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Inclusions as a Means of Identification

by

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Pyrope, almandite, and rhodolite (which is an isomorphous mixture of the two) cannot be easily distinguished from one another by their internal paragenesis. They contain, however, absolutely characteristic inclusions, which are a determinative factor in their identification in respect to other red, brown-red, purple-red, purple and red-violet stones. The best-known type of inclusion in these three closely related garnets is black acicular crystals which intersperse the host-crystals in a direction parallel to the edges of the rhombic dodecahedron, as seen in Figure 8.

So far as my studies have yet proceeded I suspect these needle- and rod-like minerals to be hornblende crystals. What discriminates them from the subtle rutile needles, called "silk", in rubies and sapphires, is their arrangement. In garnets these fine rods are distributed in a distinct tri-dimensional order, often completely filling the interior of the stone. The "silk" in rubies, on the other hand, has a bi-dimensional arrangement in that the needles are deposited sagenite-like on the accretion faces of the rubies; in consequence they lie parallel to these faces and, by the periodic succession of their growth, they often form zones or the well-known hexagonal pattern when viewed along the direction of the main crystal axis.

It may, in addition, be recalled here, that Siam rubies, which might be confused with dark red garnets, never enclose rutile needles. In the red garnets these acicular inclusions lie in seeming disorder, and only close observation reveals that their position is governed by crystallographic laws. In almandite the needle-like hornblende crystals are often so thickly disseminated that they give rise to a four-ray star on the surface of cabochon cut stones, just as the rutile needles sometimes do in star rubies and star sapphires.

In rhodolites and almandites one often finds, lying parallel to the rod-like crystals, microscopic, shadow-thin, birefringent tablets, whose perimeter is either irregular or more frequently shaped like a parallelogram with displaced angles. Such delicate billets embedded between hornblende needles are clearly shown in Figure 9.

Bohemian garnets frequently contain in addition quartz crystals with beautifully sharp forms, either as isolated individuals or in groups, as in Figure 10, or else the very strange phenomenon of small unknown het-
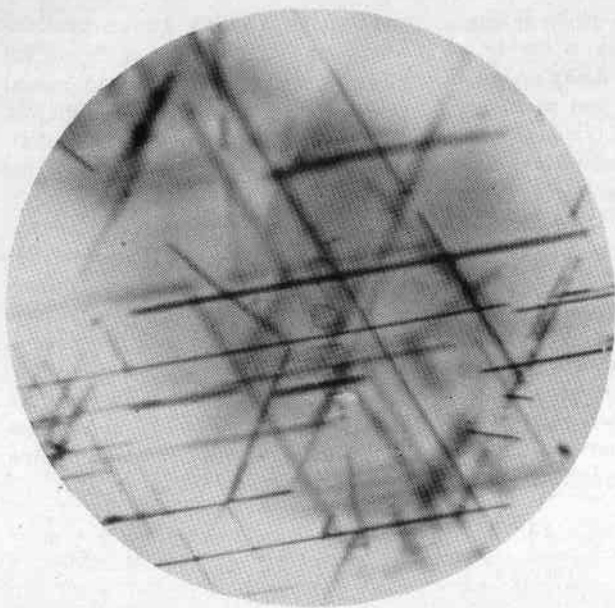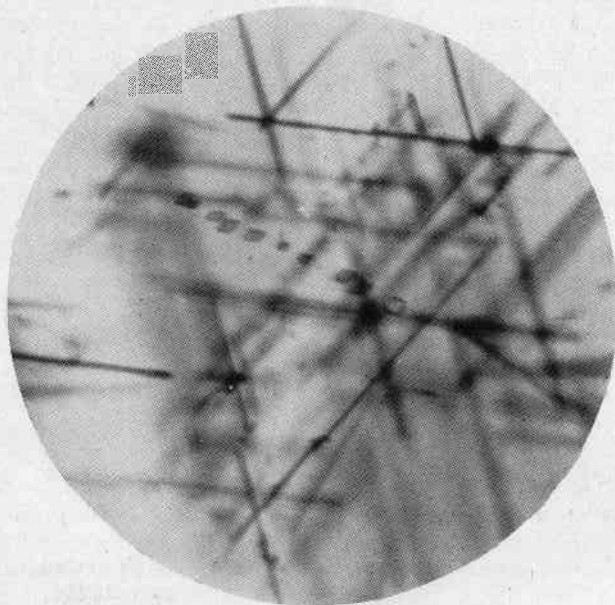
Photo by Dr. Gübelin

Figure 8
Hornblende rods as
inclusions in
almandite. 50x.

Photo by Dr. Gübelin

Figure 9
Hornblende needles
and small tablets in
an almandite. 50x.

erogeneous minerals—perhaps augite crystals—arranged in a circle, as Figures 11 and 12 manifest them. It is to be expected that many garnets from the South African diamond deposits carry diamond inclusions, as well as the reverse case occurs, since both gems join in their paragenesis.

Ceylon almandites are distinguished by an infinity of microlites more or less regularly distributed throughout the entire stones (Figure 13) showing under strong enlargement a clearly idiomorphous habit. In the intervals between these are intruded the hornblende needles described above, and, as a further local peculiarity, slightly bent, occasionally even kinked, tubular liquid inclusions. Figures 14 and 15 reveal some of their various typical shapes.

It is hardly amazing that the characteristic birth-marks of Ceylon corundums, i.e. zircons with radio halos, are evidence of their source. Here, too, the halos are caused and formed by the destructive influence of radioactive rays emanating from the enclosed microscopic zircons. Zircons and halos show exactly the same aspects as those observed in Ceylon corundums, which were mentioned in a previous article of mine in this periodical (Figure 16).

(To Be Concluded)
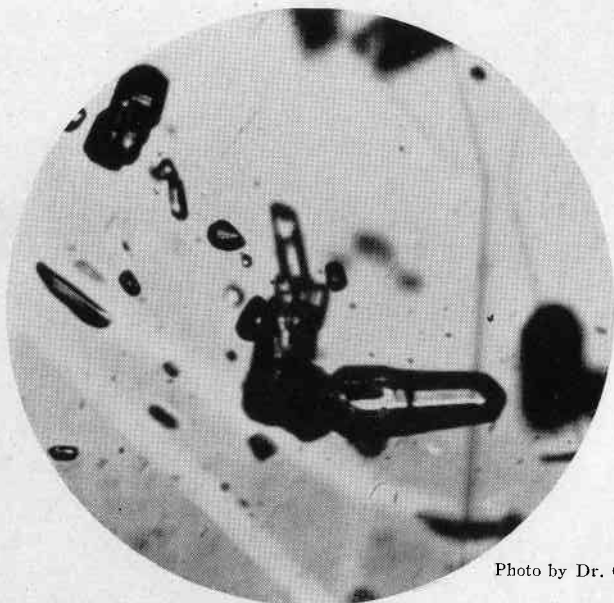
Photo by Dr. Gübelin

Figure 10
Group of quartz crystals embedded
in a Bohemian garnet. 40x.
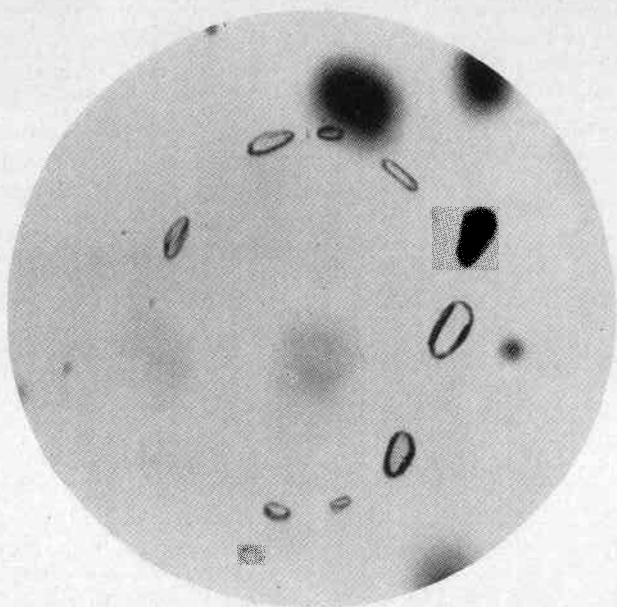
Photo by Dr. Gübelin

Figure 11
Augite (?) crystals
arranged in a circle
as inclusions in a
red garnet. 50x.

