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On the Cover

A beautifully shaped orchid brooch carved from one piece of amethyst. Actual size.

Photo courtesy American Swedish News Exchange, New York City, New York.

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Procedures for Cutting and Grading of Diamonds

by

GEORGE R. KAPLAN

In one respect, human behavior is as predictable as the "grain" of a diamond; the layman's inevitable reaction to his first sight of a rough diamond will be, "It looks like dirty broken glass; I wouldn't pick it up on the street if I saw it lying there."

That's a good, if unpoetic description of the rough diamond's appearance. It's usually heavily frosted, irregular, and even jagged in shape, yet easily indentified by its adamantine luster, and by its basically octahedral shape. The carbon atoms which make up the diamond are always arranged, with a precision inconceivable to the human mind, in a form of cubic octahedral space-lattice, and this atomic arrangement always finds some expression either on the surface or on the inclusions in the diamond. These are the clues which enable the diamond cutter to find the "grain" (cutting direction) of the diamond.

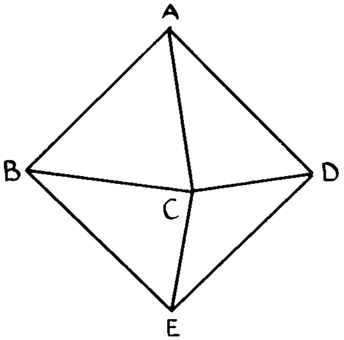
The diamond's hardness is unique. It is far harder than any other substance known to man. To the jeweler, and to his customer, this is important because therefore, the diamond, for all practical purposes, permanently resists weathering and all normal abrasion. The diamond is the only substance which can be worn for generations and still retain the exact appearance it had the day it was cut. It is possible with the diamond to "eat cake and still have it" — indefinitely. However, the diamond's hardness is not infinite; anyone familiar with the use of diamonds in industry knows that diamond points used in the dressing of grinding wheels do eventually wear down.

While the diamond is hard, it is also brittle. It is well-known that a sharp blow by a hard object, particularly on a thin portion of the diamond, may result in chipping or breaking. Certain diamonds are more apt to break than others due to excessive internal strain which can be compared to a coiled spring under pressure within the diamond. Any sharp blow or temperature change may allow this "spring" to expand, shattering the stone. For example, it is very bad practice to heat a diamond in setting, etc. and then to cool it in water. Because diamonds scratch or even chip other diamonds, it is also bad practice to throw jewelry together in a box, even if that box is somewhat padded on the inside. Any contact between diamonds will injure both to some degree; probably more diamonds and jewelry are injured inside a "safe" jewelry box than anywhere else. The remedy is simple; don't permit the individual pieces of jewelry to touch each other.

Diamonds are actually softer in some directions than in others. This is a result of the orientation of the atoms making up the diamond. The hardness of any direction in the diamond varies with the density of the atomic structure in that direction. Diamond polishing can only be successfully done because hardness varies with different directions in the same plane. The softest available direction in any plane in the diamond is called the "grain" by the diamond polisher or sawyer, as that is the direction along which he can cut the stone. These difficult hardnesses are always predictable, since they are a function of the constant atomic structure.

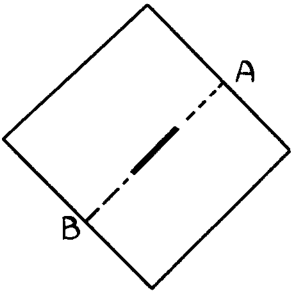
To the diamond cleaver, "grain" is actually not the softest, but the hardest available direction. The cleaver is not interested in finding the softest possible direction—he wants the most fragile direction; the direction in which the diamond will split most easily; these are parallel to the octahedral faces. There are eight octahedral faces, which, since they are in pairs parallel to each other, yield four directions along which the diamond may be cleaved. These four planes of relative fragility exist regardless of the outward shape of a gem diamond.

The process of cleaving is essentially the same as splitting wood with a chisel. The first step after it has been determined just where and in what direction the diamond is to be cleaved, is to dig a groove in the diamond by using sharp-edged pieces of diamond as tools. In the diagram, (Figure 1) the four cleaving directions are: ABC, ACD, DCE, BCE. The groove must run exactly in the direction of the cleavage plane and should be so located on the stone that it lies as far as possible from the other cleavage planes. The reason is obvious; the diamond should be allowed only one easy direction of cleavage—the one chosen by the cutter. The groove must be sharply etched, that is, the cross-section of the groove must resemble a "V". This is achieved by using progressively sharper and sharper diamond "sharps" as the groove grows deeper. It is then possible to insert a steel wedge in the groove and have it rest about half-way up the sides of the groove instead of on the bottom. A sharp tap on the wedge now will not only produce a downward force, it will also cause spreading forces which split the diamond apart. The groove has been so placed, however, that the diamond only has one convenient direction in which to split, and therefore, falls into two pieces exactly as planned by the cleaver, with the cleaved surfaces shining smooth.



• **Figure 1 Cleaves are parallel to ABC, ACD, BCE, CDE.**

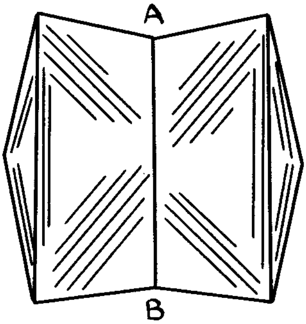
Cleaving is quick, it is safe in the hands of an expert, but it is wasteful. The cleaved pieces usually bear almost no resemblance to any diamond shape in vogue today, and therefore, the resulting polished stones may weight only 30 to 35% of their original rough weight, thus only about two-thirds the yield obtainable by sawing the diamond. Despite these disadvantages, certain diamonds must be cleaved; reasons are either one or several of the following:



• **Figure 2**

Flaws following the cleavage plane, Figure 2.

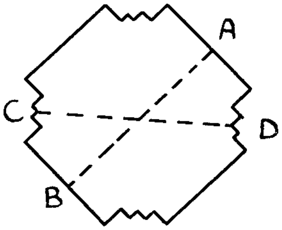
These flaws may be cracks, clouds, zonal color bands or inclusions oriented along the cleavage planes. Cleaving through this plane A to B yields two clean fragments.



• **Figure 3**

Full or partial twinning, Figure 3.

Twinned stones cannot be practically sawed. Since most diamonds are 180° twins, sawing directions or grain, in one half, is not grain in the other half. The usual way to divide such a stone is to cleave it through the twin plane from A to B achieving two single crystals which now lose all the unfortunate (for the cutter) characteristics of the twin.

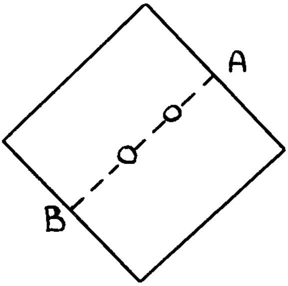


• **Figure 4**

Shape, Figure 4.

