Vol. VII No. 5 JANUARY, 1960

THE JOURNAL OF GEMMOLOGY

and

PROCEEDINGS OF THE GEMMOLOGICAL ASSOCIATION OF GREAT BRITAIN

GEMMOLOGICAL ASSOCIATION
OF GREAT BRITAIN
SAINT DUNSTAN'S HOUSE, CAREY LANE
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FACETED GEMSTONES

Cutting for Maximum Brilliance

By O. LeM. KNIGHT, B.E.(Syd.), A.M.I.E.(Aust.)

IT is surprising how little attention is paid by lapidaries to the optical properties of the gems they cut and polish, although these properties should determine the proportions of the finished gem.

Gemstones differ not only in their hardness and specific gravity, but also in their refractive index, critical angle, and degree of colour dispersion. These are the factors that must be taken into account when determining the proportions of any gem, if the maximum brilliance is to be obtained.

The early days of facet-cutting were marked by experimental attempts to find a type of cut that showed the gem to best advantage. This applied particularly to the diamond and resulted in the discovery by Peruzzi, at the end of the seventeenth century, of the " brilliant " form of cut. This first disclosed the real brilliance that could be achieved by " shaping " the diamond. Proceeding still by trial and error the proportions of the " brilliant-cut " were improved until, at the end of the nineteenth century, they were very close to the proportions that theory has since shown to be ideal.

It was not until 1918 that Tolkowski attempted to solve the problem theoretically for the diamond, and during the next twenty years a number of distinguished scientists, notably in Germany, interested themselves in the ideal proportions for a " brilliant-cut " diamond and for gemstones of other refractive indices. Not only do their results agree in all essentials, but the correctness of the theoretical values has also been confirmed by measurement of a great number of gems, particularly diamonds, which have been graded by experts according to their degree of brilliance.

Whatever may be the practice in the diamond cutting industry the fact remains that for other classes of gems these theoretical studies have been largely ignored. Books on lapidary work rarely make reference to them, and when they do it is to dismiss them as the work of theorists who have never cut a gem in their lives. It appears to be the practice to emphasize that the practical cutter learns to treat each individual piece of rough on its merits. Curiously enough, this is frequently followed by a table of proportions recommended by the particular author. Even in courses on gemmology the significance of optical properties in relation to the cutting of gems appears to be rarely stressed. Gem material does not become a gem until it is cut and the gemmologist should be an authority not only on identification of gems but also on the correctness of their cut.

For the " brilliant " type of cut it has been proved that the theoretically ideal proportions result in maximum brilliance. For other types of cut the same general principles apply even though, as explained later, it is impossible to set down precise ideal proportions.

As the studies referred to are not readily available in English an endeavour will be made to explain the basis on which the ideal proportions have been calculated and to give a summary of the

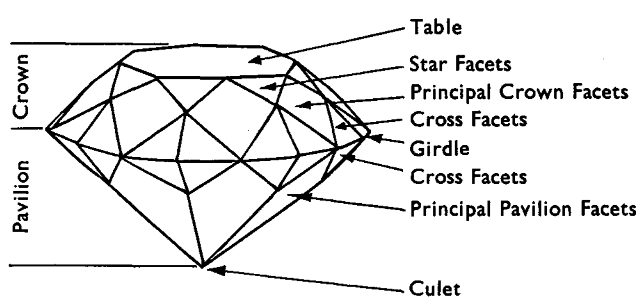

FIG. 1. *Brilliant-cut Gem.*

results. Fig. 1 shows a typical brilliant-cut gem with the terms usually applied to its various components.

In its completely general form the problem is perhaps unsolvable. It becomes necessary therefore to make two simplifying assumptions. These are that parallel light falls on the gem perpendicularly to the table and that light emerges from the gem also at right angles to the table. At first glance this may appear to be a very severe limitation on the lighting of a gem, but a little consideration will show that such is not the case.

When rays of light fall on a polished transparent surface from any direction, portion are reflected from the surface as lustre and portion are transmitted through the surface, the intensity proportions being determined by Fresnel's formulae. The rays that are transmitted through the surface of a gem fall first on the principal pavilion facets, and there they are either totally reflected on to the opposite pavilion facets or pass out in large measure through the back of the gem. Which of these two events happens depends on whether the light strikes the pavilion facet at an angle greater or less than the critical angle for the particular material. This is shown in Fig. 2, the angles being measured between the light ray and the normal to the surface on which the light falls.

The angle at which a ray of light meets the pavilion facet depends on the angle at which it is incident on the table, the refractive

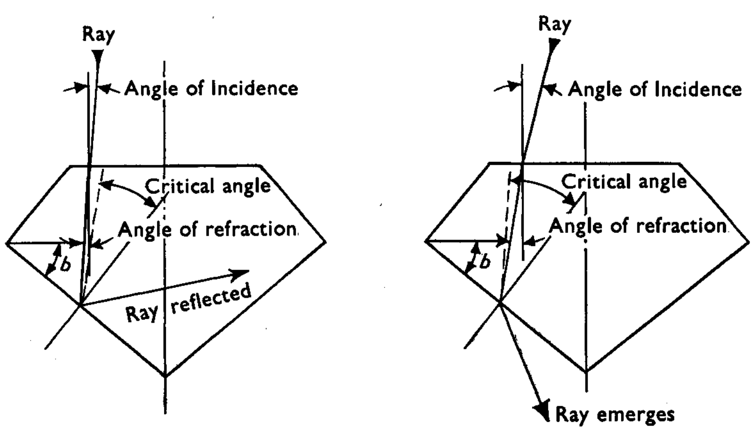

FIG. 2. *Conditions for reflection or emergence of light.*

index (n) of the gem, and the angle of inclination of the pavilion facet (b).

Light rays perpendicular to the table are not refracted on entering the gem, but inclined rays are refracted, the angle of refraction depending on the refractive index of the material. It can be shown that for gems of high refractive index light rays can be incident on the table at a comparatively large angle before being so refracted that they strike the pavilion facet at less than the critical angle. Gems of low refractive index, however, have such a large critical angle that practically all inclined rays on the table of a normally proportioned gem will strike the pavilion at an angle less than the critical angle and will pass through the facets instead of being totally reflected. Thus for diamond ($n = 2{\cdot}42$) the angle of incidence may be as high as $37\frac{1}{2}°$ before light is lost through the pavilion facets, whereas for topaz ($n = 1{\cdot}63$) the limiting angle of incidence is only about 2°.

Fig. 3 shows the effective cone of light for gems of varying refractive index, for a pavilion angle of 39°. All light entering the gem within this cone is totally internally reflected at both pavilion facets. From this it can be seen that with the exception of the diamond there is no great error in assuming that the only effective light falling on the gem is that at right angles to the table.

It can further be shown that if a gem is so proportioned that vertically incident light emerges vertically, then inclined incident light will also emerge in a direction parallel to its incidence ; i.e. towards the source of light.

Incidentally, this means that for the best effect a gem should be viewed from the direction in which it is illuminated. The import-

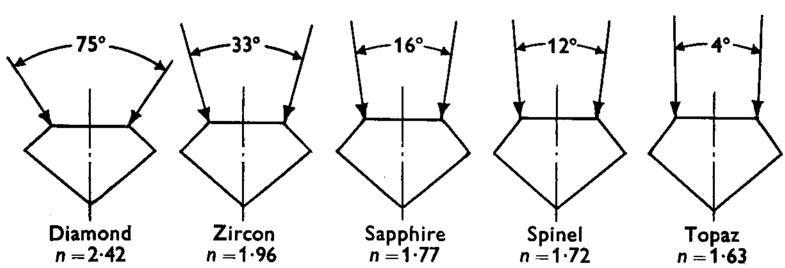

FIG. 3. *Effective cones of light for different values of* (n).

ance of this is not always realized when gems are being displayed ; nor is the fact that illumination should be from a point source and not from light diffused by opal globes or fluorescent tubes.

Having accepted the assumptions that the incident light is perpendicular to the table, and that its emergence from the gem is in a parallel direction, it is now possible to state the conditions to be fulfilled in order that a gem may have maximum brilliance. These are :

1. That the gem shall have around the table an even number of principal crown facets, and just as many principal pavilion facets, these being opposite to one another, i.e. lying in a common meridian.
2. That the angle of the pavilion facets (*b*) shall be such that the light incident on the table and principal crown facets is totally internally reflected by the pavilion facets.
3. That the light incident on one side of the table, from its centre to its edge, shall, after internal reflection, emerge from the full length of the principal crown facet on the opposite side of the table.
4. That the angle (*a*) of the principal crown facets shall be such that the internally reflected light strikes the facet at less than the critical angle, and, after refraction, emerges in a direction parallel to the light incident on the table.

