the second is a modification of the well-known Becke test, modified for use with cut stones by Dr. Thomas Clements of the University of Southern California.

The Duc de Schaulnes method is easily applied with a microscope which is equipped with a calibrated fine adjustment screw. It can be used only upon a gem transparent enough to permit the microscope to be focused through it.

R.I. of Diamond May Be Read

The method is applicable to any transparent stone, no matter how high the refractive index; zircon and diamond may be tested by this method. As a rule, the Duc de Schaulnes method can be applied accurately only to stones of over ½ carat and less than 25 carats. With an ordinary watch maker's millimeter micrometer, the depth from table to culet of the gem to be tested is measured. The stone is mounted on the microscope stage with the table up and parallel with the surface of the objective lens. The microscope is focused through the gem, onto the culet.

Great care must be exercised in securing this first focus, lest the objective lens strike the gem and be chipped. The microscope should be focused downward while the operator watches from the side until the objective almost touches the surface of the stone. Then, looking through the eye-piece, the operator turns the coarse adjustment back up until either the culet or the surface of the stone is in focus. If, during several repetitions of this operation, the culet does not come into focus before the characteristic dust specks and scratches of the table are seen, it will be necessary to use a lens of lower power and longer working distance in order to reach the culet.

When a focus on the culet is secured, it is adjusted to its maximum clearness by use of the fine adjustment screw. Then the micrometer reading on this screw is taken. The microscope is focused upward, using *only* the fine adjustment until the table of the gem being tested is in focus, and the micrometer reading again taken. The difference between the two readings is the *apparent depth* of the stone. The measurement made with the micrometer calipers is the *true depth*. Dependent upon the R.I. of the stone tested, the apparent depth will vary with respect to the true depth, being always less. The higher the refractive index of the gem, the smaller will its apparent depth be. This relation is expressed by the formula:

$$\text{R.I.} = \frac{\text{True Depth}}{\text{Apparent Depth}}, \text{ or } n = \frac{T}{A}.$$

Accuracy Is Essential

It will be seen at once that this method furnishes an easily applied test for refractive index. The measurements, however, must be taken with extreme care if inaccuracy is to be avoided.

As already stated, the focus on the culet must be made carefully. It is advisable first to measure the true depth of the stone and select the objective lens accordingly. If the true depth, for instance, is 8mm., obviously an objective with a working distance of 2mm. cannot be used. If the working distance of an objective is not known, it may be determined quickly by fitting the lens in the microscope and focusing upon a white card or a glass slip on the stage. The distance between the card and the objective lens when the instrument is in focus is the working distance of that particular objective. A stone of 4mm. true depth can almost invariably be measured with an objective of 3mm. working distance. This is due to the fact that the refractive index of the gem causes the length of the focus through it to be less than its true depth.

Large Stones Require Different Application

The fine adjustment on most microscopes will measure only a few millimeters. In case the stone being tested is too thick for a determination of its apparent depth by the above process, another procedure may be followed. Mount the stone table upon a glass microscope slip and place this on the stage. First focus on the slip away from the stone; note the set of the fine adjustment and call this reading F_1. Then move the glass slip until the stone is in line with the objective of the microscope. Focus through the table onto the culet (the tube must be raised in order to secure this focus) and call the micrometer reading at this point F_2.

The difference between these two readings is equal to the difference between the true depth and the apparent depth of the gem being tested, or:

$$D = F_2 - F_1.$$

The true depth (T) is measured with the mechanical micrometer, and the apparent depth (A) is determined from the equation:

$$A = T - D.$$

Substituting the value for A in the first equation,

$$\text{R.I.} = \frac{\text{True Depth}}{\text{Apparent Depth}} = \frac{T}{A} = \frac{T}{T-D}, \text{ or } n = \frac{T}{T-(F_2-F_1)}$$

All Measurements Made with Microscope

If this method is applied to a small stone, the mechanical micrometer may be dispensed with entirely. Focuses F_1 and F_2 are secured as explained above. Then a third focus, on the table of the stone, is secured. The microscope micrometer is again read and the reading noted as F_3.

Obviously the difference between F_3 and F_1 is the true depth of the stone; F_3-F_2 is its apparent depth. In this case:

$$\text{R.I.} = \frac{\text{True Depth}}{\text{Apparent Depth}}, \text{ or } n = \frac{F_3-F_1}{F_3-F_2}$$

This second method, while somewhat more difficult to apply with greatest accuracy, has the advantage of eliminating the use of the micrometer calipers. All measurements are taken with the micrometer of the microscope.

The Becke Method

Dr. Clements' modification of the Becke test is perhaps most valuable for use in a mineralogical laboratory. It requires the use of a series of liquids of known refractive index. In the ordinary Becke test, mineral grains are compared with a liquid in which they are submerged. It would be impossible to make this test on a cut stone. Too much liquid would be required for immersion, and a focus with the high-power objective, with a necessarily short working distance required, could not then be secured. This difficulty is neatly avoided by Dr. Clements' method; namely, placing a drop of liquid for comparison purposes on the surface of the cut gem.

The so-called "Becke line" is a bright border which appears when two substances of different refractive indices are placed in contact in transmitted light. In order to see the Becke line, which is very thin, it is necessary to use a high-power objective, at least 40^X for satisfactory results. The stone to be tested is mounted upright on the stage of the microscope and a tiny drop of the liquid to be used for comparison is dropped on the surface. Light must be transmitted through the stone. In order to achieve accuracy, the beam must be reduced to a small pencil of parallel rays. This may be done either by lowering the condenser and almost closing the iris diaphragm, or by removing the condenser and inserting a card with a small hole punched in it between the substage mirror and the stone.

The microscope is focused on the extreme edge of the drop of liquid and the illumination varied until the bright line or Becke line appearing at the juncture of the surface of the stone and the liquid is at its maximum brightness. Now, if the microscope is focused upward, the line will move either toward the liquid or toward the stone. If it moves toward the liquid, the liquid is higher in refractive index than the gem being tested. If the Becke line moves away from the liquid, the stone is higher in refractive index. When the line does not appear, the index of the stone is the same as that of the liquid.

A Mineralogical Test

This test is so delicate that a variation of .001 between the stone and the liquid can be detected, and it is by this method that the majority of the very accurate refractive indices published in tables are secured. However, as a Becke test requires a complete set of liquids, grading from 1.54 to 1.80 in steps of .01 or less, it is not practical for the gemologist's laboratory. It is used extensively in mineralogical laboratories, however.

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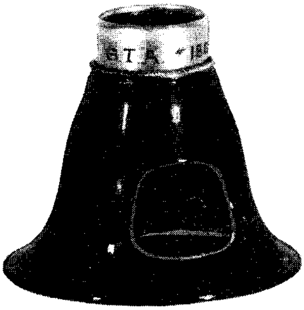

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