Certain diamonds are so shaped that cleaving is actually more efficient than sawing. Here is one common shape with well-developed etch figures or pits where the octahedral points should be. It is easy to see that cleaving from A to B yields much larger stones than sawing from C to D, where the resulting pieces would be much too flat.

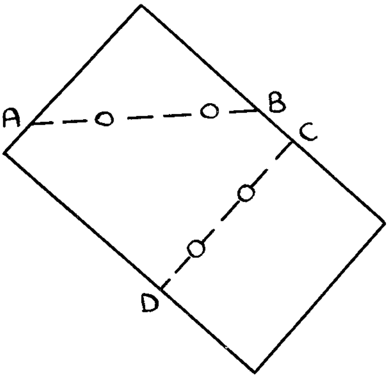
A diamond with one or more unusually developed dodecahedral faces may present a similar situation.



• **Figure 5**

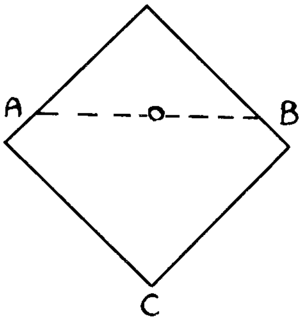
Location of flaws, Figure 5.

If all or most flaws can be eliminated with a single cleave A to B and cannot be reached with a single sawing, the advantages of a cleave are obvious; yield is sacrificed to greater clarity.



• **Figure 6**

Location of flaws plus distorted shape, Figure 6.
In this case, there is usually a combination of cleaves or of a cleave (CD) and a saw (AB). In this example, three clear pieces are obtained. Since drawings are only two dimensional, the really complicated problems of diamond division cannot be depicted—but they are often as interesting and intricate as problems in chess.



• **Figure 7**

Sawing, Figure 7.
Sawing, on the other hand, is slow, but the shapes it yields are the most economical possible, and often achieve percentages of over 50%. The reason for this is quickly seen. Sawing is performed in the cubis directions (A to B) and thus the sawed surfaces represent the largest possible cross-section of the diamond. Opposite this large surface, which becomes the table of the gem, is the natural point of the octahedron, which becomes the culet of the gem (c).

The saw used in cutting through the hardest substance in the world is a soft phospher-bronze disc hardly thicker or stiffer than a sheet of paper. Of course, a mixture of diamond dust and oil must be rubbed into the outer edge of the saw so that it will cut into the diamond. It is interesting to note that this abrasive charge is self-perpetuating. The diamond dust scraped off the saw is replaced by the diamond dust removed from the diamond being sawed, so that the soft metal disc can be used indefinitely unless some accident occurs or it is used to try to saw a diamond "off the grain" in a relatively hard direction. In order to speed up the action of the saw, and indeed, to get through the diamond at all in some cases, it is sometimes necessary to shift the point of attack as when sawing wood around a knot one will saw a little from here and a little from there. For this reason, the sawing machine is capable of fine adjustment in every possible direction, and the pressure which the saw exerts upon the diamond can be adjusted. The length of time that diamonds take in sawing is highly variable. For example, a one carat stone can usually be sawed in six to eight hours. However, an exceptional stone may require a week of incessant maneuvering by the sawyer to get through a twisted condition or an included twin. Two carat stones on the average require eight to twelve hours on the saw. Three carat stones on the average require twelve to twenty-four hours, and so on, so that a ten carat stone can be sawed through in twenty hours or may take five times that long depending on the stone. Fortunately, one sawyer can tend a whole battery of machines, often as many as twenty-five to thirty-five, and thus can saw a great many stones at the same time.

There is only one process in which "grain" plays no part — that is "bruting," or turning the stone round on a lathe. The diamond to be rounded is mounted in a lathe and held there either by a special cement or by mechanical means or both. It is then turned against a lathe tool consisting of another diamond which itself is being roughly shaped. This is the only cutting process in which a considerable amount of diamond dust is recovered. For this purpose a little box is placed just under the cutting machine. Bruting doesn't depend on grain because it is essentially a chipping operation, where each diamond is continually breaking tiny bits off the other. When properly done, the chips are microscopic in size and the girdle smooth and even. When forced, the stone is not round, the girdle is rough, and may even be "bearded" meaning that the girdle may exhibit thousands of small hair-like fissures.

Up to this point the diamond has been cleaved or sawed through its inclusions to provide clean pieces, and these pieces have been roughly shaped in bruting, but the diamond still looks dull and lifeless. It is in polishing that the beauty inherent in the diamond is brought out. Practically any facet on the diamond can be polished, but only in certain directions; each facet has one softest direction which the polisher calls "grain." A million diamonds lined up the same way would have the same grain on each of their facets, but as soon as that facet is changed slightly in its orientation the grain — the softest direction — changes as well. One of the arts of the diamond polisher is to polish as close as possible to the theoretically ideal grain.

The theory behind polishing grains is simple. The polishing abrasive is diamond dust, and since there are countless millions of these particles used on each facet these particles are arranged in random directions. The effective hardness of all these particles is the average hardness of all diamond directions, and, therefore, these particles will not effectively polish a diamond in any direction harder than the average. Thus, the necessity for finding soft directions on any facet we polish.

The diamond to be polished is held in a small vise called a "dop" which in turn is foxed by a length of very pliable copper wire to a long arm called a "tang." This is then allowed to rest on the abrasive diamond dust-covered surface of the lap, which is a large iron wheel revolving in a horizontal plane at about two thousand RPM. The wire, connecting the "dop" and the "tang," permits of extremely fine adjustments in position of the diamond while being polished; that is how the skillful polisher can make all the facets exactly the shape and size they should be, and can have the edges of the facets meet exactly where they should, in a definite pre-determined point. It must be remembered that the polisher not only must exactly shape each facet, but he must also do so while constantly changing the direction in which he is polishing these facets so that he stays in the grain.

Polishing brings out the brilliance and fire inherent in the diamond; but it only achieves the maximum brilliancy and fire possible if certain rules are observed strictly and exactly.

First, the stone must be symmetrical (if a brilliant cut, round) and there must be no irregularities or blemishes marring the polish.

Second, the table (measuring from bezel to bezel) must be just over 53% of the stone's diameter, uniform and centered.

Third, the bezel (main top) facets should be equal, properly located, should make an angle of 34° with the plane of the table.

Fourth, the pavilion (main bottom) facets should be equal, properly located, and should make an angle of 41° with the plane of the table.

Fifth, the girdle should be smooth, even and just thick enough to resist chipping.

Sixth, the culet should be centered, round and large enough to resist chipping (the culet should never be large enough to be seen with the naked eye).

Seventh, the stars and top breaks should be equal in depth.

Eighth, the bottom breaks should extend ¾ of the way from the girdle to the culet.