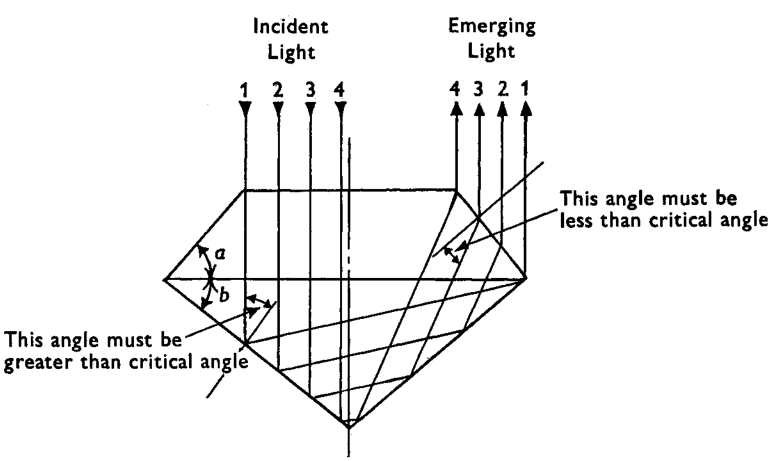

FIG. 4. *Conditions for total utilization of light.*

TABLE 1

THEORETICAL OPTIMUM PROPORTIONS FOR "BRILLIANT-CUT" GEMSTONES

Gem Material: Name	Refractive Index (n)	Critical Angle	Angles of Principal Facets: Crown (a) Fig. 4	Pavilion (b) Fig. 4	Proportions of Gem As a percentage of girdle diameter: Table Dia.	Height Crown	Height Pavilion
RUTILE	2·75	21°20′	38°56′	38°35′	·559	·179	·399
DIAMOND	2·42	24°26′	41°06′	38°42′	·561	·192	·40
CASSITERITE	2·04	29°20′	44°55′	38°48′	·571	·215	·402
SPHENE	1·96	30°41′	46°29′	38°51′	·574	·224	·403
ZIRCON	1·96	30°41′	46°29′	38°51′	·574	·224	·403
GARNET (Andradite and Almandine)	1·89	31°57′	47°24′	38°53′	·577	·230	·403
GARNET (Spessartite)	1·79	33°57′	49°10′	38°58′	·582	·244	·403
CORUNDUM	1·77	34°25′	49°45′	38°58′	·583	·247	·405
CHRYSOBERYL	1·75	34°53′	50°00′	38°59′	·583	·248	·405
GARNET (Pyrope and Hessonite)	1·745	34°57′	50°12′	39°00′	·584	·250	·405
SPINEL	1·717	35°39′	50°58′	39°01′	·586	·255	·406
OLIVINE	1·677	36°37′	51°42′	39°03′	·588	·261	·406
TOPAZ	1·634	37°44′	53°00′	39°06′	·591	·271	·406
TOURMALINE	1·631	37°52′	53°00′	39°06′	·591	·271	·406
BERYL	1·578	39°19′		39°10′			
			(43°)	(40°)	(·48)	(·24)	(·42)
QUARTZ	1·548	40°15′		39°12′			
			(41°)	(41°)	(·40)	(·26)	(·43)

Crown and pavilion angles, and heights are measured from the girdle plane. All proportions are referred to a girdle diameter of 1·0.

These conditions are illustrated in Fig. 4, which, for clarity, shows only the conditions for light incident on one side of the table. If this is repeated for the other side of the table it will be seen that all light falling on the table emerges through the crown facets. By reversing the arrows it can also be seen that vertical light falling on the principal crown facets will emerge through the table. Thus the whole of the crown is illuminated.

In 1926 S. Rosch determined, by graphical methods, the proportions and angles of the principal facets to fulfil the above conditions, and in the same year A. Johnsen arrived at identical proportions through strict mathematical analysis. Their work has since been confirmed and elaborated by other scientists and verified by practical cutting tests. Without going into the details of the somewhat involved calculations the results are tabulated in Table 1.

This table gives the actual calculated values for the refractive indices shown in Col. 2. However, the refractive index for any particular variety of gem is rarely constant, and, further, it is hardly possible to cut to an accuracy better than half a degree. For practical purposes, therefore, the angles given in the table may be rounded off to the nearest degree and the proportions to the second place of decimals without adversely affecting the result. Thus, for zircon, the angle of the pavilion facets may be taken as 39°, that of the principal crown facets as 46° and the crown and pavilion heights as ·22 and ·40, respectively, of the girdle diameter.

Three facts stand out very prominently in Table 1.

First.—The very slight difference in the calculated angles of the pavilion facets (*b*) and consequently in the height of the pavilion ; less than half a degree over the whole range. This arises from the fact that incident light perpendicular to the table is not refracted on entering the gem. It is reflected internally and therefore only subject to the law of reflection (angle of reflection equals angle of incidence).

Second.—The relatively large difference in the angles of the crown facets (*a*) and consequently in the proportions of the crown. This is due to the fact that light emerging from the crown facets is highly refracted and the amount of refraction varies with the refractive index of the gem.

Third.—The fact that for gems having a refractive index below 1·58 the calculated angle for the pavilion facets is less than the critical angle of the gem. This means that a refractive index of 1·58 is the lowest for which a theoretically perfect brilliant-cut is possible.

In regard to the third point, which applies particularly to beryl and quartz, Table 1 gives (in brackets) proportions based on a pavilion angle 1° greater than the critical angle. This gives some cutting tolerance above the critical angle. If the pavilion angle is made much greater than this the brilliance of the gem is greatly reduced. Further, increased pavilion angles require considerably reduced crown angles to avoid loss of light through the pavilion facets. For example, if the angle of the pavilion facets for quartz is made 42°, the angle of the principal crown facets must be less than 35°, if vertically incident light on these facets is not to be so lost. So much for the principal facets which determine the proportions of the gem.

Secondary Facets

These comprise 8 star facets surrounding the table and 16 cross facets surrounding the girdle both on the crown and pavilion, and, excepting for gems of high dispersion, as diamond and zircon, the angles of these facets are not critical and have not received theoretical study. For gems of high dispersion, as Rosch has pointed out, the cross facets above the girdle contribute largely to the fire and their angles should be such that the internally reflected rays strike them at only slightly less than the critical angle. This ensures maximum colour dispersion. The cross facets below the girdle serve to reflect some of the light that falls obliquely on the table and meets the pavilion facets above and outside the area lying immediately beneath the table. One point should, however, not be overlooked. An examination of Fig. 4 shows that while vertically incident rays passing through the table fall only on that portion of the pavilion facet immediately beneath the table, the whole of the opposite pavilion facet is used for their reflection. For this reason care should be taken to see that the principal pavilion facets are not unduly reduced by making the secondary facets too large.

Step-cut Gems

Some reference should be made to step-cut, or emerald-cut, gems, although these are not included in the theoretical studies referred to earlier. This type of cut is usually applied to coloured gems in which the absorption of light is appreciable, and their brilliance is thereby reduced. Their forms are too well known to need description and vary too greatly to permit the calculation of an " ideal " form. Some rules can, however, be laid down broadly to assist in obtaining maximum brilliance. In the first place no pavilion facet should ever be cut at less than the critical angle of the gem. If it is, a " window " will result ; that is, it will be possible to see right through the gem from the table. This is a particularly common fault in step-cut gems. The angle of the lowest row of pavilion facets can quite satisfactorily be made the same as the angles for pavilion facets given in Table 1. They should not, indeed, be more than a degree or two below these angles even for gems having a low critical angle, such as zircon.

The upper rows of pavilion facets are cut more steeply, but the increase in angle, particularly between the two lowest rows of facets, should not be unduly great. Steps increasing by 5° can be cut without difficulty and this should not be greatly exceeded for the lowest rows of facets. Certainly many step-cut gems are cut much more steeply than this with pleasing results. But although increased weight and greater depth of colour are thereby obtained it is at the cost of some loss of brilliance.

As the steepness of the pavilion facets is increased so must the height of the crown be reduced by decreasing the angle of the crown facets. If the bottom row of pavilion facets have an angle of 39° and the upper rows of pavilion facets increase in steepness by 5° for each row, then the total height of the gem will remain the same as in Table 1 and the angle of the crown facets will be reduced by about 10° as compared with the values shown in Table 1. As a general rule the width covered by the lowest pavilion facets should be approximately equal to the width of the table. A comparison

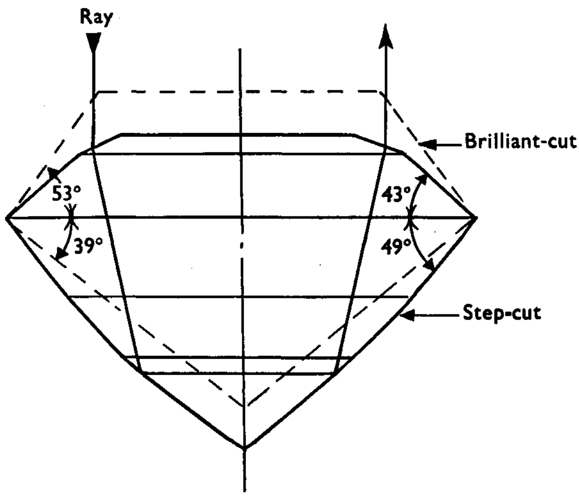

FIG. 5. *Comparison of step-cut and brilliant-cut topaz* ($n = 1{\cdot}63$).

of such a step-cut gem with an ideal brilliant-cut gem is shown in Fig. 5.

The narrow row of facets surrounding the table can be so cut that vertically incident light on a facet at one side of the table will have a symmetrical ray-path within the gem and will emerge vertically through the facet on the opposite side of the table. Such a ray is shown in Fig. 5. The angle of these facets depends on the angle of the lowest pavilion facet and on the refractive index of the gem. If the lowest pavilion facet has an angle of 39° the angle of the table facets will vary from 24° for zircon ($n = 1{\cdot}96$) through 27° for sapphire ($n = 1{\cdot}77$) to 29° for topaz ($n = 1{\cdot}63$). If the lowest pavilion facet has an angle of 38° then the angles of the table facets should be about 2° greater than these values.

It is frequently stated that stones of deep colour should be cut shallower than usual and that pale stones should have greater depth, in order to improve the colour. While the step-cut lends itself to such practices it is very questionable whether any improvement can be so gained. Any alteration to the tint, and it could only be slight, is more than offset by the loss of brilliance due to imperfect reflection within the gem. Deep coloured rough, as for example deep blue sapphires, will only show the colour to advantage if cut into small gems of the correct proportions, preferably brilliant-cut ; while for pale coloured gems the combination of maximum brilliance and pale colour is always more attractive than a " dead " stone of slightly deeper colour.

Size and Number of Facets

It is sometimes asked whether the 58 facets (including table and culet) of the standard brilliant-cut (Fig. 1) should always be applied to a brilliant-cut gem regardless of size. Rosch and others have pointed out that for a diamond, or gem of high colour dispersion, the size of the facets has an important bearing on the " fire." For this reason alone large diamonds require more facets than do small ones. Rosch has suggested an upper limit of 3 millimetres and a lower limit of ½ millimetre for the size of facets for the diamond. For a standard brilliant this would correspond to sizes from about 10 carats to 1/8 carat. For larger gems the number of facets should be increased, and for smaller gems some or all of the secondary facets may be omitted.

For coloured gems the conditions necessary for colour dispersion are not important and the standard brilliant-cut can be very beautiful for very much larger gems. For step-cut gems the number of " steps " both on crown and pavilion can be varied widely so long as the general rules set out earlier are observed.