Photo by Dr. Gübelin

Figure 12
Augite (?) crystals
forming a circle in
an almandite. 50x.
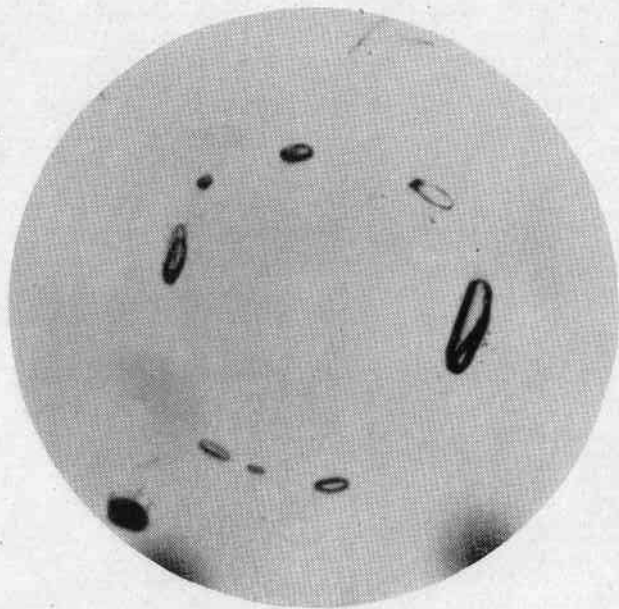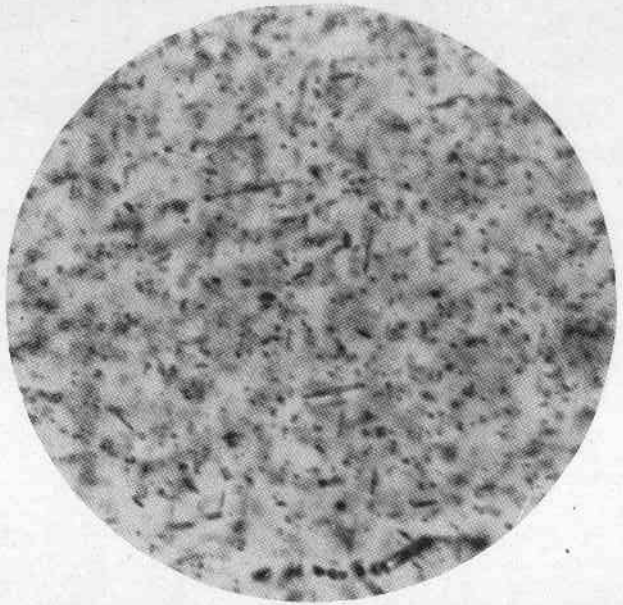
Photo by Dr. Gübelin

Figure 13
General view of
enclosed microlites
as is typical in
Ceylon almandite.
20x.

Photo by Dr. Gübelin

Figure 14
Liquid-filled tubes
and microlites as
inclusions in Ceylon
almandite. 20x.
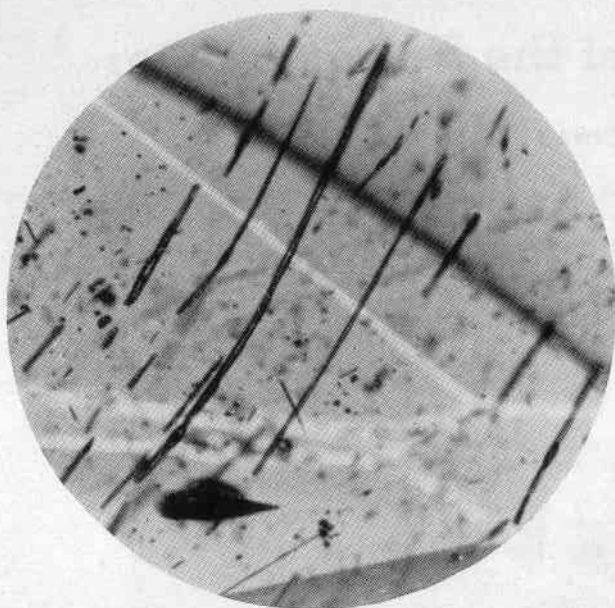
Photo by Dr. Gübelin

Figure 15
Liquid-filled tubular
inclusions in Ceylon
almandite. 20x.

Photo by Dr. Gübelin

Figure 16
Group of included
radioactive zircons
with halos in Ceylon
almandite. 80x.
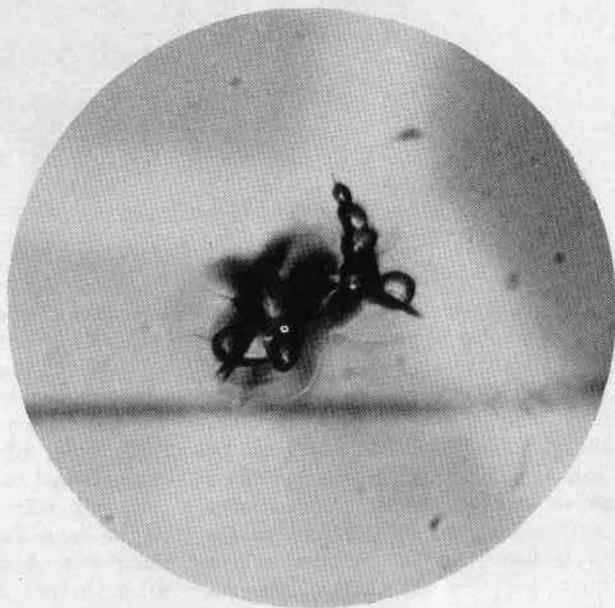
Use of the Refractometer

by

KENNETH G. MAPPIN, F.G.A., C.G.