Ninth, the polished diamond should be 60% as high as wide, with two sevenths of this height above the girdle and five-sevenths below.

Tenth, the narrow cross-section of all cuts of diamonds are governed by the same rules.

Any deviation from the above ten commandments of diamond cutting will result in loss of life, leakage of light and in confusion of reflections. There is no permissable reason for an improperly cut diamond. There is no reason to sacrifice the essential beauty of the diamond to achieve the lesser aims of greater weight or increased productivity in manufacture.

After the diamond is finished in cutting, it must be graded for size, for color, for clarity (freedom from flaws) and, last but most important, for cutting. Grading for size, of course, in properly cut stones, merely involves weighing the stone. In improperly cut stones, grading for size is far more complicated, as then both "spread" and weight are taken into account to achieve the most favorable possible assortment for the seller.

Color grading can be made into a relatively objective process. The colorimeter is one way in which the personal factor is reduced; a similarily useful yardstick is the use of master grading stones, which can be evaluated on the colorimeter if you wish to have your color grading system correspond to the American Gem Society standards. In some respects, master grading stones, if not superior to the colorimeter, are at least more flexible, for they can be used to grade fluorescent stones, blues and browns, as well as whites and yellows.

Color grading, even with the aid of master stones, should be done in light as white and as constant as possible. The ideal is uninterrupted north light on a clear day; failing this, the Diamondlite gives good results. The poorer the available light the more essential the master stones become. The background should be as pure a white as possible and arranged in a groove so that the diamonds can be examined and compared for color girdle up.

It is advantageous to have master stones not only for the grades one normally stocks, but also for all the other standard color grades. This offers protection in purchasing, in selling (to debunk the claims of over-enthusiastic competitors), and in case of trade-ins. It is important also to know the ratio in price between different grades in your color box. These ratios can, in general act as guides when comparing other sizes, or other perfections of the same colors. For example, if a flawless half-carat of color "X" will be worth twice as much as a half-carat V.V.S. of color "Y". Similarily, a flawless carat stone of color "X" will be worth about twice as much as a flawless color "Y" stone. These ratios are useful only when comparing generally similar goods. Stones of fair to fine color will not show the same ratios as stones of extremely poor color; stones of good clarity will not show the same ratios as stones which are heavily imperfect.

Clarity, in a diamond, refers to the ease with which light passes through the stone. Inclusions are serious in the degree to which they interfere with this passage and, therefore, with the brilliance of the stone. A small inclusion near the culet, since it is reflected all over the stone, often is considered a more serious defect than a much larger inclusion near the girdle; a small, sharply opaque may be much worse than a large translucent inclusion. Inclusions in diamonds are made up of three general classes; the more or less spherical pin-points, grains or clouds; the long feathers and fissures; and last, the inclusions running in planes, the fezels, the knot lines, and the zones of discoloration. Each of these types are serious when they interfere with the essential beauty of the diamond—its brilliance. Just as in colors of the diamonds, different grades of perfection bear specific value ratios to each other. In similar goods, these ratios hold good in all regular sizes and colors. However, shifts in the

(continued page 375)

Thoughts on Cause of Color in Precious Opal

by
G. FRANK LEECHMAN

It is commonly said that opal is amorphous, but this general statement is, perhaps, not strictly correct. There are so many varieties that they cannot reasonably be put all under one heading. It is true that common opal may be amorphous, but X-ray investigation shows that this mineral has normally some regular internal structure. (References 6 et sequi).

Precious opal must not be confused with common opal, particularly as it obviously contains areas with definite formation. Casual examination will show, in any piece of precious opal, the presence of bright colored patches. With a small loupe these are seen to be composed of numbers of approximately parallel threads lying side by side in each area. Under the microscope (using oblique lighting, not substage illumination), the structure is quite obvious and bears a distinct resemblance to asbestos, crocidolite and chatoyant or cat's eye quartz. The fibres form small sheets, not necessarily flat, and the edges of the sheets are often rectilinear, which implies crystallization, in contrast to the curves seen on the edges of fractures.

It is frequently said that the color is produced by interference caused by cracks, but the patches which show the colors are not similar to the typical fracture of opal, and in nearly all cases the colors are not interference colors (which are necessarily polychromatic), but are pure prismatic monochromatic hues. (See note A). Further, if these are cracks which have been invaded by a secondary incursion, why, it may reasonably be asked, do we never see any larger cracks? Then again no air is found trapped, liquids are enclosed, sometimes with large air bubbles, but in opal no patches of color have air adjacent to them, as are to be seen, for instance, in iris quartz. It should not be difficult to obtain a piece of opal (either precious or common) which is obviously cracked, so that a comparison may be made between the actual crack and the hypothetical. It will be seen that there is great dissimilarity not only in (a) the outlines, and in (b) the contours of the areas, the one being almost flat, the other nearly conchoidal, but also (c) the internal surfaces of true cracks are not fibrous or striated and (d) the quality of the color generated is quite different, as different as oil on water is from a rainbow.

Some of the earlier writers (Hauy, Behrens, Brewster, Butschli, Reference 1 - 4) suggest that the cracks are regularly striated, if so, would that not prove that the opal is not completely amorphous? The areas are certainly striated, being formed of parallel fibers—layers of silica threads—but they do not appear to be fracture surfaces.

Sosman (Reference 5) has described the precristobalite state of quartz as consisting of silica threads which he says may commence to form at high temperatures while the silica is still gaseous. In the liquid state the simple tetrahedra will have linked up into fragile chains of colloidal dimensions, free to move and orient themselves as the temperature slowly decreases until cristobalite in the solid state is formed. When SiO_4 tetrahedra are generated in water, similar chains will be built up by simple polymerization, forming a colloidal hydrosol. If this gels rapidly, truly amorphous common opal will be produced, but, as stated previously some structure (believed to be cristobalite) is usually present, and when a considerable degree of orientation is possible, due to very slow gelation, precious opal will normally result.

In order that brilliant colors may be emitted it is necessary that, apart from the development of the chains and sheet structure, the inter-ionic spacing must be such that the space lattice constant in any given direction will be a near harmonic of the wave-length of the color of the beam seen from that direction, as is the case in X-ray diffraction work.

Specimens have been obtained showing definite formation on fractured surfaces of precious opal, in the form of striated blocs.

Many pieces of opal (probably over 2000) have been critically examined and indications of a "film-pack" structure are clear. It appears probable that the silica threads in the sol link up into sheet structure (of cristobalite rather than of quartz) and that in good specimens several sheets develop one behind the other like cards in a deck. Where the optical effects are most strong it is suggested that the spacing between the sheets or films is accurately related to the wave-length of a specific color, so that rays entering laterally between the films will be reflected and transmitted frontally in monitored rhythm, each film receiving colored reflections from the one behind and passing these forward in beat with the others. Thus the unusual brilliancy of precious opal—a brilliancy only equalled by that of total internal reflection — is accounted for, the changes of color are explained and also the purity of hue.