In any case, and whatever the type of cut employed, the general principles outlined above should be followed. That is, that vertical light falling on the table should be totally internally reflected and should emerge from the crown facets (not through the table) at an angle as nearly perpendicular to the plane of the table as possible. If these conditions are fulfilled the maximum brilliance will be achieved.

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Gemmological Notes

JAPANESE CULTURED PEARLS

JOHN PROBUS

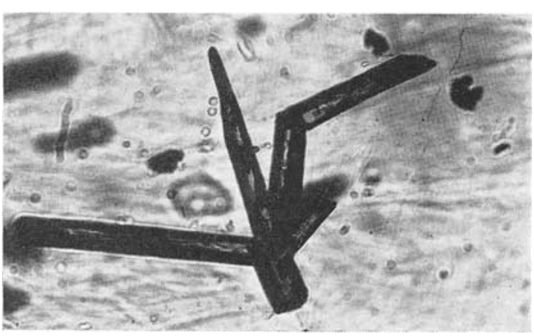
The Japanese cultured pearl fisheries have been badly hit by a hurricane. There is likely to be only about half of the normal production during 1960 and prices of cultured pearls have hardened.

CRYSTAL INCLUSION IN EMERALD

V. G. HINTON

A microscopic examination has been carried out on an emerald having interesting inclusions. The emerald was of poor quality, country of origin unknown, and of no commercial value. It was a very flat, square step-cut emerald of pale colour and when viewed with a hand lens showed a great many dark inclusions. On closer examination with a microscope these were found to be needle-like crystals, and when viewed with a white light appeared as yellow-brown fluorescing crystals. These were sharply defined, as shown in the attached photomicrograph. There appeared to be some form of growth on the surface of the crystals, but this may have been a dendritic overgrowth. There was no method available for identifying the crystal inclusions but their crystal form and physical properties suggested aragonite.

The crystal was the property of Mr. H. L. Blackmore, who gave permission to publish the photograph.



Crystal inclusion in Emerald

PLONK TESTING

A. E. FARN.

My fellow gemmologist and friend, Dr. E. H. Rutland, delights in, and is an expert at " Plonk Testing." To " plonk " (an unusual gemmological term meaning " to go off the deep end ") is to view a gemstone, usually *not* one of the better known gemstones, which has recently come to hand and to state categorically what the stone is—usually to the delight of the possessor since he is usually armed with details in advance.

A rule of thumb approach and a keen eye backed by knowledge of gemmology are the essentials to expertise. Possibly the hardest school is that which backs its judgment by placing not the stone upon the refractometer but its hand in its pocket.

Having attended many lectures and listened to much theory on the subject of gem testing and the rival and relative merits of certain instruments, I am reminded of certain examination questions phrased in the following style :—

" What do you consider the equipment necessary to furnish a model laboratory ? "

or "What are the most important or imperative instruments a gemmologist needs ? "

To answer such questions one usually has or shows a marked preference for certain instruments or gives obvious indications of techniques favoured by an instructor. Some people are keen on refractometer work, others specific gravity or the spectroscope, and some of course combine the use of each. There are some tests so rudimentary and positive that it is needless to go further, which of course admits a knowledge of gemmology.

Whilst testing by sight is not necessarily accurate, it is usually applied with a background of knowledge and reasoning. I should have stated earlier that perhaps a lens is permitted, but no more. An instance of such testing could be a completely colourless (or white) stone, whichever term is preferred, with one or two minute bubbles, no double refraction discernible but perhaps a slight " chatter-marking "—a sure sign of heating of corundum. Therefore the stone would be a synthetic corundum. This, of course, is a very obvious instance. There are, doubtless, countless others which will spring to mind. Most gemmologists, of course, test stones for enjoyment at leisure; professionals test against the clock and seldom have much time to browse amongst the undoubted beauties of inclusions in Burma or Siam rubies. The latter, though less expensive commercially, are amongst the most beautiful stones from an inclusion point of view. Having tested some tens of thousands of stones I am afraid I do not linger too long in throes of delight on seeing either a Ceylon zircon spectrum or hessonite garnet inclusion. These are merely speedy recognition signs for testing.

Quite recently a parcel of 284 cts of mixed round stones of various colours, and approximately 3,500 stones came into my possession. My first reaction was to glance swiftly through the stones spread out on the table on a sheet of white paper and pick out any likely stones, i.e. those which " looked " interesting. Most seemed to me to be the product of Ceylon—later proved correct. Two stones only proved to be of a likely hue and appearance. The remainder I sorted by colour into piles of brown hessonite garnets, red/pink Ceylon garnets, pale blue, green and yellow Ceylon sapphires, and an intriguing assorted coloured section of zircons of every hue. The colourless portion, thank goodness, was very small —these are always a headache except in this instance.

Having decided the piles on colour, the next step was to check by spectroscope. Every pink/red garnet was swiftly pushed into a spot of light from an intensity lamp focused onto the table, and the garnets fed from left to right. With the spectroscope held in the right hand some 600 stones were accurately observed and dealt with in about two hours (having all the same spectrum helped a lot). The zircons came next and the same procedure took place, except that here some had a full Ceylon spectrum and some just a hint of the 6535Å line, some metamicts. Again this was a speedy test of approximately similar quantities and time. A point of interest here is that the quick focus spot method of scattered light will give a sharp absorption spectrum from a stone of less than one-tenth of a carat whereas by transmitted light through a microscope it would be flooded out and the eye would quickly become fatigued. The next parcel, possibly the largest in number, were those "plonked" as hessonites. Here there could be (I hoped) a Spessartite or two and the spectroscope came into play once again. None of the stones showed a spectrum, my eye being focused on the blue section end looking for a sign of manganese in the make-up of the stone. There was no need to take the R.I. of any of these stones since a quick check of samples by lens and use of corn tongs showed all had the familiar diopside crystal inclusions—the characteristic sign of hessonite. After a time, when one has concentrated solely on one colour of gemstone, the eye becomes attuned and exceedingly quick to distinguish any unusual stone. These three groups had reduced the bulk by about 85%.

The next lot were the potential Ceylon sapphires. Knowledge of colour shades indicated no synthetics being present, since these latter stones are usually a finer colour than their natural counterparts.

Although the spectroscope was speedy in picking out green-blue sapphires, it only gave a hint of chromium being present in the pale shades of blue sapphires. This was interesting to note, since the evidence was also proved by the slight change from pale blue to pale lavender or pink when being transferred from daylight on the table to the artificial light on the focus from the intensity lamp. Although these stones were small, quite a fine bright fluorescent line could be picked up by eye on tilting the spectroscope to the left. This is a useful tip when " searching " for a spectrum, e.g. commercial quality Ceylon sapphires do not readily or easily show a 4500Å line, but tilting the spectroscope will often bring it into view. (In the latter case the spectroscope is tilted to the right). Having hinted perhaps that my tuition was carried out in an atmosphere partial to absorption spectroscopy, I must state the obvious and point out that for a gemmologist it is red on the left, blue on the right, when looking through a spectroscope. The pale blue and yellow sapphires together were checked by lens and tongs for chatter-marking and feathers, of which fortunately there was an abundance. Ceylon liquid feathers and two-phase inclusions are a joy in speedy establishment of origin.

The hard core of " seeded " stones now came to be tested. Several mauve/brown stones proved to have the refractive index of natural spinel, two other deep golden brown stones were chrysoberyl, whilst the remainder of colourless stones were quartz and topaz respectively. Considering its travels and origins I was lucky not to find a single paste or synthetic stone in the parcel.

SYNTHETIC EMERALD

D. Wheeler

There has been objection in the U.S.A. to the use of certain descriptions which have been used in promoting the sale of

" Chatham cultured emeralds." There has also been a denial of all the material allegations and the matter is now before the Federal Trade Commission. In many countries these laboratory-made stones have been described as synthetics and the jewellery trade has accepted this without question. Presumably the new hydrothermally produced rubies, from the same laboratory, will be affected in what they may be called by the Commission's future decision. There is good reason for calling these products synthetic, as, on the other hand, there is a reasonable case for calling them by a name which indicates the method by which they have been formed. The Vernuil synthetic is a flame-fusion product and the " cultured " stones are grown from a saturated solution, by what has been called a melt-diffusion process.

SYNTHETIC DIAMONDS

JOHN PROBUS

De Beers Consolidated Mines Ltd. have fairly quickly followed the General Electric Company of America in producing synthetic diamonds of industrial quality. Similar processes were used by both companies and other developments are expected from Holland and Sweden, where synthetic production has previously been announced. The latest report of the G.E.C. is that both the colour and shape of the crystals can be controlled. The scientist in charge of the De Beers production was Dr. J. H. Custers, Director of the De Beers Adamant Laboratory.

MORE RUBIES FROM THE LABORATORY

G. ANDREWS

Following the report in 1959 (Journal of Gemmology VII, 1, 16) of the production of hydrothermally produced corundum, C. F. Chatham has announced the making of ruby in his laboratory. The problem for gemmologists and jewellers is distinguishing these new products from the natural and first evidence indicates that it may be more difficult than differentiating between natural and laboratory-produced emerald. Curved growth lines are obviously absent and the new product contains various types of inclusions similar to those which occur in the natural stone, due no doubt to the crystals used as " seeds " for the new growth. The new stones fluoresce brightly but not all phosphoresce. The new product raises issues of considerable importance to the jewellery trade.

AN UNUSUAL STAR-BERYL

By W. F. EPPLER

BERYL with asterism must be very rare, as it is seldom seen among gemstones. The gemmological literature mentions only a few cases of beryl with this phenomenon. V. Goldschmidt[1] described a ball of a bluish and transparent beryl (aquamarine) from Brazil, with fine tubes parallel to the c-axis. Under proper illumination the tubes cause a complete circle of reflection round the ball, so that in this case a cat's-eye effect is exhibited.

On the other hand, Hauswaldt[2] demonstrated an impressive asterism on beryl in transmitted light, showing a sharp-lined, six-rayed star.

E. H. Rutland[3] described a dark brown beryl from the Gov. Valadares area of Minas Gerais, Brazil, which has a somewhat poorly developed star. It was found by the writer[4] that coarser and finer skeletons of orientated inclusions of ilmenite were responsible for this asterism.