There are various methods of measuring the refractive indices of gemstones, as an aid to identifying their mineralogical species, and while all of them have their uses in spe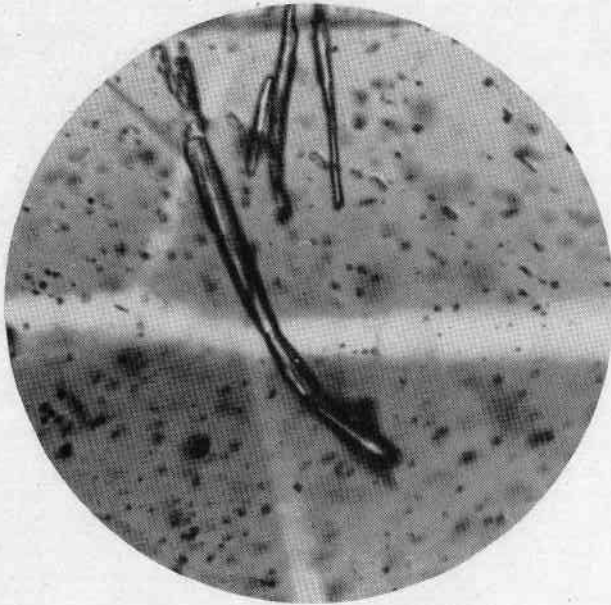cial cases, by far the most useful and practical for the gemologist is the employment of an instrument known as a refractometer.

fractive indices of the two media in contact and the critical angle at total reflection; and, while it is limited in range by the refractive index of the constant medium, it has the great advantage of giving direct readings, thus eliminating all further calculations. These direct read-
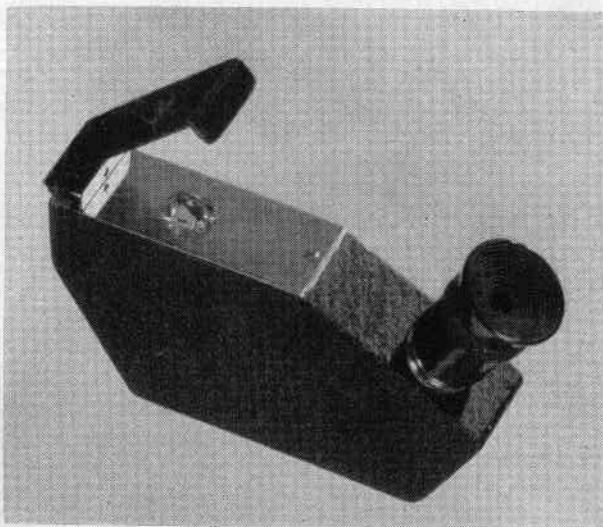
The Rayner Refractometer

strument known as a refractometer.

It is hardly necessary in an article such as this to go into the details of the construction of the instrument which has been well covered in the G.I.A. educational courses by Shipley's *Gemology*, Herbert Smith's *Gemstones*, and other authoritative textbooks on the subject. This method is based on the relation which exists between the ratio of the re-

ings take the form of a line running horizontally across a graduated scale, so that all that is necessary is to look through the eyepiece and take the reading where the light and dark fields meet, which is the horizontal line referred to above.

As all refractometers are based on the same fundamental principles the choice of the instrument is not so important as is the source of

light which is vital for accurate results. If white light is the source of illumination, the shadow edge on the scale appears coloured. This coloured edge is in reality a spectrum, with the violet lying in the dark portion and the red merging into the light portion. The correct reading for the stone lies somewhere in this coloured edge and is taken as a rule where the yellow and green meet.

If, however, a monochromatic light is used, such as a sodium flame, the shadow edge on the scale is sharp and clear so that an accurate reading can be made without difficulty. In the past it has been difficult for gemologists to obtain a suitable type of monochromatic equipment because few have the advantage of a laboratory, having to do their work in the store itself or at best in an adjacent office. The Gemological Institute of America has completely overcome this problem by the production of an excellent outfit which can be used anywhere, which was described in *Gems & Gemology* in the Spring number, 1945. The writer has used many types of equipment from the burning of salt in the flame of a Bunsen burner to quite elaborate apparatus and has no hesitation in recommending the G.I.A. set to anyone contemplating changing from ordinary to monochromatic light.

So far we have mentioned the one shadow edge given by singly refractive material. But the greater number of gemstones are doubly refractive and will show two distinct shadow-edges on the dial of the refractometer. In some gems such as olivine (peridot) 1.658-1.696, the edges are so widely separated that they may be seen even with ordinary light,

while others such as beryl 1.575-1.582 are so close together that practice is required to separate them with monochromatic light, and in white light it would be practically impossible to do so.

Further examination of the effect produced by doubly refractive material will reveal some very interesting facts. If the stone is revolved so that the facet under observation remains parallel to the plane surface of the glass of the refractometer it will be noticed that the edges will move up or down the scale. It is necessary to manipulate the stone until the highest and lowest readings obtainable are noted. These are the greatest and least of the principal indices of refraction, and the difference between them is the maximum birefringence of the stone. If the facet selected for observation is perpendicular to the crystallographic axis, i.e., the direction of single refraction, neither edge will move in the case of an uniaxial stone, while if it is biaxial, one edge remains fixed and the other moves between the extreme values of the other two principal refractive indices. For identification it is not necessary to bother about the intermediate index because the greatest and least of the principal indices are all that are required.

If the stone to be tested were placed so that it rested directly on the glass of the refractometer, a thin film of air would intervene and prevent a reading being obtained. To obviate this, a drop of some liquid is placed between the stone and the glass to ensure good optical contact. This liquid must have a higher refractive index than the stone under test, and a drop of it

is first applied to the glass; then the stone is pressed firmly down onto it, care being taken to avoid any sliding or sideway movement which might scratch the exceedingly soft glass of the instrument. In view of the fact that the R.I. of the liquid 1.780. So, it is wise to check periodically the liquid itself on the refractometer to avoid confusing the shadow-edge of the liquid with stones of approximately the same R.I., such as corundum or almandine garnet. There are many highly re-
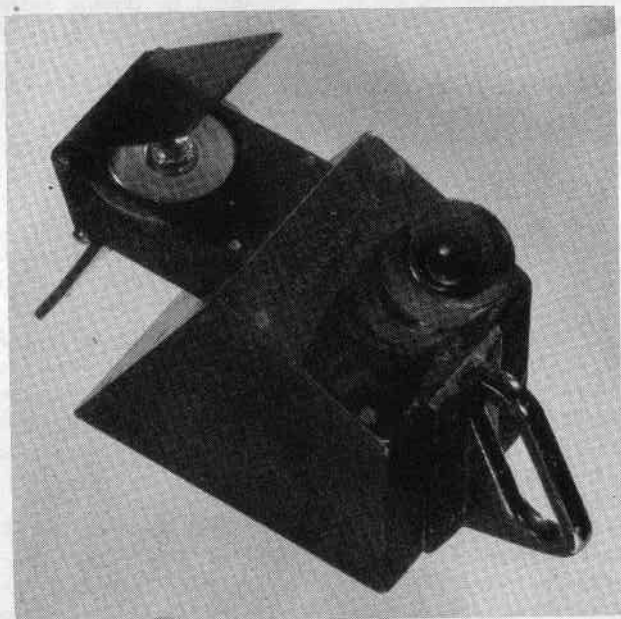
The Tully Refractometer

must be greater than that of the stone, it is desirable to have one with as high a refractive index as possible. Probably the most convenient liquid for general use is methylene iodide (CH_2I_2). Pure methylene iodide has a refractive index of about 1.742, but this can be raised to about 1.800 by saturating it with sulphur, which is sufficiently high for the majority of gems. In common with most highly refractive liquids the saturated solution of methylene iodide is not constant, the excess sulphur gradually crystallizing out, causing the index to fall to about fractive oils on the market with indices up to about 1.70 which are much pleasanter to use and comparatively constant, and I would recommend that at least one of these oils be kept, in addition to the saturated solution of methylene iodide, and used whenever possible; falling back on the higher liquid if necessary. The majority of gemstones have refractive indices lower than 1.70 and the use of methylene iodide is unnecessary with those.