Examination of a specimen of precious opal will show that it consists of colored patches with clear opaline material between them. This is clearly visible in water opal and in some Mexican opal, where careful inspection will show that the areas emitting color are actually individual crystalline developments. In high quality gem material the large number of film-packs is confusing, but in less colorful specimens the shape and formation of individual discrete lattices may be studied, and the strength of the evidence appreciated.

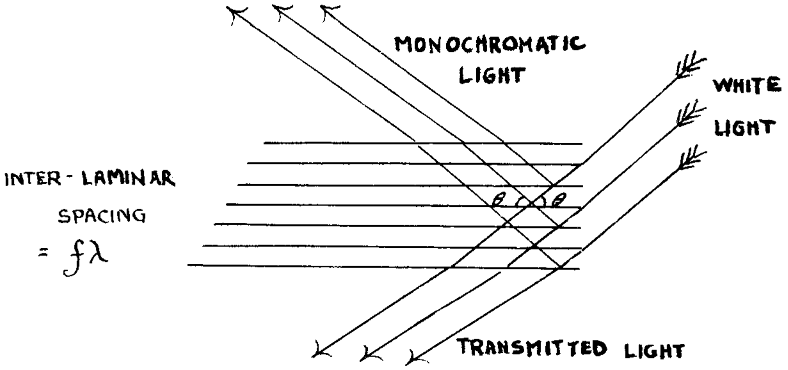
Details of the geological conditions necessary for the production of opal need not be given here, but the results of detailed work indicate two major points. First, that the impervious layer of sandstone over the beds — the duri-crust — is essential to the formation of precious opal as it permits very little evaporation below it, so that the sol takes many years to gel. Secondly, many conditions have to be fulfilled before precious opal, natural silica gel, can be deposed. (See note B). Of these the amount of silica is important, as an excess of this results in the opaque common opal known as potch. However, if the excess is only slight the silica may show as small discrete particles suspended in the gel which give the appearance of an indefinite blue mist, while a little more silica will appear as stronger blue clouds having definite outlines. Further increases cause more cloudiness and pale blue, grey or milky potch forms, according to the size and quantity of the silica particles to (Reference 17).

The production of color may be illustrated by hand specimens or micro-slides showing five nominal stages. First, the indefinite blue misty patches and, second, the definite blue clouds already mentioned. The third stage is best seen in clear water-opal or fire-opal—individual sheets or films, varicolored, tenuous and evanescent, approximately planar, with rectilinear edges.

With further crystal development we get obvious fibers — the main body of the stone is partially amorphous, but in it are areas where the silica threads have had time to orient themselves into bands, regular and fairly bright, each built up of many molecular layers, suitably spaced in the lattice and so reflecting definite wave-lengths. The fifth stage shows the final, yet still incipient, crystallization in the gel. The fibers have linked up laterally to form sheets and these are found to be in blocs or film-packs which control the light so that in any specific direction a monochromatic beam is transmitted, other wave-lengths being damped out.

Successive films act in support of each other, after the manner of resonators, and thus a much greater proportion of the light is emitted than would be reflected from a single unsupported film. (See note C).

In conclusion we may summarize by saying that the colors are not caused by refilled cracks (which would prove a cause of weakness. See reference 15), but apparently by incipient structural development of a crystalline nature whose lattice constants are in mathematical harmony with the wavelengths of the rays emitted.



$n\lambda = 2c \sin\theta$

λ = WAVE-LENGTH

c = INTER-LAMINAR SPACING

θ = ANGLE OF REFLECTION

Note A: The colors of thin plates are produced by the cancellation of certain wavelengths, leaving all the others operative — thus if yellow were obliterated we should see a mixture of those remaining — red, orange, green, blue and violet — a rather unpleasant tone, far from monochromatic and deficient in brightness, since all the yellow is missing; these peculiar shades are typical of interference colors, but are never seen in precious opal. Here the white light is analysed by refraction and becomes prismatic. Its monochromatic nature can be demonstrated experimentally, with the sodium, strontium or other flames.

Note B: In order for precious opal to form, the following conditions appear necessary: —

1. The ground waters must have lost all their soluble salts ($NcC1$, $CaS0_4$ etc.).
2. The ground waters must contain soluble silicates, Na_2Si0_3 (colloidal).
3. The surface waters must contribute an acid radicle, precipitating silica.
4. Concentration of the solutions must be sufficient to develop a light mobile gel yet not so high as to produce excess silica (potch).
5. The pH value of the initial sol must be suitable (pH5 — pH7).
6. Temperature must be satisfactory. (40° — 60°F).
7. Gelation must be extremely slow, implying impervious strata above.
8. The development of the structure must accord with a suitable wave-length.

Note C: Assuming that each film normally reflects to the front only 20% of the total light falling on it laterally, then we should get a nominal brilliance of 20%. But one film in support will increase this by a further 16% (i.e. 20% of the 80% transmitted by the first); another film as an resonator will add a further 13% and a third a further 10%, making a total of 59% reflected — three times as bright as the original 20%.

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A Process for Recovering Alluvial Diamonds

by

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Diamonds are found in kimberlite pipes which are of igneous origin, and also in alluvial deposits which are formed when the pipes are eroded by the action of wind and water.

To recover the diamonds which occur in kimberlite is a comparatively simple matter since it only requires the application of the diamond and kimberlite mixture to a sloping greased surface. The diamonds which are non-wettable adhere to the grease, while the kimberlite is washed away by a stream of water which is applied over the surface of the grease for that purpose.

Alluvial diamonds, however, in many cases will not stick to grease. Their surfaces have become wettable due to the attachment of water soluble salts with which they have been in contact at some stage of their existence. Until recently, the only method evolved to recover the diamonds which do not adhere to grease, was to pick them by hand out of the gravels in which they occurred. This method is very inefficient, costly, and encourages theft.

To overcome these difficulties, the problem of recovering these diamonds efficiently was studied by the Diamond Research Laboratory. After some investigation, it was found that it is possible to alter the surface state of these diamonds from the wettable to the non-wettable and thus render them recoverable on grease. This is accomplished by treating the diamondiferous gravels, after suitable gravity concentration, with a solution of Oleic acid in water which is made alkaline with caustic soda. By regulating the time of application and the strength of the solution, it can be arranged that mainly the diamonds present in the concentrate are affected, the surfaces of the gravel particles do not become non-wettable to any great extent and consequently do not stick to the grease when the treated mixture is applied in the ordinary way.

There is, however, one disadvantage to this method of treating the diamonds. The dust which is always present with the gravel is rendered water repellent to some extent by the Oleic acid solution and rapidly coats the surface of the grease to which the diamondiferous mixture is applied. When this happens, the diamonds in the mixture are prevented from coming into contact with the grease and consequently will not stick. No separation is then possible. It is, unfortunately, not possible to wash the dust out of the gravel before treatment.