An unusual star-beryl, owned by Mr. B. W. Anderson, represents a valuable rarity. It is of an agreeable greenish colour with a greyish tint, translucent to nearly opaque, and it exhibits a perfect star of the quality of a good rose-quartz asteria. Anderson found the S.G. to be 2·682 and the values for the R.I. with $n\omega = 1{\cdot}569$ and $n\varepsilon = 1{\cdot}564$. The size of the well cut stone was 93 carats.

(This had been the original weight, for Anderson generously agreed that from the convex back a slice could be sawn to obtain the material for further investigations. The operation did no harm to the beauty of the stone, even if it caused the loss of a number of carats).

A first look through the microscope revealed that the star-beryl itself is transparent. Only a multitude of crystal inclusions of different kinds reduces the transparency strongly. The inclusions are densely distributed throughout the entire stone (Fig. 1). They consist of opaque flakes and groups of transparent crystals. In reflected light (Fig. 2) it is easy to observe that the flakes are six-sided and that they are orientated parallel to the basal plane of the host crystal. By using a higher magnification (Fig. 3), they reveal a bronze-yellow colour. It was found that they consisted of pyrrhotite, FeS, including in themselves brighter spots of a brass to

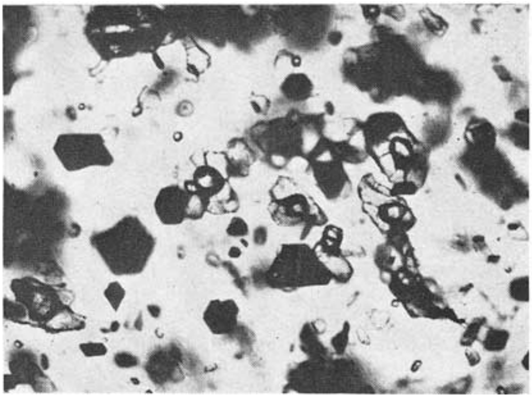


FIG. 1.
Star-beryl with inclusions of black flakes of hexagonal shape, and of transparent crystal groups. View perpendicular to the basal plane (0001) ; transmitted light, 50 ×

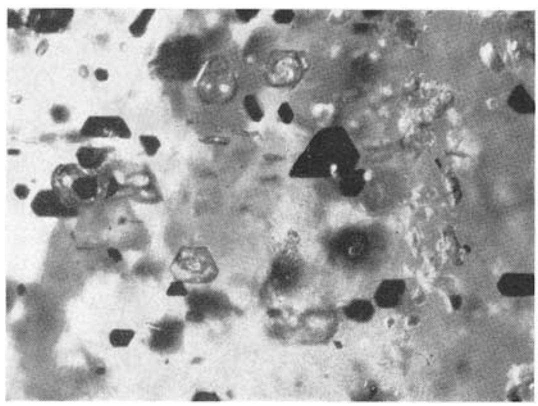


FIG. 2.
Same as Fig. 1, in reflected light, 65 ×

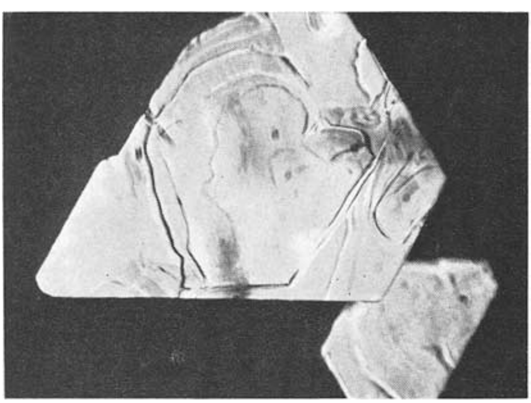


FIG. 3.
A tabular crystal of pyrrhotite as the cause of asterism in the star beryl, part of Fig. 2, reflected light, 220 ×

golden yellow colour of the tetragonal chalcopyrite, $CuFeS_2$. In Fig. 3, the small spots appear faintly on the left side and in the upper right corner of the big plate.

These very thin but strongly reflecting tabular crystals of pyrrhotite are the cause for the star-effect of the beryl. Their orientation parallel to the basal plane with their edges parallel to the first order prism of the host beryl makes it obvious that they originated by exsolution. They are, therefore, of secondary or epigenetic origin.

The transparent crystal groups, which have no particular orientation to the host crystal, do not contribute to the star-effect. They present difficulties with respect to their nature and origin. As it is shown in Fig. 4, each group consists of several individual crystals, which one kind differs considerably in R.I. from the other. To anticipate the results of testing, which will be explained later, the following seems to be very likely. The darker and mostly rounded crystals in the centre of each group have a higher R.I. than the including beryl. They proved to be epidote. They are overlying one or several fragment-like pieces of another crystal with a R.I. lower than beryl, and which could be determined as quartz. The pieces of quartz have different orientations. In each group they are closely put together and sealed or cemented by the over- (or under-) lying epidote crystal. Such a combination of two different kinds of crystals as inclusions in a third crystal is very strange and not yet known in any other gemstone.

Besides the flakes of pyrrhotite and the crystal groups of epidote and quartz, the star-beryl contains further inclusions of less frequent distribution. One of these is clusters of pyrite of which, unfortunately, no photomicrograph could be taken. Finally, acicularly developed crystals of apatite with the typical cleavage cracks could be observed, of which Fig. 5 represents an example.

The method of investigation, in this case, was absolutely unorthodox. From the slice of star-beryl, a piece of sufficient size was taken and crushed in a steel mortar by a few gentle blows. The fragments obtained by this brutal procedure varied in size, but they proved to be very useful. Fig. 6 and 7 show such a fragment of random orientation, embedded in bromoform and in benzylbenzoate respectively. Both pictures give a general view of the distribution and the arrangement of the dark-rimmed epidote and the brighter quartz likewise.

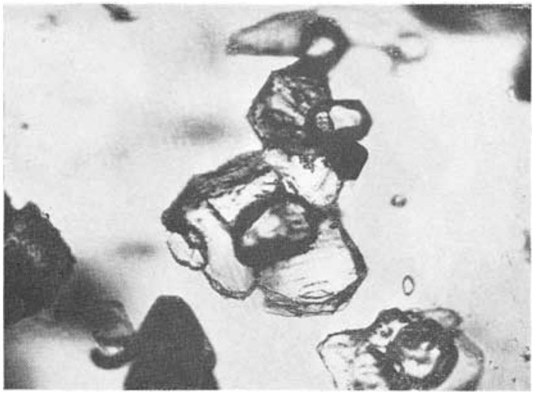


FIG. 4.
Groups of transparent crystal inclusions seen perpendicular to the basal plane of the star-beryl, 120 ×

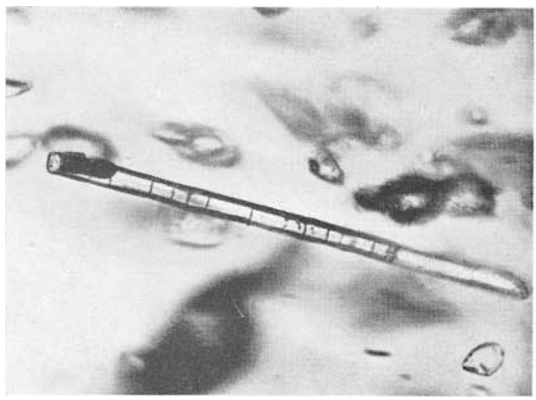


FIG. 5.
An unorientated apatite as an inclusion in the star-beryl. The lack of sharpness at the right end of the crystal is due to other overlying inclusions, 120 ×

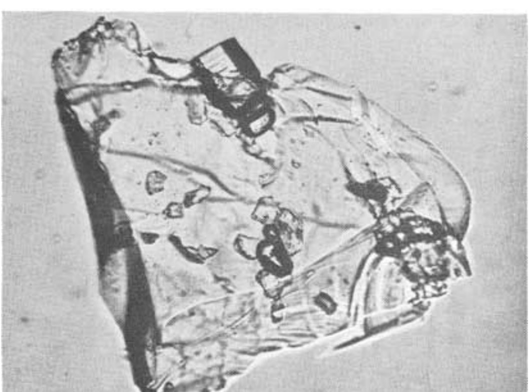


FIG. 6.
A fragment of star-beryl embedded in bromoform (n = 1·59), 65 ×

Fig. 8 and 9 represent another fragment of the star-beryl in ordinary and in polarized light. The flakes of pyrrhotite appear as small but somewhat indistinct lines indicating that the fragment nearly follows the direction of the c-axis. Also in this direction, the distribution and the arrangement of the epidote-quartz inclusions are practically the same as in Fig. 6 and 7. From this can be concluded that the crystal groups do not prefer a particular orientation. A confirmation is offered by Fig. 10, which shows a fragment approximately parallel to the base-plane of the beryl. This orientation can be deduced from the inclusions of pyrrhotite, which appear in this position as six-sided plates. Also in this case, no preferred orientation of epidote and quartz can be observed.