Let us now summarize the uses to which the refractometer may be

Zincite

by

E. P. HENDERSON

Associate Curator, Mineralogy and Petrology
U. S. National Museum

Zincite, the well-known mineral from Franklin, New Jersey, possesses a most striking bright red color. It is so common that persons interested in minerals are likely to have a reasonably good specimen of it in their collection. However, to have zincite as a gemstone is indeed rare, in fact, it has not been listed in the popular texts on gems. Since some cut gemstones recently appeared in collections, it seems worthy of a brief note, calling them to the attention of gemologists and at the same time to record their properties.

Most of the zincite is massive, granular and without external crystal form, but there are a good many specimens of this mineral which exhibit well-developed platy cleavage. Now and then there are small areas in some of these cleavage pieces which show a clear, translucent gemmy material but because of the cleavage it is unfit for cutting material. When sizeable areas are found which yield small cut stones it is usually irregularly colored with red and orange-yellow areas.

Mr. R. B. Gage, a well-known collector and dealer in minerals from Franklin, at the time of his death had in his private collection a mass of quite clear zincite which was found on study to be worthy of cutting. Mr. Nicola Goodwin D'Ascenzo, who acquired part of the Gage collection, and is himself interested in obtaining gems from as many of the different minerals as possible, decided to have this material cut. From this one specimen[1] six zincite stones were cut and three of them are now in museums. The largest cut stone weighs 16.27 carats and is in the American Museum of Natural History; the next largest of 12.7 carats is in the Philadelphia Academy of Sciences, and the Roebling collection of minerals of the U. S. National Museum now contains a 5.12-carat stone. The remaining three stones are in the private collection of Mr. D'Ascenzo of Bala-Cynwyd, Pennsylvania, and their weights.are as follows: one of slightly over 12 carats, another 1.17 carats and the smallest of 1.10 carats.

The important physical properties of zincite which are noteworthy to students of gemology are the following: Color is deep ruby, the hardness is 4, which makes it far too soft to ever become an important gemstone. It has a subadamantine luster, and refractive indices of ω 2.013 and ε 2.029, both of which are well above the range in which gemologists are equipped to determine the indices. Zincite is not pleochroic. Specific gravity is 5.5-5.68.

The color of zincite is of interest since chemically pure zinc oxide

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[1]Mr. D'Ascenzo supplied the weights of the zincite gems.

GEMOLOGICAL DIGESTS

American Synthetics Easily Identified

The Gemological Institute of America has not been able to substantiate recent reports concerning the comparative difficulty of detection of the new American synthetic rubies and sapphires, as compared with those of prewar European manufacture.

An exhaustive sampling of the new American synthetics has shown that, contrary to report, the new American stones are very much easier to identify than the great majority of prewar European synthetic rubies and sapphires. Anyone who has passed the Junior Gemologist examinations of the G.I.A. should be capable of detecting any of these new synthetics.

Sampling was accomplished by the G.I.A. through cooperation of its members in several cities, who either loaned or purchased cut and uncut stones which were tested and classified in the Institute's Los Angeles laboratory.

No American synthetic ruby or sapphire was found which a Certified Gemologist, using 60x magnification, could not have identified quickly and easily.

Gems & Gemology readers will recall that the Spring 1944 issue carried a reprint of an address, "American-made Synthetic Crystals," by A. K. Seemann, engineer of the Linde Air Products Company, manufacturers of synthetic corundum, confined so far in the trade to ruby and to white sapphire.

In a recent discussion of his organization's policy, Mr. Seemann stated emphatically that there had been no attempt upon the part of the firm to produce stones without the inclusions by which the synthetics are distinguished from the genuine stone, nor did the firm desire to eliminate such characteristic inclusions.

This is consistent with all previous evidence which supports the belief of those in the jewelry trade that the firm desires to work with and for the best interests of the industry, and to keep the industry advised of the exact nature of its products.

A Chrysoberyl with Chatoyant Effect

A flattened double cabochon stone, weighing 115 carats, was recently examined, which, though not a specimen of any beauty, was of some scientific interest.

The stone was practically opaque, and showed a fairly clear chatoyant ray along the length of the oval-shaped piece, but in addition there was a feeble ray to be seen at right

angles to this, forming a crude 4-point "star."

The appearance was reminiscent of some Ceylonese chrysoberyls I had seen previously, and my supposition was confirmed by a density test, giving a value of 3.71, and by a broad absorption band in the violet seen when a concentrated beam of light was passed through the thin edge of the stone. There was no opportunity to study the internal structure of the specimen.   *B. W. Anderson.*

Use of the Refractometer

(Continued from Page 250)

put by the gemologist, assuming that he is using monochromatic light:

1. It is possible to obtain the refractive index or indices of a stone by simply reading it off a scale, at least to the second place of decimals. And, with a little practice, to calculate the third place by eye.

2. In most cases it is possible to tell whether a stone is singly or doubly refractive.

3. The birefringence can be measured.

4. The negative use: The refractive index of the liquid is known, or can be read on the scale. Place the stone under test in position. If no reading is obtained, then the refractive index of the material is greater than the liquid, so that all stones with a lower index can be eliminated.

5. All these tests can be applied equally well to a mounted stone.

In submitting a stone to tests on the refractometer, greater accuracy is possible if the instrument is fitted with a polarizing eyepiece; but if not, equally good results may be obtained by rotating a piece of polaroid in front of the ordinary eyepiece.

If monochromatic light is not available and white light is used, an orange-coloured filter placed over the aperture will reduce the dispersion.

In conclusion, a word on the care of the refractometer. Like all optical instruments it is very delicate and easily damaged, and has a very vulnerable point in the highly refractive glass hemisphere where the stone is placed, which is very soft. The stone must be put carefully *"down onto"* the glass and not pushed into position sideways.

When not in use the glass should be covered with a thin layer of vaseline, and when removing this it should be dabbed at the start and then rubbed carefully with a clean lens paper.

Before use, see that the surface of the glass is clean. If it is stained or dusty, a little carbon tetrachloride or jewelers' rouge may be used to bring it back to a bright, high polish.

Always wipe the glass clean immediately after using methylene iodide, otherwise the glass will become stained.

The G. I. A. Fluorescent Unit

by

JOHN T. SHANNON, E.E., M.E.

Because of its design and construction, the high-intensity mercury lamp is especially suitable for many laboratory tests and inspection purposes, and for the activation of fluorescent materials.

Of these lamps which are made in several sizes and shapes, those having an inner lamp of fused quartz and a hard glass outer envelope are best suited for most of the purposes we will cover in this article.

Research in the Gemological Institute of America's laboratories has shown that the lamp described here is the most efficient for activation of fluorescence in diamonds especially. Its results are comparable to those of an arc lamp with a Wood's filter, which was cumbersome and

dangerous for the jeweler to use. No harm, either to eyes or skin, can be caused to the operator of this fluorescent lamp, even if it is used over long periods, as its wave lengths are too long.

The G.I.A. Fluorescent Unit, which fulfills the jeweler's and gemologist's requirements better than any others, consists of: A spun aluminum housing which contains the transformer ballast with a 6'

cord with standard attachment plug to fit into any convenient outlet; a filter holder into which the lamp snaps (held in place by three shock-proof springs); a socket in a small aluminum cover which screws onto the back of the lamp (with both a bracket for holding it to the top of the transformer ballast can and a bale which can be used as a carrying handle, or, together with the bracket, may be converted into a stand when the lamp is used remote from the ballast).

The unit consumes 100 watts of current in the lamp itself, but requires, for proper functioning, a ballast transformer to control the current and voltage to the burner.

To prevent the lamp's use without the transformer ballast which is necessary for all mercury lamps (by being screwed into a standard socket) the base is of the admedium screw type, slightly larger than a standard lamp socket and smaller than a mogul.