To overcome this difficulty caused by the dust it was necessary to devise a machine that was capable of continuously producing a fresh grease surface. The machine is known as a "grease belt."

The grease belt which was developed at the Diamond Research Laboratory consists of an endless rubber belt, two feet wide, which is mounted on two drums about seven feet apart. The belt travels across a flat table, which provides the necessary support for the section of the belt between the two drums. The upper surface of the belt is covered with a layer of grease.

The belt is driven by a ½ h.p. electric motor geared to one of the drums and the belt moves at a speed of 14 feet a minute.

The whole unit is mounted in a steel framework so that the transverse axis of the belt is inclined at about 14 degrees to the horizontal. The longitudinal axis of the belt is arranged at right angles to the direction of the flow of gravel.

At one end of the belt is a box to hold the grease to be applied to the belt surface. A weighted piston in the box forces the grease through the box and on to the belt. Before coming into contact with the belt, however, the grease is warmed by electrical heating elements which are placed at the bottom of the box. This ensures that the grease in the box is softer than that on the belt, and can thus be applied to produce a perfectly even and smooth surface of grease.

An electrically-heated scraper is placed at the opposite end of the belt, and is adjusted so that the edge of the scraper just touches the surface of the grease on the belt. As the belt turns, the scraper removes the diamonds and anything else that adheres to the grease. Any grease that is removed by the scraper is replaced from the box as the belt rotates.

After treatment with the Oleic acid solution the diamondiferous gravels are dropped from a height of a few inches on to the surface of the grease belt. A stream of water flows over the grease and washes the wettable gravel particles away. The treated diamonds stick to the grease, and are taken out of the water stream by the sideways rotation of the belt. As they reach the scraper, the diamonds drop off into a receptacle, which stands in a tank of boiling water. The boiling water removes any grease that adheres to the diamonds; and the diamonds are taken periodically from the receptacle.

The grease belts and the chemical process are used to treat the larger sizes of the gravel on one of the alluvial mines in Africa, and the process is shortly to be installed at another mine. After more than a year's operation, continuous and careful sampling of the plant tailings has revealed that more than 99 per cent of the diamonds have been recovered by this method.

Testing Drilled Pearls with Ultra Violet Light

by

JOHN G. ELLISON

There has been a general tendency for gemologists to refrain from testing pearls by simple methods, due to the inconsistencies common to any form of testing short of the advanced x-ray or endoscope methods. Of course the expense involved in the latter equipment makes it prohibitive for all but the larger laboratories. The purpose of this article is to outline a simple test that may be used on drilled pearls.

The basic instruments necessary for this form of testing are a source of ultra violet light and some form of strong magnification, preferably a microscope. Since both of these instruments are available in any well equipped laboratory, no added expense is entailed.

It is a well known fact that nearly all cultured pearls are highly fluorescent under ultra violet radiation whereas but a small quantity of natural pearls fluoresce strongly. In addition, although the mother-of-pearl core in a cultured pearl also fluoresces, it normally has a different degree of fluorescence than the outer coating. In like manner it has been noted that each of the different layers of a natural pearl fluoresce to a different degree.

As noted in the title of this article, this method is only of assistance with those pearls which possess a drill hole. And for best results the drill hole must be freed of all foreign matter, such as cement, dirt, etc.

The pearl in question is placed in the microscope so the drill hole may be observed and the ultra violet unit is placed in such a position as to stimulate fluorescence in the pearl. It is usually advisable to bring the fluorescent unit into as close proximity as possible to the pearl since the stronger the fluorescence the easier will it be to observe these characteristics.

By observing the sides of the drill hole you will be able to note, in the case of most natural pearls, the different layers fluorescing in different degrees or in the case of those which do not fluoresce in this manner, the diffused lighting provided by this method will tend to make the separation between layers stand out much more distinctly than would be observed under normal illumination. The sharp division between layers would appear at one point only on a normal cultured pearl, i.e. between the nucleus and the outer coating.

The accuracy of this form of testing will be largely dependent on practice and familiarization, therefore one should begin by testing pearls of known identity.

An Unusual Characteristic of Gemstones

by

JOHN G. ELLISON

For several years the "feel" of polished surfaces of different gem species has been recorded in an effort to confirm the impression that noticeable differences did exist between different gems. Obviously a test based on the comparative adherency of a stone to one's finger as the stone is rubbed does not fall into the category of important tests.

However, to those familiar with the procedure at least an occasional advantage will be gained.

To verify and apply the findings listed below, one's hand must be free of excessive moisture and skin oils and also the stone itself must be reasonably clean. The next step is simply to grasp the stone between the thumb and forefinger in a manner that enables a surface, preferably the table to be rubbed. Larger stones should be tested first since the larger facets tend to emphasize the differences. However, to one familiar with the test, even small stones of less than one carat in size will yield a characteristic "feel." In order to test the "feel" of small stones a slight variation in testing methods is required. In such cases, the stone is rolled between thumb and forefinger, under pressure. This provides a larger area to be tested and yields much of the characteristic "feel" of the stone. For practice, a garnet and glass doublet is suggested as this will best illustrate the method to be employed and also demonstrate the difference in "feel" between top and bottom portions of the stone. The reaction to rubbing a stone in this manner is that the surface will either feel *smooth* (slick) or it will tend to be *sticky.*

Although the following list of stones has only been divided into two classifications, namely slick and smooth, it will be found that the degree of smoothness or stickiness varies with each species or variety. However, since most commercial stones are not polished to their ultimate and other factors such as grease, skin moisture, etc. affect the "feel" of the stone, it would be best to adhere strictly to this list for the most accurate results.

Gemstone or Substitute	*"Touch" or "Feel"*
Almandite Garnet	Smooth
Amber	Sticky
Andradite Garnet	Sticky
Beryl (All)	Sticky
Chalcedony	Sticky
Chrysoberyl	Smooth
Corundum	Smooth
Diamond	Sticky
Glass	Sticky
Heat-treated Zircon	Sticky
Hematine	Sticky
Hematite	Sticky
Jadeite	Sticky
Jet	Sticky
Labradorite	Sticky
Lapis	Sticky
Microline	Sticky
Natural Zircon	Smooth
Nephrite	Sticky
Opal	Sticky
Orthoclase	Sticky
Peridot	Sticky
Plastics	Sticky
Pyrope Garnet	Smooth
Quartz	Sticky
Rhodolite Garnet	Smooth
Spinel	Smooth
Spodumene	Sticky
Synthetic Corundum	Smooth
Synthetic Emerald	Sticky
Synthetic Rutile	Smooth
Synthetic Spinel	Smooth
Topaz	Smooth
Tourmaline	Smooth
Turquois	Sticky
Yellow Peridot	Smooth

Jeweler's Notebook Memories

Part IV

by

GEORGE MARCHER, C.G.