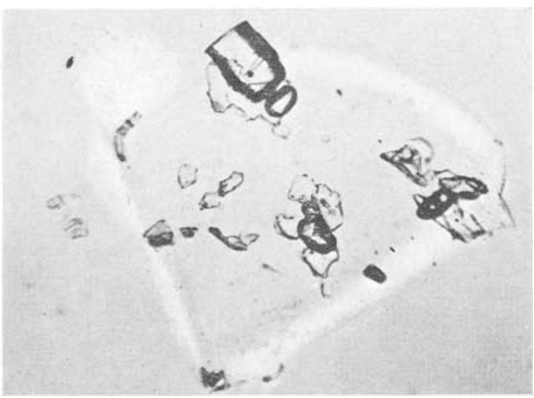


FIG. 7.
Same fragment of star-beryl embedded in benzylbenzoate BBE ($n = 1{\cdot}570$), 65 ×

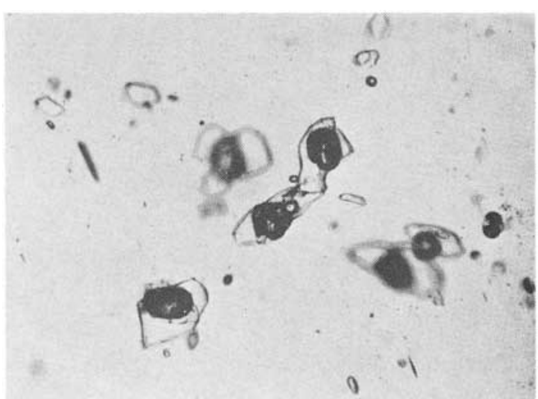


FIG. 8.
A fragment of star-beryl nearly parallel to the c-axis, embedded in BBE ($n = 1{\cdot}570$), 65 ×

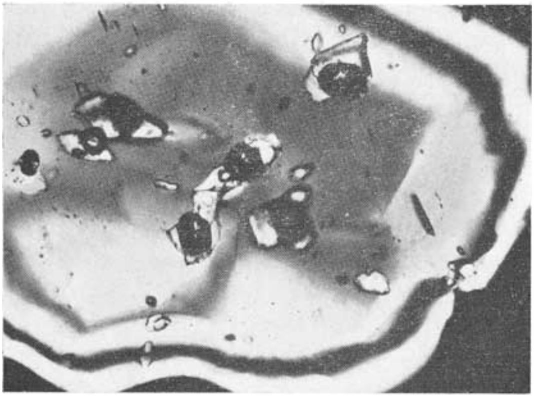


Fig. 9.
Same fragment of star-beryl embedded in BBE ($n = 1{\cdot}570$), in polarized light, 65 ×

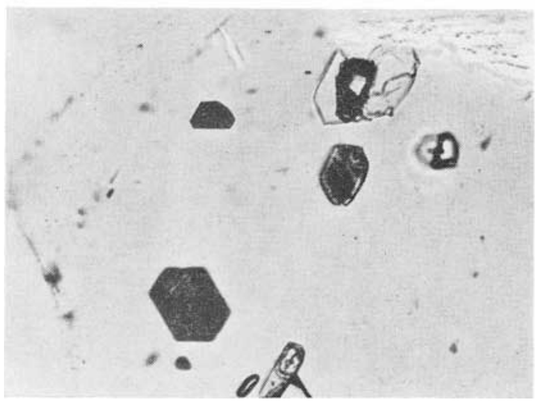


Fig. 10.
A fragment of star-beryl approximately parallel to the base plane, embedded in BBE ($n = 1{\cdot}570$), 120 ×

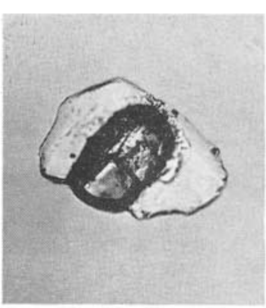


Fig. 11

Fig. 12

Fig. 11.
A crystal group consisting of two differently orientated quartz particles in contact with a rounded crystal of epidote; separated from the star-beryl, embedded in BBE ($n = 1{\cdot}570$), 120 ×

Fig. 12.
An epidote crystal separated from the star-beryl, embedded in BBE ($n = 1{\cdot}570$), 65 ×

The smaller fragments of the crushed star-beryl have been carefully examined to find pieces of pyrrhotite, but without any success. It can only be assumed that the brittle and very thin plates of these crystals—they have a thickness of a few microns only—have been powdered into such small particles, that their size lies below the given possibilities of observation.

Other of the smaller fragments of the star-beryl proved to be epidote, quartz, apatite, and pyrite. Fig. 11 displays a crystal group, separated from the star-beryl by the crushing process. It consists of two pieces of quartz of different orientation, which have no crystal faces but look like broken chips with irregular borders. Their seam is covered by a rounded epidote crystal. Also single chips of quartz can be encountered in the star-beryl as well as in the powder obtained by crushing. The latter have been tested by the use of proper liquids which allowed to find the R.I. to be between 1·54 and 1·56 and the S.G. at 2·65. A comparison with similar chips obtained by crushing a natural quartz crystal had the same results.

It is extremely difficult to understand what might have been the cause of embedding chips of quartz in a beryl. Even more difficult is it to find an explanation for the fact that two or more quartz chips are in tight contact and, moreover, cemented by an epidote crystal which, on its part, looks as if it had been strongly water-worn. Only one fact seems to be certain, namely, that quartz chips and rounded epidote crystals are pre-existing inclusions, which had already passed an impetuous period of crystal life before they finally became entrapped within this particular star-beryl.

Among the smaller fragments of the powdered beryl, a certain number of epidote was present, with different shape and size. With the aid of the immersion method it was found that their R.I. is very closely near 1·74, and with the heavy liquid method resulted a value for the S.G. of approximately 3·4. Every crystal of this kind is doubly refractive, and has an angle of inclined extinction within the limits of 1° to nearly 3°. These figures are in conformity with those quoted for epidote by E. S. Larsen and H. Berman.[5] It seems somewhat puzzling that the enclosed and the separated crystals of epidote did not display even a shadow of the usually marked green colour. But the colour may change with the different contents of iron. On the other hand, the smallness of the crystals can make them appear to be colourless.

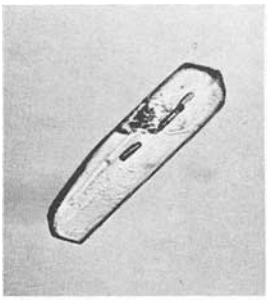


FIG. 13.
An epidote crystal separated from the star-beryl with elongated crystal inclusions ; embedded in alpha-bromonaphthalene ($n = 1{\cdot}659$), *120* ×

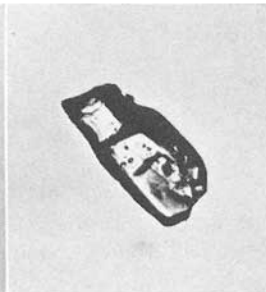


FIG. 14.
Part of an epidote crystal with inclusions, separated from the star-beryl, embedded in BBE ($n = 1{\cdot}570$), *65* ×

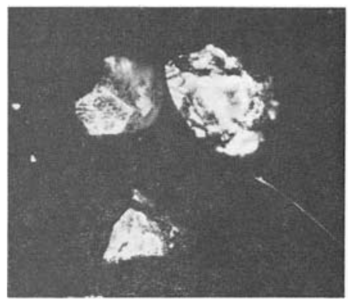


FIG. 15.
Exclusions of pyrite, obtained from the star-beryl. One of these particles exhibits a pentagon, 22 ×

Figs. 12-14 show three typical forms of epidote separated from the star-beryl. Fig. 12 shows a rounded crystal, with a marking of the spot where formerly two chips of quartz had formed a borderline. It is the broader black line in the middle of the crystal which indicates a still existing step. Besides this, the epidote contains some inclusions of an unknown nature.

The epidote in Fig. 13 is embedded in a liquid of higher refraction. • Therefore, elongated inclusions of doubly refractive crystals are visible, the R.I. of which is distinctly lower than that of the host crystal.

Among the crushed pieces, the apatite with its characteristic cleavage cracks was only met with in very small pieces. It could be found that the R.I. of such pieces is not far from 1·64, and the S.G. nearly coincides with the value of Thoulet's solution (3·17). These figures, in combination with the typical appearance of the material as an inclusion in the star-beryl (Fig. 5) are sufficient for its identification.

No photomicrograph could be taken of the clusters of pyrite which the star-beryl contains. But the "exclusions," which are shown in Fig. 15 could be determined as pyrite. One of the particles exhibits a pentagon, the crystal face of the pentagonal dodecahedron (210). In this crystal form pyrites can be very often encountered.

Summary

The unusual star-beryl consists of transparent beryl, which contains a multitude of crystal inclusions. Because of this, the stone appears to be translucent to nearly opaque. The inclusions are : tabular and very thin pyrrhotite, FeS, which is the cause of a perfect star ; crystal groups consisting of a combination of quartz chips and rounded crystals of epidote (both kinds of materials also appear as independent inclusions) ; rod-like developed apatite and clusters of pyrite.

Acknowledgment

The author is indebted to Mr. B. W. Anderson for so generously allowing a slice to be taken from the star-beryl and to Prof. Dr.Ing. A. Maucher, Director of the Geological Institute, University of Munich, for the determination of the pyrrhotite and pyrite inclusions.

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3. E. H. Rutland. *An Unusual Brown Beryl*, Gemmologist, Vol. XXV, No. 304, Nov., 1956, 191-192.
4. W. F. Eppler. *Notes on Asterism*, Journal of Gemmology, Vol. VI, No. 5, Jan., 1958, 208-212.
5. E. S. Larsen and H. Berman. *The microscopic determination of the nonopaque minerals*, Geological Survey Bulletin 848, Washington, 1934, pp. 191 and 195.

Gemmological Abstracts

LEIPER (H.). *Botryoidal nephrite find in California.* Lapidary Journ., Aug. 1959, p. 394.

A conglomerate mass of serpentine, with botryoidal lumps of nephrite closely packed together throughout the piece, has been found in San Diego County, California. The nodules are complete in themselves and the colour of the jade is light to emerald green. When some of the nodules were sliced, the centre of the slabs were a white mutton fat, the outside a pleasing green. It has been suggested that the material is a pseudomorph after chalcedony nodules—the forms they take are identical. Very little is known about the causes of metamorphic changes affecting nephrite and its associated minerals.

S.P.

CROWNINGSHIELD (G. R.). *Highlights of the Gem Trade Laboratory in New York.* Gems and Gemology, Nos. 9 and 10, Vol. IX, pp. 268-270 and 286 ; 291-294, Spring and Summer, 1959.

Reports red and blue-green colours in irradiated diamonds. The red-coloured diamonds showed the absorption line at 5920Å and the blue-green stones a strong line at 4800Å and a weaker line at 4900Å. Many more yellow diamonds are now being tested in this laboratory. Some comments on other diamonds tested are given. A number of jade imitations sent in for identification included aventurine quartz, calcite, dyed serpentine, smithsonite and glass, also dyed jadeite. There is difficulty in identifying turquoise from the many simulants now produced. Comment is made on white coral and its simulation by pinkish conch shell and reference is made to a press report of a black coral from Hawaii. A yellow-green glass had a refractive index greater than 1·80 and a density of 5·40. A blue fluorescent diamond, which showed two bright fluorescent lines at 4350 and 4420Å, and a brown fluorescent diamond, which turned a green colour on exposure to sunlight but returned to brown after being returned to the dark for some time, were two unusual diamonds examined. Clam pearls are more

frequently encountered. A warning is given that a case is extant where a yellow sapphire had badly faded on exposure to strong sunlight and it is inferred that the stone had been treated with X-rays to improve the colour. Star-stones, with two sets of rays (one a twelve-rayed stone) showed each set of rays to have different colours, a blue and a yellow.
1 illus. R.W.