In addition to the minute amount of mercury in the lamp there is also a modicum of argon gas, which acts as a carrier gas for starting. When the current is turned on a small spark occurs between this starter contact in the burner and the nearest cathode; this spark creates sufficient heat at the activated cathode to release a few electrons which travel through the carrier gas to the other cathode and thus provides a conducting path the length of the burner for the main line current which starts to flow and slowly heats up the lamp. The auto-transformer ballast prevents any runaway current and as the lamp slowly heats this control prevents too rapid heating with possible injury to the burner.

Current at the start is nearly twice that of normal, but voltage, internal pressure, and of course, temperature, are low. As temperature rises, pressure and the voltage increase and the current comes down. At the end of three minutes stabilization occurs and the lamp will operate at its normal and proper rating of 800 MA and 142 V.

As a certain amount of the activating oxides are lost during each starting and heat-up period, the life of the lamp is really based upon the number of starts and stops and not upon the hours of burning, so the fewer starts and stops the better. If the lamp is turned off it will not re-light until it has cooled. It will then automatically start again if the current has been turned on and the regular cycle of starting and heating to stabilization point again occurs.

The light of this fluorescent lamp is not all full spectra with continuous light of every color merging into the next color like that of an incandescent lamp, but in narrow bands in the ultra violet, violet, blue, green, and yellow. By the use of filters and combinations of filters these bands may be separated and light of one particular color may be obtained as wanted:

	Angstrom	Filter Numbers
Ultra Violet (for creating fluorescence)	3650 line	5860 or 5874
Violet	4050 line	306, 428, 597 in combination
Blue	4360 line	038, 511 combination
Green	5460 line	Complete isolation with all three— 350, 430, 512
Green	5460 line	350,512 transmits some red (which is lacking in mercury)
Yellow	5780 line	348,430

Some gemstones have not only their own particular refractive in-

dex, but also their fluorescence characteristics, and a study of individual gems from this standpoint is not only of great interest, but leads to some very valuable and scientific knowledge of the gems themselves.

Two filter holder rings are furnished with the unit. One is a 5" roundel, No. 5874, Corning, blacklite filter (heat resisting, red purple). The other is designed to take the standard 3⅛" square filters.

Square filters of the various colors mentioned below, and Angström lines, are obtainable for use with this lamp. The only square filter furnished regularly with the G.I.A. unit is the yellow filter, which being 5780 Angström units approaches, but does not equal, the efficiency of the G.I.A. Monochromatic Lamp.

Since refractometers are calibrated for the D lines of sodium, which lines are from 5890A to 5900A, and also since the wattage of the lamp itself is too great, G.I.A. recommends this filter (on this Fluorescent Unit) only as a substitute for its Monochromatic Lamp Unit, but does consider its use more efficient than that of daylight.

A spill ring louvre is supplied, if desired, to prevent light spread. All of the filter holders and louvres are slip-on fits, and all fit one another so they may be used interchangeably.

For the jeweler and gemologist perhaps the greatest value of this fluorescent unit is its use to activate fluorescence in diamonds. Not only does it instantaneously reveal those diamonds which will slightly vary in color grade between artificial light and unfiltered daylight, but it is already being used by jewelers to more strongly individualize diamonds.

Zincite

(Continued from Page 251)

should be white. Most analyses of this mineral show the presence of manganese oxide and it has been assumed some of the manganese is present as Mn_2O_3 which could impart such a color to the host mineral.

The zincite gem in the U. S. National Museum is emerald cut and measures 9.3x7x4 mm. It contains an internal fracture and a small inclusion of the reddish-orange color can be detected in one end. Along one side there is a small white inclusion assumed to be calcite. To the unaided eye this zincite is otherwise clean and displays a beautiful rich red color. When examined under the microscope numerous delicate fibers are noted, some of which are in tufts while other individual threadlike inclusions are scattered through the clear gemmy areas. These inclusions are not identified but since this mineral occurs in a metamorphic limestone it is quite likely that these delicate fibers are one of the amphibole asbestus group, probably byssolite.

Note: For a more complete description of zincite the readers are referred to any standard text on mineralogy or to Professional Paper 180 of the U. S. Geological Survey, "Minerals of Franklin and Sterling Hill, Sussex County, New Jersey," by Charles Palache, 1935.

Absorption Spectra of Pyrope Garnet and Red Spinel

by

B. W. ANDERSON, B.Sc., F.G.A.

(Continued from Page 233, Summer Issue)

To return now to a more complete description of the two absorption spectra which concern us, let us deal with the garnet first. "Pyrope" is, in a sense, a courtesy title, for no garnet even approximating the pure theoretical pyrope, $Mg_3Al_2(SiO_4)_3$, has ever been found in nature.

As is well known, the garnets form an isomorphous group, and all varieties of garnet are mixed to some extent with other garnet molecules. In the case of pyrope, almandine is . the main intruder and the majority of red garnets used as gemstones are strictly neither pyropes nor almandines but almandine-pyropes. To avoid using this cumbersome term we usually acknowledge as pyropes those blood-red specimens from the Cape, Bohemia, Arizona, etc., which have refractive indices in the region 1.74-1.75, and include as almandines the more purplish-red garnets with indices 1.76 upwards to 1.82. As a fact, this classification accords well with what the spectroscope tells us. Almandine has an easily recognizable absorption spectrum of which the strongest bands are three in number. These, which are rather broad, and almost amalgamate in a deep-coloured specimen, are centred at 5750, 5270, and 5050A. These bands

are due to iron and are part of the make-up of the almandine molecule.

By observing the strength of the bands in the spectroscope the observer can obtain a rough idea of how much of the almandine molecule is present in any particular garnet. With the pyropes instanced above, the main colouring agent is chromic oxide, and the weak almandine spectrum is more or less swamped by the intense broad chromium band. The strongest and narrowest of the almandine bands, however, at 5050A in the blue-green, is usually to be discerned—and while it is seen the distinction between pyrope and spinel is solved by this feature alone.

Turning now to spinel, the pure red and pink types have, in common with ruby, the faculty of emitting fluorescent red light when strongly illuminated. As with ruby, when the brightly lit stone is examined obliquely through the spectroscope, narrow discrete fluorescence bands can be seen. Whereas in ruby, however, the emitted light is concentrated almost entirely in one brilliant line (actually a pair of lines very close together) with spinel the effect is noticeably different. A group of five distinctly separate lines can be seen in the deep red, the two in the centre of

the group being the strongest, though even these do not approach the ruby doublet in intensity. The effect is that of a "fluted" band reminiscent of the violet cyanogen bands seen in any carbon arc.

When these fluted fluorescence lines are seen the stone can be definitely claimed as spinel, since, in my experience, only three gemstones show narrow fluorescence bands in the red, and of these spinel is the only one to show this multiple effect. The third mineral alluded to is pink topaz, in which I have detected a very feeble red fluorescence line on several occasions: the effect is far too faint to be confused with that shown by the other two minerals.

Spinels of darker red may show quite a number of narrow bands in the red and orange; the strongest being a doublet, as in ruby. When specimens of a more purple-red are studied it will be noted that apart from the broad central absorption region, the typical chromium features have disappeared. With still more bluish specimens we begin to note the iron spectrum typical of blue spinel, which will be dealt with later on in a separate article.

As this article has been somewhat discursive, I will try to summarize the features by which the absorption spectra of spinel and pyrope can be distinguished from those of other red minerals, and from each other.