After we had warmed our shivering car, we left the scene of the Rain Dance in Zuni and proceeded back to Gallup. We arrived soon after midnight ready for a warm fire and a refreshing sleep.

Early after breakfast we began a series of one day trips to visit certain dealers with whom we had previously done business. One of these journeys led us to the headquarters of a certain Indian trader whose name, as well as the exact location, I cannot recall, although the incident is one that sticks. His simple hut where he conducted his business with the Indians was off the highway a short distance on a level stretch of barren sand. After unsuccessfully showing him some of my turquois and variscite our leavetaking was interrupted as we suddenly heard the clatter of horses hooves and a horde of young Indians appeared. Believing that they would like to buy even though the trader didn't, I asked him whether I might show them the material I had. Very graciously he replied, "O.K. Sell 'em if you can."

Placing a little table at my disposal he went on about his business, while I quickly opened some papers of large stones and spread them out for their inspection. Immediately they became mildly excited — picking up the stones and rushing to the door with them for better light, stirring around applying the lighted match test to them for the presence of paraffin, and returning back again for other stones. They all looked alike to me and I could not understand a word of what they said to me or to one another except a brief "no" when they came back to the table. No sale. Soon they all vanished as suddenly as they had appeared. Though they had left our sight, they would not be leaving our memory as I discovered on closing the stone papers they did not seem to be as full.

Quite certainly I had disposed of turquois that I "wot not of." Later, on mulling the matter over in my mind, I wished that I had scratched around in the deep sand by the door where our dusky visitors had stood. We all try to think well of our American Indian, but the opinion is frequently voiced among those who deal extensively with them that they think we owe them more and more for "this good land of ours."

After completing our visits around Gallup we proceeded to Albuquerque to make that city our headquarters for another short period of exploration. Feeling an urge to visit another turquois property down near Douglas, we soon headed in that direction.

Our rough and narrow dirt road led us through the ghost town of Tombstone, and it happened to be nearing the ghostly time of night. In fact, it was almost too late to disturb any of the unghostly souls who inhabited this placid place of the past. Having secured the information we needed, we rode on to a lodging place near enough to our destination to be able to arrive early enough to see the mine in daylight.

On our way early the next morning we found few opportunities to get information about where the property was, and how to get there. Finally, we met a rancher who was quite familiar with the place and the owner. After giving us the needed traveling information he concluded with this admonition:

"When you get there be alert and cautious: the owner (whose name I do not recall) patrols the property, more or less, with a rifle on his shoulder and he might show resentment toward unknown visitors. He's quick on the trigger. Not long ago he entered into an agreement with a man to work the mine on some sort of sharing, or percentage, deal. He figured he got a trimming, and he ordered the man to get off and stay off. Later, when the man came back, the owner recognized him from a distance and called out to him to 'git.' When the poacher stood still and remonstrated with him he fired two rifle shots that landed uncomfortably close, and the battle was won."

Moving on in a mood quite willing to heed the well-intended advice, we finally arrived at his little cabin without incident. We were pleasantly greeted by his half-breed common-law wife, who informed us that he was not in, but would return soon. Invited in, we had not long to wait till he arrived, stood his rifle in a corner, and listened attentively to my introduction and explanation of my mission. My companion was well armed with a full flask in his luggage and I will add, to my frequent embarrassment, he was always quick on the draw.

As soon as the amber fluid was dispensed with "Happy Days Were Here Again" and friendly relations were firmly established. Although I am not a teetotaller I never could get used to the alcoholic approach. However, I was assured by this companion and others that it was the "open sesame" to good business relations with all the mining folks. I still don't believe it.

After a brief discussion of the history of the mine and of his recent unpleasant experience with the share leasor, he invited us to stay over night and go to the mine several miles away in the morning. His wife proved to be an excellent cook, and after a good sleep and a delicious breakfast the three of us drove up to the mine.

I was amazed at the immensity of the excavation. As we climbed down and down over huge rocks and little the great arched dome, or ceiling, seemed to be a hundred feet high. It was easy to believe the assertion of the owner that much work had been done there by the Indians before the white man came with his steel and explosives.

According to the findings of the archaeologists, a method used by the Indians to conquer the hard turquois-bearing rock was to build hot fires against it until a sudden dash of cold water would crack off pieces containing the much-desired turquois. (How much a carat would you estimate?)

Back to the mine. The hard rock and narrow seams of beautiful blue were quite like the La Cerrillos showing, only there were more little streaks of turquois. On the dump outside, and along the path for a quarter of a mile away, we found—and were permitted to keep—attractive specimens that contained layers of turquois about one eight of an inch—too thin to work satisfactorily. Later I chipped and ground away the rock on one side to leave the dark blue facing for beautiful specimens — some with plane surfaces, others undulating to follow the gentle curves of the gem layer.

Having completed our personally conducted tour of this prehistoric mine we returned to the mine owner's car and bumped our way back over the little used road. After we had enjoyed another simple but savory repast we expressed our appreciation and departed. I then turned another page in my gemological experiences and we started on our return trip northward.

One time we needed to travel late into the night to get to a trading post where we could sleep. At that time there were long distances between stopping points, and habitations along the way were almost nonexistent. Since it had been snowing, melting and then freezing, careful driving on the narrow turnpike road was important. A momentary glance to my left revealed an unusual pattern in the snowy side of a bluff we were passing and I remarked to my companion, "See the windows in the side of that hill." For some unaccountable reason the snow had melted away from several regularly spaced oblong patches of white that appeared much like frosted windows in the dim moonlight. It interested my companion. "Look, George, it does look like windows. Look at it." My look was about a fifth of a second too long; when I snapped back to my driving the car was gently veering to the opposite side of the road. But there was no halting it or turning it back to the "straight and narrow." Like a willful animal it kept right on going down the edge and finally rolled over on its side about five feet below the road level. I landed uncermoniously against my laughing companion. As he did not own the car and the stock of gemstones he was in a frame of mind to see more humor in our predicament than I did. Bracing myself as well as I could against the wriggling man beneath me I began pushing up the door to crawl out. The heavy "lid" resisted my efforts as if it willed to keep me there as a prisoner. Finally I succeeded in holding it up and getting out. Then the problem of what to do in the situation confronted us. After turning off the ignition to avoid any chance of fire, I searched for possible leakage of gasoline or battery fluid, but both seemed all right. While pacing back and forth on the roadway we were soon cheered by seeing headlights approaching from far down the straight away road. Quickly getting our flashlights from the car, we stationed ourselves on either side of the road, and began waving them as the car approached. To convince this other midnight traveler that we were not hold-up men we turned our lights frankly upon ourselves and also pointed them toward our helpless car. Stopping his machine a short distance from us the stranger stepped cautiously out with his gun under his coat and listened to our tale of woe. He was a trader.