SINKANKAS (J.). *1800 sea-green carats.* Gems and Gemology, No. 10, Vol. IX, pp. 299-305, Summer, 1959.

An enormous mass of sea-green spodumene weighing 3675 carats was cut into an octagonal step-cut stone of 1804 carats. The dimensions of the stone when finished were $3\frac{7}{8}$ inches by $2\frac{1}{4}$ inches. Cutting involved the construction of special equipment.
3 illus. R.W.

LAMB (N. F.). *Determination of mounted stones.* Australian Gemmologist, No. 2, Vol. II, pp. 11 and 12, August, 1959.

Some notes on the methods which may be used to identify mounted stones (with particular reference to the identification of mounted stones in the practical examination of the Gemmological Association of Australia). The scheme suggested has good points, specially in that a careful examination by a lens should be the first to do, but later methods appear to suffer from the fact that the use of absorption spectroscopy is completely ignored. Its use would give conclusive results and save valuable time.

R.W.

GÜBELIN (E.). *New fakes to simulate black opal.* Gemmologist, No. 337, Vol. XXVIII, pp. 141-142, August, 1959.

Opal is imitated by an opalescent glass and by fusing together two plates of glass in such a way as to produce an interference effect. Opal doublets are made of a slice of real opal cemented on to a second piece of opal, or on to a black glass or black onyx. Two new types of opal composite stones are described, the first consisting of a colourless cabochon of quartz, which is backed by a thin layer of white or black opal and the whole completed with a backing of a piece of opal cemented with black cement. The refractive indices of the top are that of quartz (1·55) and the base will give a reading of 1·45, that of opal. One such composite stone gave a density of

2·48. A second type of opal triplet has similarly a rock crystal top with a thin slice of opal below, but in this case the base is finished with a base of black glass which has a refractive index of 1·49. The density of one such stone was found to be 2·62. In both cases the stones look " wrong " and the play of colour is seen to lie conspicuously deep below the cabochon surface. Unset, the stones show a pronounced line of joining of the component parts, but if set this is hidden and recourse may be made to the immersion of the whole jewel in water. When viewed sideways the colourless top of quartz is made clearly visible.

R.W.

METCALFE (B.). *Experiments on colouring diamonds by nuclear radiation.* Gemmologist, No. 338, Vol. XXVIII, pp. 161-164, September, 1959.

The author has been engaged in experiments in the bombarding of diamonds. Some of the history of earlier experiments on the colouring of diamonds by radium emanations is given. The article is mainly concerned with the types of treatment, colours produced, and something of the methods used in irradiating diamonds to-day. The cause of the colour-change produced in diamond by irradiation is due to the disturbance of the crystalline arrangement of the carbon atoms. The degree of this disturbance and the way in which the original lattice is distorted give rise to colour-centres which change the visible colour of the stone. Heat at various temperatures produces a partial annealing of the disturbed crystal structure and can change but not destroy the colour. Neutron, electron and proton bombardment and gamma-ray irradiation have been used in the experiments. In experiments using neutrons, with irradiations of 1, 2, 5 and 50 hours, the shorter exposures were found to give a green colour to diamonds, the depth of colour varying with the length of exposure. The long exposure (50 hours) produced a coal-black stone. It was found that a given intensity of colour at a given neutron flux was inversely proportional to the cube root of the weight of the stone. The colour produced is additive and in no way could the colour of an originally coloured stone (Cape stones) be reduced. Heating experiments on green irradiated stones showed them to turn to a yellow, amber, or cinnamon-yellow colour, and the depth of the yellow colour was relative to the depth of the induced green colour. Electron bombardment by the use of a Van de Graaff generator was the subject of other experiments, and the methods and apparatus used to hold the stone in the electron beam are given. The colours produced by electron bombardment are light green to green-blue or blue-green, but the stones were found not to give identical results. A pale green colour was induced in one stone treated with protons. Gamma irradiation was carried out by using Cobalt 60 and a bluish-green colour was produced in the stones. A summary and a short list of references is given.

3 illus. R.W.

WEBSTER (R.). *The jades.* Gemmologist, Nos. 337 and 338, Vol. XXVIII, pp. 153-157 and 166-168, August/September, 1959.

Jade is the name applied to two minerals, nephrite and jadeite. The derivation of the names, characters and localities of the two minerals are discussed. Mention is made of the so-called " buried jades." Some notes are given on the fashioning of jade and on such minerals as simulate the true jades. These are bowenite serpentine, prehnite, massive grossular garnet, massive idocrase, microcline feldspar, smithsonite, chrysoprase and green aventurine quartz, saussurite, smaragdite, pseudophite, verdite and agalmatolite. A green material from New Guinea, called astridite, is composed of chrome-rich jadeite intergrown with picotite, quartz, opal and limonite, which has been derived from olivine rock. Jade is stained to an Imperial jade colour and to a strong mauve. Notes are given on the new jadeite triplets and the imitations of jade in glass and plastics.

2 illus. P.B.

HILL (D. K.). *Glass and Gemmology.* Gemmologist, No. 337, Vol. XXVIII, pp. 143-150, August, 1959.

An article based on the Gemmological Association's Herbert Smith Memorial Lecture of 1959. The nature of glass and the effect the differences between crystal and glass show to an X-ray beam are mentioned. It is a fundamental property of glass that it has no fixed melting point, thus it has a continuous viscosity temperature curve. Many glasses are deliberately prepared with inclusions ; such glasses are the opal glasses, aventurine glasses, etc. Orientation of the inclusions can only be made in one direction, to produce satin and chatoyant glasses. The effect of the inclusion of colouring oxides in glasses, and manufacture of "dichroic glasses," which show different colours according to the nature of the light or when of different thicknesses. The methods used for the production of glass and glass wares are explained. The uses of glass in art and industry conclude the article.

3 illus. R.W.

TRUMPER (L. C.). *Zincite ; a rare gemstone.* Gemmologist, No. 334, Vol. XXVIII, pp. 81-83, May, 1959.

A report on the characters of a cut zincite. The stone, of a deep red colour, which weighed 1·528 carats, was found to have a density of 5·665. Using the differential reflectometer devised by the author, the refractive index of the stone was estimated to be between 2·00 and 2·10. No dichroism could be assessed owing to the masking effect of the deep red colour, and no fluorescence was observed, nor was any transparency to short-wave ultra-violet light found. The absorption spectrum showed an absorption of the blue-violet, the edge being at 5150Å, and there was a broad and deep absorption band between 5900 and 6300Å. The inclusions present were of two types, hair-like inclusions and clouds of small dot-like inclusions. The only source of gem zincite, an oxide of zinc (ZnO), is at Franklin Furnace, New Jersey, U.S.A.

2 illus. R.W.

HARDY (E.). *The Australian Pearl Shell Industry.* Gemmologist, No. 334, Vol. XXVIII, p. 98, May, 1959.

A short description of the present state of the pearl shell fishing industry of Northern Australia. The large *Pinctada maxima* is the oyster fished. Modern diving dress is used by the divers. When the diver finds a good patch of shell he is tempted to stay down too long with the likelihood of developing air bubbles in the blood-stream—"the bends." To avoid this a table of safe times and depths to work, based upon Royal Navy diving experience, is used as a guide. Most of the pearl shell is exported to the U.S.A., Germany, Britain and Italy. An expert of U.N.F.A.O. visited the Red Sea fisheries to instruct the native fishermen in the use of a newly invented Italian diving equipment of simple form.

R.W.

WALTER (D. R.). *Some notes on a recent West Australian mineral discovery.* Australian Gemmologist, No. 11, Vol. 1, pp. 16-17, May, 1959.

Describes the recently discovered " opalized tiger's-eye " found in the north of Western Australia. The material has been formed by the gradual replacement of asbestiform serpentine by compact opal, the fibrous structure being retained. The colour range of the material is from lemon yellow to yellow-green, grey-green, honey brown, and chocolate brown. A similar material is said to be found at Eyre's Peninsula in South Australia.

R.W.

BOOK REVIEWS

SINKANKAS, JOHN. *Gemstones of North America.* 675 pp., 176 illus. 112s. 6d. D. van Nostrand, New York and London, 1959.

Well known as the author of a standard work on gem cutting, Captain Sinkankas has written an excellent treatise on the gems and gem minerals of North America. Almost all of the book is given to descriptions of the gems and their localities. The properties of gems and their terminology are treated briefly and further reading suggested. In addition to the essential data on the chemical and physical properties of the individual species there is abundant information on locality occurrence, the author having visited and worked in several of the areas mentioned. Unnecessary mineralogical data are sensibly omitted. The arrangement of the book is in accordance with the abundance and rarity and commercial importance of the various species that are found.

The chapter on rarer and unusual gems contains several unfamiliar names and one day gemmologists will have to come to terms with the recording of minerals which have been faceted or cut en cabochon at the whim of the collector. There is a brief section on pearl and other organic gem materials.

International nomenclature is followed and the book is refreshingly free of the many fanciful names that are sometimes given to gems by American enthusiasts. The labelling of quartz with the name " topaz " is rightly condemned but the use of " Spanish topaz " or " Madeira topaz " for heat-treated amethyst does not earn similar disapproval. Chrysolite is named as a variety of olivine, a name which is discouraged in Europe.

There is a comprehensive geographical and locality index, a tabular review of the geology of gemstone deposits, notes on collections and the collecting of gems and a useful glossary. The bibliography is excellent with, as an unusual feature, the author's comments about each work mentioned. It is noteworthy that Captain Sinkankas considers that G. F. Herbert Smith's " Gemstones " is " the best general treatment of the subject of gemmology in the English language."