Both spectra can be distinguished from that of ruby, as they lack the clear-cut fluorescence line in the deep red and the three narrow bands in the blue, typical of ruby. Pyrope shows no fluorescence lines; faint narrow bands in the red and a broad absorption region extending from the yellow to the green. A narrower band at 5050A can usually be seen, and serves to identify the stone as a garnet. Spinel, when pure red, shows a group of 5 fluorescence lines in the red, giving a fluted appearance. Deeper red specimens show a broad absorption region centred noticeably nearer to the green than in pyrope. Comparison with known specimens of either mineral or with permanganate absorption bands etc., as suggested earlier in the article, will help to establish the position of the broad central band on which the decision may rest. With the editor's permission, in my next article I will venture to step outside the limits of my subject for a little, and consider some of the other means by which red spinel and pyrope may safely be distinguished from one another.

Errata

BOOK REVIEW

Dictionary of Gems and Gemology, First Edition, by Robert M. Shipley, founder and executive director of the Gemological Institute of America, and of the American Gem Society; assisted by Anna McConnell Beckley, the late Edward Wigglesworth, Ph.D., C.G., and Major Robert M. Shipley, Jr. Published by the G.I.A. and obtainable through its Book Department; 254 + XI pp.; price $5.50.

This book, of handy, relatively small size, is a glossary of over 4000 English and foreign words, terms and abbreviations which may be encountered in English literature concerning gems, or in the gem, jewelry or art trades. The subjects covered also include ornamental, decorative, and curio stones.

The senior author has also written two other published works: *The Story of Diamonds,* in its second edition in 1941; and *Famous Diamonds of the World,* in its third revised edition in 1944. Mr. Shipley was a jeweler with years of successful commercial experience before he inaugurated systematic gemological study in the United States.

The definitions were written by the compiler, Mr. Shipley, and were condensed and checked against books, reports and articles from English, French and German sources. Naturally we find that the definitions and classifications are different from those of some standard authors; but many such points show improvement, being up-to-date in most respects.

Following the Introduction we find a chapter giving directions for the proper use of the book, certainly a desirable feature. In the future

revised editions which are promised, constant improvements will be made. There will also be as a companion book, a *Dictionary of Diamonds,* to consider this subject in ratio with its true importance.

The author states: "In determining the format of this book the compiler's principal purpose was to produce a compact, all-inclusive reference book which for the layman or the beginning student would (1) be a pocket-size volume, (2) contain a definition of every unusual word or term used in any of its own definitions, and (3) contain all essential gemological information in such form that it will create a demand that it be revised and expanded frequently . . . "

The book is intended for several groups of readers, (1) the prospective buyer of jewelry or gemstones, (2) the beginner in the study of gemology or novice in the jewelry trade, (3) the reader of other gem literature, (4) the graduate or advanced student of gemology. The reviewer would like to add that for those interested in mineralogy and geology, and for those who appreciate or collect gemstones, the book will prove of outstanding value. In the words of a well-known authority

on the subject of mineralogy, this is a work to which "every mineralogist should have access."

The terms discussed are printed in easily read, bold-face type, and erroneous or misleading names of gems are distinguished by being enclosed in quotation marks; both of these are ·very desirable features, preventing confusion. Names of authorities mentioned in the definitions appear with a brief biography of their books in the alphabetical entries of the dictionary. An effort has also been made to include in alphabetical order the names, descriptions and addresses of organizations, museums, laboratories and periodicals which are especially concerned with gems.

The reviewer finds the book impartial in its views and statements, and free from any very noticeable errors or serious omissions. Opinion may vary on some details, as, for instance, whether the tree-like inclusions in moss agate must always be green; and the geologist or petrographer would certainly say that thin sections of rocks and minerals are much more widely used by the student of structural materials such as building-stones, and in the study of rocks and ores associated with them, than by the mineralogist.

The whole subject of definitions and related matters seems to be fairly and completely presented so far as present knowledge allows; in future editions this should be even more complete. The fact that many of the definitions have already appeared in serial form before the author's public (in a glossary published quarterly in *Gems & Gemology* from 1934 to 1940) assures a certain measure of accuracy and authenticity.

There has more recently appeared a somewhat similar book entitled *The Jeweler's Dictionary*, published in New York, 1945, by the *Jewelers' Circular-Keystone* (Chilton Company). This work of 272 pages covers a wider field than that of gemology proper; it pays as much attention to watches, metals, metalcraft and apparatus connected with the setting of gems and watchmaking, as it does to definitions directly pertaining to gems and gemology, which are therefore very much fewer in number.

The printing in Shipley's *Dictionary of Gems and Gemology* is clear and good, and the quality of the paper stock is excellent in spite of wartime conditions. Paragraphs and words are well spaced. A pronunciation key is furnished for terms which are expected to give difficulty to the reader or student. Cross-references are numerous; entries are in bold type in the definitions, to indicate those to be consulted in other parts of the book. A page of corrections and additions is given with the book to give the very latest information.

In recommending it for more serious consideration of those interested in the subject of gems, the reviewer can only say that he has greatly profited in its inspection.—
Alfred C. Hawkins.

DIAMOND GLOSSARY

(Continued from page 238 of last issue)

parure. A set of jewelry, such as a parure of diamonds, consisting of rings, bracelets, earrings, brooch, etc.

Pasha of Egypt Diamond. One of the world's famous diamonds; an East Indian diamond described by Emanuel as an octagonal brilliant weighing 40 (English) carats, of good quality and "lively." Purchased by Ibrahim, viceroy of Egypt (1848) for £28,000, it was the most magnificent gem in the Egyptian Treasury, where it still remains, according to Farrington, Smith and Schlossmacher. However, when Ismail, first khedive of Egypt (1863-1879), was deposed and exiled, historians of the period recorded that he carried with him an immense treasure. George Young, an authority on Levantine conditions and Ottoman law, states, "When Ismail embarked on his costly yacht (June 30, 1879) with a cargo of crown jewels and other public property, he took with him no regrets of the Egyptian people." Later it was reported that the diamond was sold to an Englishman and offered for sale by Streeter. The name of the purchaser was not revealed.

paste. (1) A name now used loosely to mean any variety of glass employed as an imitation of diamonds or other gemstones (Kraus, Anderson). (2) More specifically, any lead glass similar to strass (Anderson). (3) A name used generally for cheap, inferior glass

imitations as distinguished from strass (Smith).

Patos Diamond. An alluvial Brazilian diamond found in 1937 near Patos, Minas Geraes, in the Sao Bento River. Weighed 324 m.c. Color, brownish. (Pough)

Patrocinho or Patrocinio Diamond. A Brazilian diamond mentioned by Streeter, in 1882, as having been found in 1851 "near the source of the Rio Patrocinho"; weight, 120⅝ carats.