After listening to our brief story he threw a quick glance at the object of our plight, then raced back to his car. With the precision of a one-man wrecking crew he yanked an emergency tow rope from his belongings, threw one end of it over the car and worked it back underneath and deftly tied it to the framework. Switching his car cross-wise the road and hitching the other end of the rope to his bumper, he pulled the old Buick proudly up again on its four wheels.

Then he jumped in and drove it a half block or so to a point where he could run it up on the roadway. A deed well done — a friend in need, a good Samaritan. With the swiftness of his arrival, he drove off into the night, and I have never seen him since.

To dispose of some of the Indian jewelry and rugs accumulated during our various trips, while the depression was still on we cooperated with a man named Ralph Dodge, who had provided a big car and trailer and had driven "F.A." around through the Indian country.

The plan was for Dodge to supply a small troupe of Indian dancers to appear on an upper floor of a department store while we, in turn, were to supply the Indian merchandise to the store on consignment for a few days.

The sale was preceded by a few days of advertising to make the event known to everyone who was interested in Indian lore and Indian merchandise. A large part of the upper floor was assigned for the entertainment and the Navajo handicrafts.

The entertainment was to consist of Navajo men dancing and playing Indian music on their simple instruments. Of course the dancers were to be dressed in their native costumes complete with feathered headress.

In October of 1932 such a show was scheduled in O'Connor's, San Francisco. I personally was to go up with the jewelry while Dodge was to take the rugs and his troupe of half a dozen Indians. I went separately.

During that particular period buses were still hectoring the railroads and competing for passengers, while unauthorized cars were hectoring the buses. If one wanted to drive his own car to San Francisco he could go to a special agent who operated only from a desk and tell him how many passengers he could accommodate, as well as the time of his departure. After reaching his destination he would later receive his cutrate fare less a commission for the man with the desk.

Being anxious to save anything I could during this tough period, I went into such a place in the next block from our store and paid for a round trip. On the way up to San Francisco we were in luck as our driver was a fine fellow with a good and also pleasing personality. For the sake of better gasoline mileage, he maintained a fairly steady gait up hill and down, as well as when passing other cars. This trick he had learned during an earlier time when he had been a regular bus driver. No laws had been passed at that time to suppress these pirate passenger carriers, so motor cycle cops had been instructed to try to spot such cars and catch them exceeding the speed limit if possible. Knowing the limit to be 45 miles per hour, he carefully held the speedometer at a safe and steady 43. After reaching San Jose late in the evening, and dropping off a couple of women passengers at their respective destinations, we proceeded to San Francisco, arriving at about 11:00 P.M.

(To be continued)

Recovery of Alluvial Diamonds by Electrostaic Separation

by

A. A. L. LINHOLM

(Diamond Research Laboratory—Johannesburg)

In this issue of *Gems & Gemology,* an article appears describing the grease belt process which is used to recover alluvial diamonds. For a number of reasons this process is difficult to apply satisfactorily to diamonds which are smaller than 3 mm. To separate the smaller stones from the gravels in which they occur, the Diamond Research Laboratory in Johannesburg has made use of the fact that diamonds are very poor conductors of electricity whereas the great majority of the gravel particles are better conductors. This is the principle of Electrostatic Separation.

An electrostatic separator consists essentially of an earthed electrode and a charged electrode placed opposite each other and fairly close together. A high tension field is maintained between the two electrodes, the charged electrode being of positive polarity. When a mixture of diamonds and gravel is passed through the high tension field, all particles obtain an induced charge. The gravel particles, being relatively good conductors, allow their charge to leak away to earth as they pass over the earthed electrode of the separator. In this way they acquire negative potential and are, therefore, attracted towards the positive high tension electrode. The induced charge on the surface of the nonconductive diamonds cannot leak away quickly enough, they retain their positive charge, and are therefore repelled from the high tension electrode. A separation is thus achieved.

In the process developed by the Diamond Research Laboratory to recover the smaller diamonds on one of the South African alluvial mines, the diamondiferous gravels are first sized and subjected to gravity concentration. In this way the lighter constituents are removed and the original quantity considerably reduced. The heavy concentrates which contain the diamonds are then cleaned by a milling process, after which the —6 mm. fraction is screened out, dried in an oil-fired rotary drier and fed to the electrostatic separator.

The separator which is used is capable of separating diamonds as large as 6 mm. from the gravels in which they occur. In this machine there are six superimposed stages, each of which has a rotating, earthed, metal roll electrode, serving as a feed roll, and two non-metallic, stationary electrodes opposite the metal roll. The electrodes and the feed roll are eight feet long. The hot, dry gravel is uniformly fed on to the metal roll by means of electromagnetic vibrating units. Each stage of the machine removes a certain quantity of gravel from the feed, the remainder passing to the next lower stage for further concentration. The diamondiferous concentrates from the sixth stage fall into a locked bin under the machine from which they are periodically removed. The capacity of this machine is about 1.2 tons of −6 mm. gravel an hour, and for every ton of gravel treated about eight pounds of gravel containing diamonds are removed as a concentrate. Ninety-nine per cent of the diamonds originally present in the gravel are now contained in this concentrate from which they are easily picked out by hand.

In addition to the large separator described above, the Diamond Research Laboratory has also produced a smaller version known as a Laboratory Model. The laboratory model has only one stage and can only treat a small quantity of diamondiferous concentrate. It is useful for the investigation of problems dealing with the recovery of small diamonds and it is also used to retreat the concentrates from the 8′ machine. When this is done, instead of having all the diamond present in one ton of gravel contained in eight pounds of gravel, the concentration is further increased so that only two pounds of gravel remain, thus making it still easier to recover the diamonds. A further use of this machine is to recover the very small diamonds from conventional grease table concentrates; these diamonds are too small to be separated by eye. In this form the Laboratory model separator is used on the mines in which the diamonds are found in kimberlite pipes.

Diamonds

(continued from page 360)

market may alter these ratios; for example heavily imperfect stones in the last five years have steadily increased in value as compared to flawless stones of the same size, color and cut.

Cutting has already been discussed; there is only one proper cutting and all deviation from that reduces the value of the stone to the degree that it interferes with the purpose of cutting — the achievement of maximum brilliancy and fire. For example, the facets which most control the passage of light through the diamond are the pavilion facets, and therefore, the most serious defects in cutting occur when these facets are too high or too shallow. Next most important are aberrations in the other main facets; the bezels, the table and the culet. Of course, a slight defect in the table, for example, is worse than a slight defect in the pavilions. To sum up, all stones should be properly cut, but if one must grade an improperly cut stone, it is essential that its value be appropriately discounted; faults in cutting may reduce the value of a diamond by as much as fifty per cent.