The author has received valuable assistance with the many photographs which are reproduced, but the handsome coloured illustrations (unfortunately too few) and numerous drawings are his own work. They are beautifully done.

Gemmologists in North America are fortunate in having such a competent book, which is accurate in detail and in which the clarity of the text makes it easy to read. Captain Sinkankas, who is serving with the U.S.A. Navy, has made hobbies of collecting and fashioning gems. His second major work has established him as a gemmological author of first rank.

S.P.

WEINSTEIN (MICHAEL). *The World of Jewel Stones.* Sheridan House Inc., New York. 50s.

Michael Weinstein is already known by name to many gemmologists as the author of a short book, "Precious and Semiprecious Stones," published by Pitman thirty years ago, which has since been through several editions. " The World of Jewel Stones " is a much more ambitious work, being a large and well-produced volume of more than 400 pages. It represents an attempt, as stated in the author's foreword, " . . . to give the reader some general information on all gemstones and also the more important materials (apart from metals) which may be seen in modern jewellery." Mr. Weinstein continues " . . . All too often a purely scientific approach to this subject is offered to the general reader, but here it is hoped that those interested will find sufficient information of both a practical and theoretical nature, presented in plain language, which can be pleasantly and profitably assimilated."

One may say that the author's aim has been fulfilled with a fair degree of success. Unfortunately, the publishers make far more pretentious claims for the book: " About once in a generation there is written a definitive book on a great subject. This is the great book on gems and jewel stones for the present time." The book has far too many shortcomings, particularly on the technical side, to be worthy of the adjective " great."

On the purely descriptive side the book has much to commend it. The author has had a lifetime of experience in the precious stone trade, and he has obviously been at pains to cull from various sources information concerning the mining and recovery of gemstones, and the quantity and value of stones mined in historic and recent times. The book has none of those preliminary sections on the crystallography and physical properties of gems which are apt to alarm the non-scientific reader. After a brief chapter on " The Antiquity of Jewel Stones," the author leads straight on to a description of individual gemstones, beginning, as is usual, with the commercially most important stones, diamond, ruby, sapphire, and emerald. His descriptions of amber and jade are particularly good (as they were, one remembers, in his smaller book), and it will please the collector to find that he manages to give brief coverage to the rarer gems which are seldom if ever seen in jewellery.

With the " general reader " in view, one can understand the author's reluctance to introduce technical details into the descriptive part of the book, but one could wish that when these *are* included they had been made more accurate and truly informative. Too often a " half-baked " statement is made which will satisfy nobody and must certainly irritate the informed gemmologist or the student in search of information. For example, with obvious reference to Type I and Type II diamonds, Mr. Weinstein writes: " Actually, diamonds may be divided into two types, the one being a more perfect single crystal than the other. This is shown by the difference in cleavage; and also the one class is transparent while the other is opaque to certain ultra-violet and infra-red rays." This statement merely leaves a muddled impression: surely it would have been wiser either to omit all mention of these interesting variations in diamond, or to have been more explicit. Again, instead of a clear account of the important fluorescent behaviour of diamonds under ultra-violet light, which is so fascinating both to the layman and to the scientist, Weinstein writes (in his diamond chapter): " In a vacuum and exposed to a high tension current of electricity, diamonds phosphoresce in different colours . . . ."

giving the reader the impression that only in an elaborately equipped laboratory can the fluorescence colours shown by diamond be observed. In a later chapter, it is true, a paragraph is devoted to fluorescence effects under ultra-violet light; but this is summarized from the work of physicists who are unfamiliar with gemstones, with the result that such mis-statements as that aquamarine " gives a strong reaction " under the rays are included.

There is a carelessness, too, in the author's use of English. " Mitigates," for instance, is used more than once where " militates " is obviously intended, and such phrases as (pink beryl) . . " is the largest pink transparent stone found " and (aquamarine) . . . " which does not change in artificial light " abound.

In dealing with synthetic gemstones—a subject of great importance to the jeweller—the author is less than adequate. The sintered blue synthetic spinel which is used to simulate lapis lazuli, for example, is not mentioned, nor is strontium titanate, the most successful imitator of diamond. In mentioning synthetic rutile, Weinstein states that it cannot be confused with diamond on account of its low hardness and greater specific gravity, without mentioning the two characters which make this synthetic immediately recognizable—its outstanding dispersion, rendering it as full of colours as an opal, and its enormous double refraction, visible under even a low-power lens.

The technical chapters, particularly those entitled " The formation of gemstones and their general physical properties " and " The discrimination of gemstones," are the weakest in the book. Space is wasted on descriptions of laboratory apparatus such as the Bragg X-ray spectrometer, never used by gemmologists, and the Tully refractometer, which is obsolete, while directions for the use of simple and more practical instruments are not sufficiently exact or correct to enable the student or interested amateur to use them. The author's description of the table spectrometer (as a means for determining refractive indices) is quite extraordinarily muddled, while immersion methods for refractive index determination, which are often of essential importance to the gemmologist, are dismissed in one vague paragraph. There is also much overlapping, e.g. in the description of the refractometer and its use, between the two chapters mentioned, and a great deal of space could have been saved or more valuably used.

The last two chapters in the book, "Jewel stone weights and values" and "Prospecting and buying, judging for value," contain useful information derived from the author's own experience, of a kind not found elsewhere. The book concludes with a chronologically arranged bibliography, lists and tables, and an index.

There are a number of illustrations in colour and black-and-white. Most of the coloured plates (derived from drawings by two Dutch artists) depict cut gemstones and the rough crystals from which these are derived, in juxtaposition. This is basically a good idea, but the reproductions are unfortunately not clear enough to give the reader more than a very vague idea of the actual appearance of the stones concerned. The black-and-white plates are taken from excellent photographs.

Within the pages of "The World of Jewel Stones" there is enough good material to make a useful book for the general reader. It would, however, need drastic pruning and revision before it could honestly be recommended to the serious gemmologist.

B.W.A.

WILD (K. E.). *Zur Geschichte der Schmucksteinschleiferei im Gebiet der oberen Nahe und Saar.* History of the gem cutting mills of the Upper Nahe and Saar. 71 pages. Birkenfeld 1959.

One of a series of books published for local industries of the Birkenfeld region, this book deals with the gem cutting industry of the area of the Nahe, Saar, Mosel, Auerbach and Speyerbach rivers of the German Pfalz. The development and working of the gemstone-cutting from medieval times are discussed, but the post-war and present state of the gem-cutting industry of Idar-Oberstein does not seem to be covered. In 1905 there were 69 agate-cutting water-mills operating along the Idarbach, but in 1925 there were only 31 working. Five original manuscripts are printed, beginning with one concerning the mill at St. Arnual-Saarbrücken of 1478. Others concern the Guild of Agate-cutters of Oberstein of 1609 and an inventory relating to Johann Kraysens of Brebach, Saar, of 1628. The diary of Johann Hoffman, who with Mattes Krätsch, searched for coloured stones around the district of Baumholder during 1600, is given. There are extracts from Collini's study of the mineralogy of the Oberstein region, and of the finding and cutting of the agates found there. There are twenty illustrations, two maps and a bibliography of 33 references.

R.W.

SCHLOSSMACHER (K.). *Edelsteine und Perlen.* Precious Stones and Pearls. 2nd edition. E.Schweizerbart'sche Verlagsbuchhandlung, Stuttgart, 1959. 340 pages, 133 illustrations, two colour plates. DM30.

Since the first edition of Prof. Schlossmacher's book was published, five years ago, great developments have occurred in the field of gemmology. Synthetic diamonds—so far only industrial boart—and non-nucleated cultured pearls have appeared on the market ; synthetic corundum has been produced by hydrothermal methods. All these and other " advances " have been faithfully reported by the author, who is an eminent mineralogist and the director of the Gemmological Institute at Idar-Oberstein, one of the centres of the gem and diamond cutting industries. Practical gemmology uses many branches of science and in spite of international contacts and translations of books and articles, teaching and application is largely influenced by the background and the preferences of the outstanding personality in the Institutes of the different national centres. Thus a British gemmologist will miss in this book an adequate survey of the determination of gem species with the spectroscope ; or of the possibilities of immersion in suitable liquids to show differences in refractive indices. The author does not fail to observe the difference in refraction, but does not concede that it is possible to determine which substance has the higher or lower R.I. (p. 40).

The tables of physical constants are not based on own observations, but taken from R. T. Liddicoat.

The second edition is an appreciable improvement on the first. The general part is enlarged by 40 pages, the sections relating to reflection and refraction are much clearer and the determination of optical properties with the microscope is a masterly exposition. The special part of the book, too, has been enlarged by 20 pages to bring the survey up-to-date.

The fundamental difficulty of writing a book of the middle road, which serves all those connected with gemmology, consists in choosing the subjects which require explicit description and those which allow mere indications. On the whole the author's choice is excellent, but it is still to be hoped that he has not descarded the idea of revising Bauer, Schlossmacher's " Edelsteinkunde."

W.S.

ASSOCIATION NOTICES

GIFTS TO THE ASSOCIATION

The Council of the Association acknowledges with gratitude the following gifts :—

From William E. Kelley, F.G.A., Cleveland, Ohio, the sum of $25 for the Sir James Walton Memorial Library.

Various publications concerning jade, from Robert Webster, F.G.A.

Tavernier's Travels in India (two volumes) from R.J.S. Ltd., London.

A copy of *Os Grandes Diamantes Brasileiros* from the author, Esmeraldino Reis, Brazil.

A copy of Gemstones of North America by John Sinkankas, from the Officers of the Canadian Gemmological Association.

Various examples of faceted and cabochon gem material for students' study, from John R. Fuhrbach, Texas, U.S.A.

LIBRARY

The following books are required :—

GOURJON, M. *The Indian connoisseur ; or the nature of precious stones.* London, 1785.

BARBOT, C. *Guide pratique du joailler : ou traité complet des pierres précieuses.* Paris, 1858.

EPPLER, A. *Die Schmuck- und edelsteine.* Stuttgart, 1912.

EPPLER, A. and W. F. *Edelsteine und Schmucksteine.* Stuttgart, 1936.

MIKIMOTO, K. *The story of pearl.* Tokyo and London, 1920.