Paul I Diamond. An Indian diamond listed by Emanuel, and later by Dr. Sydney Ball, G. F. Herbert Smith and other writers on gemstones as being in the Russian Treasury, ruby red in color and weighing 10 carats. Emanuel states that Paul I paid 100,000 gold rubles for the diamond. Dr. Fersman, in his "The Russian Diamond Treasure of the Union of Soviet Republics" does not list a ruby red diamond known as the Paul I, but describes a "celebrated" rose diamond weighing 13.40 m.c., "often mentioned by Russian novelists, for which Paul I cheerfully paid 100,000 gold rubles."

pavilion. The portion of a fashioned diamond below the girdle.

pavilion facets. (1) In general, the facets on the pavilion of a diamond or any other gemstone of any style of cut. (2) In the diamond cutting trade, the term applies especially to the four main bottom facets of the brilliant cutting. The other

four large facets on the pavilion are called the **bottom corner facets.**

Peach Blossom Diamond (Fr. *fleur de pêcher*). A rose-colored diamond, one of the few remaining gems of the French crown jewels, purchased by Louis XIV and later displayed in the Louvre museum in Paris. Listed in the inventory of the French Regalia (1791) are three diamonds of a peach blossom hue: a pear-shaped diamond of 24 13/16 carats, valued at 200,000 francs; a brilliant of 14 14/16 carats, valued at 25,000 francs; and a brilliant of 14 12/16 carats, valued at 30,000 francs.

pear or **pear-cut diamond.** Term sometimes used to describe a pendeloque diamond or any other diamond the girdle outline of which resembles a pear in shape.

pear-shape diamond. A term loosely used to describe any diamond the girdle outline of which resembles a pear in shape. Such diamonds, in fact, possess more or less flattened pear shapes.

"Pecos diamond." An incorrect name for quartz from region of the Pecos River in Texas and New Mexico.

pectolite. A secondary mineral found in the Kimberley pipes; sometimes deposited in fissures or deep fractures in the surface of diamonds (Sutton). H. 5; S.G. 2.7-2.9; subtranslucent or opaque; whitish or greyish (Dana).

pendant-cut brilliant. The anglicized name for a pendeloque.

pendeloque (pahn'd'loke). A French word, meaning *pendant*, used in the American gem trade to describe the pear-shaped or egg-shaped modification of the round brilliant cut, but with the nar-

rower end more pointed. The wider end may vary from a semicircle to the width of a narrow marquise. It differs from the briolette in that it has a **table**, usually eight-sided, and a **culet,** usually round. It also differs from the **oval cut.**

pentagon (cut). A name for any of several modifications of the **step cut,** the girdle outline of which possesses five sides. A **modern cut** of which the **bullet cut** is one variety.

"perfect." A term which has been widely used in the United States to describe diamonds. Defined by the Standard dictionary as "without defect or lack," it implies such an ideal condition to the uninformed buying public. Therefore a few retail jewelers used the term *"perfect diamond"* to mean a diamond free from internal or external flaws, or other defects, of fine color quality, of almost ideal proportions and excellently polished. Other jewelers omitted from its meaning any reference to proportions or polish, while the majority used it to mean only a freedom from inclusions or other internal flaws. The strength of magnification used in detection of flaws varied in the trade from two power to fourteen power, with two to six power in the majority, but with ten power aplanatic loupes in use by most diamond importers. In 1938 the **Federal Trade Commission** promulgated a ruling in which the word *"perfect"* was defined as meaning absence of "flaws, cracks, carbon spots, clouds or other blemishes or imperfections of any sort when examined by a trained eye under a

(To Be Continued)

Diamond Cutting by the Electric Arc Method

Postwar announcement of a method to greatly increase the industrial diamonds cutting rate in certain directions has been made. The method, developed during wartime by Chauncey G. Peters, and his associates, Karl F. Nefflen and Forest K. Harris, of the National Bureau of Standards, employs the electric arc, and has not yet been commercially applied to gem diamond cutting.

Mr. Jan Taeyaerts voiced the opinion of certain industrial diamond authorities (in his article, "Will Electric Arc Diamond Cutting Reduce Diamond Costs?", in the September, 1945, issue of *Guilds*) that while the arc method is a step forward, its value, commercially, has not yet been established. That article gives in detail the bases for the statement.

To quote briefly from the National Bureau of Standards' Research Paper RP 1657:

Abstract

The method universally employed for cutting plane surfaces or facets on diamonds has been to place the diamond in contact with a flat cast-iron lap charged with diamond powder and rotated at about 2,000 revolutions per minute. In the work described in this paper it was found that by producing a high-voltage electric arc at the contact between the diamond and the lap, the cutting rate is materially increased for all orientations of the diamond, and good progress can be made directly on a natural octahedron face, where cutting without the arc is almost impossible.

By applying the arc to a diamond saw the sawing rate is greatly increased, and diamonds can be sawed regardless of the orientation of the cut relative to the crystal axes.

Summary

By connecting the lap of a diamond cutting machine to one of the secondary terminals of a 5,000-volt power transformer having a current of about 0.5 ampere flowing through the primary circuit and the dop to the other terminal, a bluish arc is produced at the contact of the diamond and lap. Under these conditions the cutting rate is materially increased for all orientations of the facets relative to the crystal axes of the diamond. Good progress can be made directly on the octahedron faces, where no appreciable cutting could be effected by the methods generally employed. Similarly, by applying the arc to the diamond saw the sawing rate is greatly increased and cuts can be made in the diamond under any orientation.

The details from the Research Paper which are of the greatest interest gemologically are:

Test of Cutting Rate

To determine the effect of the electric arc on the cutting rate, experiments were run on some 25 different diamond crystals, including octahedrons, cubes, dodecahedrons, three-point, capes and macles.

Several well-formed diamond crystals were especially prepared by cutting a base and table accurately parallel to one another. The distances between these two facets before and after making the test cuts were carefully measured with a

micrometer. The tables were cut to an area of about 8 square millimeters, 0.013 square inch, before the rate data were recorded. Thereafter, the time required to remove an additional thickness of from 0.010 inch to 0.040 inch was used to determine the cutting rate, which is taken as the time required to remove a layer of 0.001-inch thickness from a facet of about 8 square millimeters, 0.013-

cut parallel to the octahedron face, which makes angles of 35 degrees with the three crystal axes. Figure 2 shows the facets cut parallel to a dodecahedron face, which is parallel to one axis and makes angles of 45 degrees with the other two axes. Figure 3 shows the facets cut parallel to the cube face, which is parallel to two axes and perpendicular to the third.
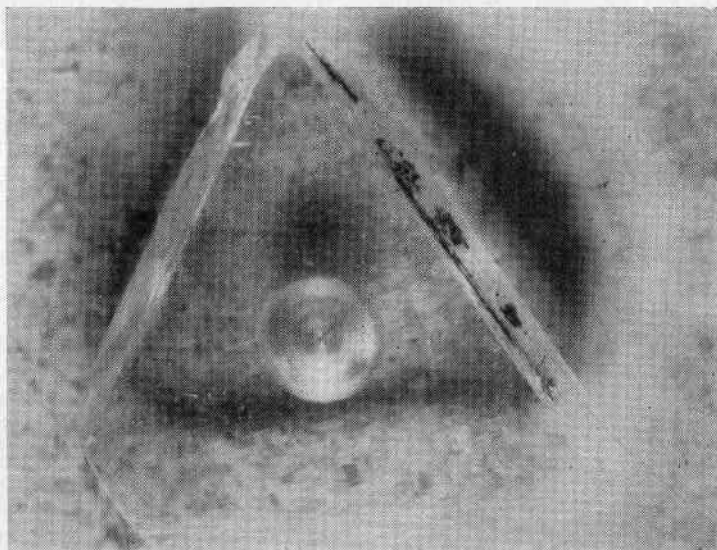
Journal of Research of the National Bureau of Standards

Figure 1.—Facet cut on the octahedron face of a diamond.

square-inch area. Test cuts were also made on the back faces of diamond dies, figure 1. The thickness removed was accurately determined by means of a micrometer microscope sighted through the die window.