The essential beauty of the diamond; the quality which sets it aside from the other colorless transparent stones is the brilliancy and fire which can be brought out in the diamond by proper cutting. Faults in cutting are the defects which most easily interfere with this maximum brilliancy and, therefore, are the defects which can be seen most easily even at a distance. It is astonishing that jewelers who would never dream of handling a watch with imperfect lettering or of handling a warped piece of china will countenance sloppy or "swindled" work in the diamonds they sell. It is also true that, just as a 75 watt bulb looks larger when lit than a 60 watt bulb of the same size, just so does the really brilliant diamond look larger than another poorly polished diamond of equal size. Finally, more and more, to the point where it is approaching unanimity, the most successful retail establishments of this country are insisting on fine cutting — on maximum brilliancy — in all of the grades of diamonds they handle; — and one can't argue with success.

Gemological Digest

DE BEERS REVEALS DIAMOND STOCKS

Sir Ernest Oppenheimer, of De Beers Consolidated Mines, says that, contrary to public opinion, stocks are not fabulous nor is mining restricted.

In an effort to clear away the mystery which has surrounded the De Beers policy of not revealing the value of stones in stock, they have issued figures and a complete denial of the "bags full of diamonds" misconception.

At the end of 1952 De Beers held 311,946 pounds sterling worth of diamonds at cost of production and Consolidated Diamond Mines of South West Africa had a stock of 414,055 pounds worth at cost of production. The Diamond Corporation had a stock worth 5,782,832 pounds sterling at cost of purchase.

Sir Ernest referred to another erroneous impression, that the diamond companies mine in such a way as to restrict production to cause an artificial shortage which would keep diamond prices at unreasonably high levels. He points out that this view is contradicted by two important principles which operate in the diamond trade. The first is that the selling arrangements in force contain provisions by which each producer is guaranteed, over a period of years, that however hard the general trade conditions are, his sales will not fall below an agreed minimum. The second is that the industry has always equipped its mines to operate at their maximum capacity.

When the trend of prices and demand has warranted it, considerable sums have been spent in reopening old mines which previously could not be exploited economically.

There are no agreements among producers to restrict output, and mining is governed by the nature of deposits and capacity of the equipment.

Book Reviews

PRAKTISCHE EDELSTEINKUNDE *by Dr. Ing. Walther Fischer, Verlag Gustav Feller-Nottuln, Ketturg / Ruhr, Germany. Paper-bound,* $4.00. 187 *pages,* 48 *figures,* 5 *tables,* 3 *plates. Reviewed by Dr. W. F. Foshag.*

This book was written by this well-known German mineralogist for the professional and amateur lapidary. Dr. Fischer was director of the State Museum of Mineralogy and Geology, Dresden, for 20 years, and is now director of the trade schools of Idar-Oberstein, including the School for Diamond, Gem and Gold-Working. In addition to his own broad scientific knowledge of gemology he has had the accumulated knowledge of some of the master cutters of Idar-Oberstein available to him.

The first half of the book relates to crystallography, crystal-physics and crystal-optics as they concern the cutting, polishing and proper orientation of gems. This part of the book is the most interesting to the professional gemologist. The exposition of these subjects is not too detailed or too technical for the ordinary reader, yet scientifically presented. This section, although succinctly written, contains all the pertinent information. Examples are frequently given to illustrate the use or importance of the characteristics discussed. Attention is called, for instance, to the hazards of cutting or mounting a stone showing anomalous birefringence, or the application of wetting a stone to distinguish diamond from glass. This reviewer knows of no book for the gemologist that presents these subjects in a more concise and readily understandable manner.

The second half of the book is devoted to 62 gem mineral species and their varieties. This part is interesting chiefly to the lapidary, but contains much of interest to the gemologist. The subject includes a very brief section on the properties of the mineral, a short discussion of the important producing localities, the distinguishing characteristics of the gem, and a paragraph concerning optimum proportions of the stone, and the proper polishing laps and abrasives for the best results. The chief criticism that may be made of this part of the book is that the American localities cited are often inconsequential producers, as, for instance, Amelia Court House, Virginia, for golden beryl; Branchville, Connecticut, and Maine for kunzite and others.

This book differs from other recent works on the lapidary art in that it does not discuss equipment and techniques, but the fundamental scientific principles of gem cutting and the basic properties of gemstone minerals that influence their proper elaboration. For this reason it will have more interest for the professional gemologist than other works intended primarily for the hobbyist. It is in all respects an authoritative scientific work.

DIAMOND TECHNOLOGY *by Paul Grodzinski, published by N. A. G. Press Ltd., London,* 1953. 784 *pages.* $10.00.

This completely up to date book on the production methods for diamonds and gemstones should prove extremely valuable to any person interested in the manufacture or sales of gem diamonds and industrial diamonds, abrasives, machine tools, and those interested in the lapidary art. A listing of the chapter headings best describes the tremendous scope of the subject material covered. These include: *Grinding and Polishing Diamonds, Grinding and Polishing Gemstones, Bruting, Dividing Diamonds and Gemstones* (cleaving), *General Survey of Grinding and Polishing, Technology of Machining Methods, Drilling and Boring Holes, Carving and Engraving, Polishing Gemstones for Jewellery* (English spelling), *Diamond Powder — Its Production and Use, Manufacture of Watch and Instrument Jewels, Manufacture of Diamond and Sintered Carbide Dies, Grinding and Lapping of Sintered Carbides, Industrial Diamonds — Selection and Orientation, Setting Diamonds in Tools,* and *Production of Piezo-Electric and Optical Crystals.* The Appendix is a gold mine of general information and the Bibliography is very complete and up to date. The book includes 486 illustrations and 93 tables as well as both subject and name index.

As a mechanical engineer, the author uses an engineering approach to all the subjects covered but keeps his wording simple and direct. He has been actively engaged in the study of the applications of diamonds and other hard materials since 1926 and has been head of the Industrial Diamond Information Bureau, a part of the Research Organization of Industrial Distributors, Ltd., since 1943, carrying out the research work for the African Diamond Producers Association. Certainly, few men are as well qualified as Paul Grodzinski to write such a book and fewer would put forth the time and effort needed to assemble the information it contains.

MANUAL FOR GEOMETRICAL CRYSTALLOGRAPHY *by Caleb Wroe Wolfe. Published by Geopublishing Company, Watertown, Massachusetts, 1953. $4.00*

C. W. Wolfe, Professor of Geology at Boston University, belong to the student of crystals an excellent text on crystal projection, measurement, and the derivation from there of crystal geometry.

The Manuel is in its nature an advanced text for—"those who work extensively with crystals." It takes up the study on the presumption of an introduction such as that furnished by most elementary mineralogy courses or texts. The presentation is detailed and straightforward.

To the student of crystals, the MANUAL FOR GEOMETRICAL CRYSTALLOGRAPHY furnishes an invaluable addition to the literature now available.

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