The base and table in each case were cut accurately parallel to one of the principal crystal faces of the diamond. Figure 1 shows the facets

On the octahedron face the rate of cutting was the same for all directions of motion of the lap surface. On the dodecahedron face the maximum cutting rate resulted when the direction of the lap motion was parallel to the crystal axis shown by *A* in figure 2, and the rate was at a minimum at 90 degrees to that direction as shown by *B*. For the cube

face, the cutting rate was at a maximum when the lap direction was parallel to one of the two axes as shown· by *A* in figure 3 and at a minimum at 45 degrees to those directions as represented by *C*. For intermediate directions the cutting rate lies between these extremes. In the table are given the maximum and minimum cutting rates, as defined above, with and without the arc, for diamonds cut on the three crystal faces. For like conditions of crystals face and lap direction there was but little variation of rate between individual diamonds.

COMPARISON OF CUTTING RATES

	Time in minutes	
	Without arc	With arc
Dodecahedron face (fig. 2) :		
Lap direction *A*	5.3	4.8
Lap direction *B*	255.0	63.0
Cube face (fig. 3) :		
Lap direction *A*	15.0	9.2
Lap direction *C*	110.0	45.0
Octahedron face (fig. 1) :		
Three-point cape and macle	>5,000	62.0
Regular octahedron	>5,000	39.0

From these data it is seen that when cutting is done on the dodecahedron face with the lap direction parallel to the axis, *A* (which appears to be the most favorable condition for cutting diamonds), the rate is about the same with or without the arc. With the lap direction at right angles to the axis, *B*, however, the arc increases the cutting rate about four times.

On the cube face, when the cutting was parallel to one axis and at right angles to the other, *A*, figure 3, the arc doubled the rate, and at 45 degrees to the two axes, *C*, it increased the rate by about two and one-half times.

For the octahedron faces without the arc, no cutting resulted in any direction of the lap motion; that is, not as much as 0.0001 inch layer could be removed in a day's time. This agrees with the experience of expert lapidaries.

With the arc, however, the cutting rate on the octahedron face equals the rates found for the unfavorable directions on the cube and dodecahedron faces, which in turn have been augmented about four times by the use of the arc. That the arc facilitates such rapid cutting directly on the octahedron face is the most striking result of this work. This should make it possible, in designing industrial diamond tools, to take full advantage of the orientation of the crystallographic directions of the diamond with respect to the cutting surface of the tool.

The data presented here have been obtained from facets cut parallel to the three principal crystal faces. Additional quantitative cutting-rate data are being accumulated for other definite orientations of the facets.
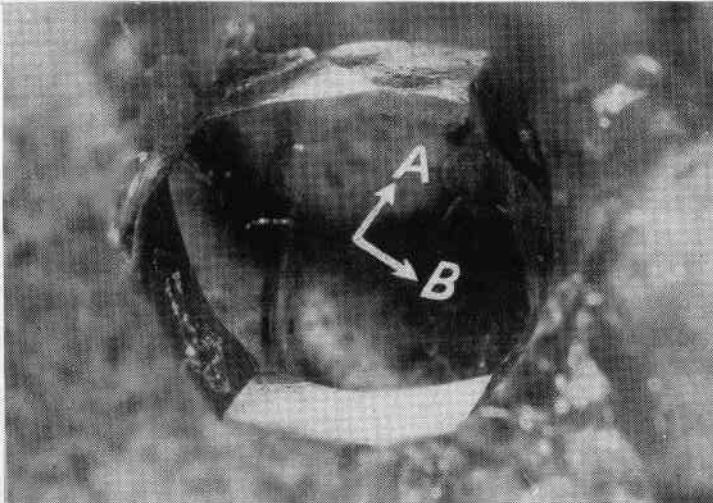
Test of Sawing

Sawing diamonds by established methods can only be performed in certain directions parallel to either a cube or dodecahedron face and have been called the "sawing grain." According to Grodzinsky, "It is almost impossible to saw the diamond in other directions even if they differ a few degrees from the original axis." It should be added that when sawing parallel to the cube or dodecahedron face the direction of motion of the saw edge should be nearly parallel to one of the crystal axes.

To test the effect of the arc when applied to diamond sawing, a saw previously employed for slicing sapphire and spinel during an investiga-

tion of jewel bearing materials was employed. This machine, which has a phosphor bronze disk 6 inches in diameter and 0.012 inch thick rotating at about 2,800 revolutions per minute, cannot be considered efficient for sawing diamonds. The diamond was mounted in an insulated metal block, which was connected to one secondary terminal of the trans-

inch long, 0.015 inch wide, and 0.017 inch deep was produced in 75 minutes. Sawing on the dodecahedron face of the diamond in figure 2 with the direction of motion of the edge of the saw parallel to the crystal axis, that is, in direction A, a cut 0.14 inch long, 0.020 inch wide, and 0.030 inch deep was made in 15 minutes.

Figure 2.—Facet cut on the dodecahedron face of a diamond.
Direction A, parallel to one axis ; direction B, perpendicular to one axis.

former and the disk was connected to the other terminal. With the aid of the arc, which is formed at the contact of the diamond and saw edge, the diamond can be sawed regardless of the axial orientation.

The relative sawing rates for different directions agree with those found for similar directions when cutting was done with the flat lap. Sawing directly on the octahedron face of the diamond in figure 1, with the direction of motion of the saw edge parallel to the face, a cut 0.14

When sawing at right angles to the crystal axis or in direction B, figure 2, the sawing rate was about the same as for the octahedron face.

If we define the cutting or sawing direction as the direction of motion of the diamond particles imbedded in the lap or the edge of the saw, the maximum cutting rate results when that cutting direction is parallel to one of the crystal axes. Under this condition the cutting direction makes angles of from about 35 to 45 degrees with the octahedron faces or
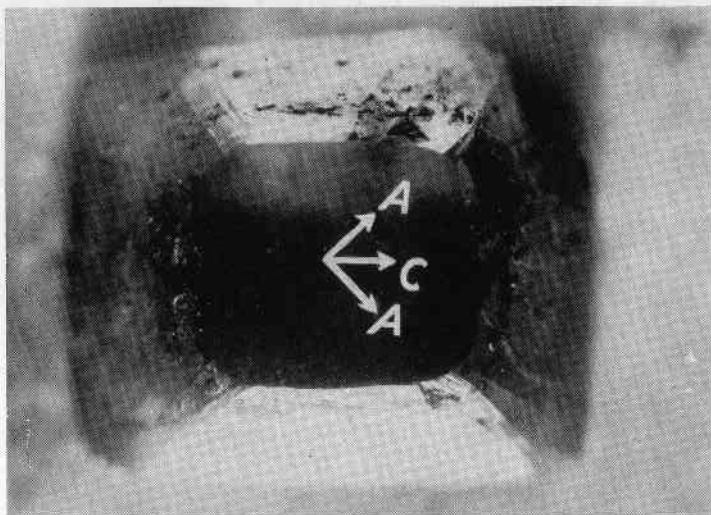
Figure 3.—Facet cut on cube face of a diamond.
Direction *A*, parallel to one axis ; direction *C*, 45 degrees to two axes.

cleavage planes. When the cutting direction is parallel to the octahedron faces or cleavage planes the cutting rate is at a minimum. For other orientation the cutting, or sawing, rate lies between these two extremes. These same rules should hold for the rate of wear in diamond dies.

Experiments are now in progress the purpose of which is to find the explanation of the electric phenomena involved in the arc cutting, sawing, and drilling of diamonds. However, the data now accumulated do not justify definite conclusions regarding the nature of the process.