FRÉMY, E. *La synthèse du rubis.* Paris, 1891.

TRAILL, G. W. *Treatise on quartz and opal.* Edinburgh and London, 1867.

PRESENTATION OF AWARDS

Most of the London recipients of the diploma of the Gemmological Association, and a welcome number from Ipswich, Birmingham and other centres, even so far afield as Glasgow, came to Goldsmiths' Hall recently to receive their certificates from Lady Walton. Mr. Knowles-Brown was in the chair, and welcomed Lady Walton, the large gathering of Fellows and the new diploma holders and their friends. He said that he was old enough to look back on the progress that the Association had made in nearly half a century. His father, he recalled, held Diploma No. 9. Now the certificates were numbered in thousands, and membership extended throughout the world. He considered why the diploma was held in such high esteem in the gemmological world, and felt that the Association's approach to training and examinations commanded respect by its maintaining of high standards. There was also something more—for the Gemmological Association endeavoured to keep one step in advance of events. Some years ago, the Secretary had issued a warning about the new synthetic emeralds of size being made in the United States. At that time, imports were severely restricted. Now the restrictions are off, and we have Chatham synthetic rubies as well—and the gemmologists of Britain are prepared for them. Research, too, was important, and vigilance, eternal vigilance, was more than ever a necessity in the present age of the synthetic gemstone. It was vital for the gemmologist to keep up to date, with reading and practice and discussion at meetings and lectures.

After she had presented the Rayner prize to Mr. P. W. T. Riley, of Chester, and diplomas to 25 new holders, Lady Walton said she had a word of encouragement for the less successful examiness. She told them not to be discouraged, but to fight their difficulties. She thought of gemmology as of especial importance nowadays as part of the whole science of the universe. It was an absorbing study, and she told how her late husband, Sir James, took up gemmology when he was more than 60 years old. He studied and persevered and eventually wrote a book about it, and became chairman of the Association. She said that the wonderful library, founded by the N.A.G. in association with the Gemmological Association, would have delighted Sir James, whose name it bears. She concluded with a word of gratitude to the hard-working instructors and examiners who needed so much patience and so much experience to pass on their knowledge.

Mr. Norman Harper thanked Lady Walton for so graciously presenting the awards. He said that the Association liked the diplomas to be presented by someone connected with the science, and Lady Walton had maintained her husband's interest in the Association. He presented on behalf of the Association, the framed original of the bookplate used in all the books in the Sir James Walton Memorial Library.

The meeting concluded with thanks from the chairman to the Prime Warden and Court of the Worshipful Company of Goldsmiths for permission to use their Livery Hall.

Before the presentation of awards there was a happy reunion of about one hundred members of the Association.

OBITUARY

The death has occurred of Joseph Azzopardi, F.G.A., the Association's first member in Malta. He was one time Consul for the Maltese goldsmiths and silversmiths and a keen supporter of the Association.

The Association also records with regret the death of Edward H. Howell, London (D.1923), and John W. Reynolds, London (D.1945).

Mr. Reynolds was one of the retail trade's well known silver buyers and he had been employed by Wilson & Gill, Ltd., of Regent Street, London, W.1, for forty years.

The death has also occurred of John Melson Peyton Biggs, Chairman and Managing Director of Carrington & Co. Ltd., Regent Street, London.

COUNCIL MEETING

A meeting of the Council of the Association was held on Tuesday, 17th November, 1959, at Saint Dunstan's House, Carey Lane, London, E.C. Mr. F. H. Knowles-Brown presided.

The Council received with regret the resignations, for personal reasons, of Miss Elsie Ruff and Mr. A. R. Popley, and recorded their appreciation of the work which they had done as members of the Council.

The Council formally received notification of the formation of the Canadian Gemmological Association and approved affiliation between that organization and the British Association.

The following were elected to Fellowship of the Association.

Battersby, Keith W., London
Betts, Geoffrey N., Birmingham
Buckler, Albert N., London
Buitenen, A. Th. C. v., s-Hertogenbosch, Holland
Davis, George, Glasgow
Diggan, Gerald, London
Durrant, Anthony W., Ipswich
Hall, Edwin F., Smethwick
Hedges, F. C., London
Kay, Jonathan G. D., Liverpool
Marshall, Michael, Hull
Neil, Peter B., Glasgow
Patience, Kenneth, Norwich
Pilot, Lawrence M., London
Plews, William A., Edinburgh
Raven, Robert H., Chelmsford
Sack, Karl A., San Diego, California, U.S.A.
Schoien, Magnus, Skien, Norway
Seneviratne, Seetha, London
Shane, Leon, Toronto, Canada
Shapland, Roger S. C., Cookham Dean
Smith, James S. A., Glasgow
van der Vlerk, Hendrik T., Schiedam, Holland
Wall, John S., London
Whyte, Archibald G., Edinburgh.

The following were transferred from Ordinary and Probationary Membership and elected to Fellowship.

Blignaut, Adi, Johannesburg, S. Africa
Mendelsohn, Michael, Cape Town, S. Africa
Phillips, Alan L., Bardsey, Nr. Leeds
Britchfield, Charles F. J., Gravesend
Brousseau, Murray P., Toronto, Canada
Engstrom, Hans W. E., London
Etienne, Lorette, Bangkok, Thailand
Gryska, Stephen, Worksop
Hope, Kenneth, London
Kelley, William E., Lakewood, U.S.A.
Langton, Edward G., London
Meadows, Everard C., Purley
Pragnell, John W., Bournemouth
Whitehead, Henry J., Edinburgh
Weatherhead, Albert V., Wellington, New Zealand
Yates, Roy F., Manchester

The following were elected to Ordinary and Probationary Membership.

Attygalle, Cyril E., Ratnapura, Ceylon
Beattie, Louise G., Bangkok, Thailand
Booley, Edward, Chatham
Budd, Douglas H., Kingston, Jamaica, W. Indies
Cohen, Adolphe, Nice, France
Cole, Kenneth C., Salisbury, S. Rhodesia
Dyball, Frank G., Coventry
Eggers, Jodie G., Karachi, Pakistan
Fisher, Peter J., Cookstown, Co. Tyrone
Geiger, Jacob C., Curacao, Netherlands Antilles
Guy, Frederick L., Hull
Hamblyn, James H., Wellington, N.Z.
Hyman, Geoffrey M., Blackpool
Ostwald, Joseph, Kalgoorlie, West Australia.
Pavitt, John A. L., Singapore
Schwartz, Jonathan P., New York, U.S.A.
van Halem, Adrianus C., Singapore
White, George A., Norwich

Catton, Cedric T., Ipswich
Childs, Allan J., Hornchurch
Church, Bruce A., Wakefield
Patni, Chandulal G., Nairobi, Kenya
Schidlowski, Dietrich, Pretoria, S. Africa
van Gurp, Fransiscus P. C., Curacao, Netherlands Antilles

MEMBERS' MEETINGS, 1960

February	10	New diamond film, "Stars that shine for ever," British Council Cinema.
March	4	Midlands Branch Meeting.
April	12	Herbert Smith Memorial Lecture. Dr. A. F. Hallimond on " Polarization." Goldsmiths' Hall, London, E.C.2, 7 p.m.
,,	21	West of Scotland Branch Annual Meeting.
,,	29	Midlands Branch Meeting.
May	5	30th Annual General Meeting, Saint Dunstan's House, London, E.C.2, 6.45 p.m.
June	4	West of Scotland Branch summer outing.

TALKS BY MEMBERS

BLYTHE, G. A. : " Gemstones," South Essex Natural History Society, 22nd October, 1959.

WELLER, G. T.: " Lesser known gems," Tunbridge Wells Toc H, 26th October, 1959.

WARREN, K. (Mrs.) : " Gemstones," Eltham Congregational Ladies' Friendship, 27th October, 1959.

FORSEY, PATRICIA (MRS.): " Gemstones," Women's Senior Auxiliary of Grace, United Church, Dunnville, Canada, October, 1959.

GILLOUGLEY, J. : " The diamond story," Sanderling Wives' Club, Royal Naval Air Station, Abbotswich, Paisley, 3rd November, 1959.

CAIRNCROSS, A. : " Gemstones," Dunbarney Men's Guild, 22nd October ; Dunning Parent Teacher Association, 7th December ; Scone New Church Women's Guild, Perthshire, 8th December, 1959.

AN EXHIBITION OF GEMSTONES AND JEWELLERY

City Museum and Art Gallery, Birmingham, from 17th February until 16th March, 1960. (Industrial section in the Museum of Science and Industry, Newhall Street).

Open daily from 10.30 a.m. until 6.30 p.m. and until 8 p.m. on Tuesdays, Thursdays and Saturdays. Sundays 2 p.m. until 5.30 p.m. Admission free.

This exhibition, the largest of its kind ever held in the provinces, will include a great many famous, historic and priceless pieces that are rarely seen and that never before have been gathered together for public display. Her Majesty the

Queen has graciously lent several magnificent jewels. Others have been borrowed from a number of private and public sources in order to create, with the aid of the City's own collections, a quite fabulous display that will not readily be seen again. All departments of the Museum and Art Gallery have contributed to the exhibition. In order of time the Department of Archaeology is showing jewellery dating from 2000 B.C. up to 1600 A.D. and from then until the end of the nineteenth century follow the displays by the Department of Art. Gemstones as such are the contribution of the Department of Natural History, and at the Museum of Science and Industry is an exposition of the modern industrial uses of diamond.

During the course of the exhibition, there will be films and demonstrations concerning gemstones and the making of jewellery, and on successive Thursday luncheon hours there will be talks on various aspects of the exhibition given by distinguished visitors. Dr. Joan Evans, the well-known authority on the design and history of jewellery, will open the exhibition at 5.30 p.m. on Tuesday, 16th February.

The Devonshire Emerald, a diamond necklace and wonderful natural crystals of aquamarine focus attention on the beryls, but bidding fair in rivalry are the rubies and sapphires, zircons and topaz, tourmalines and garnets. These, with the spinels and chrysoberyls and olivines, are stones in their profusion to admire. The quartz group contains beautiful chalcedonies, amethyst, citrines and rock crystal. There are ornamental stones, many of ancient usage, turquoise and lapis-lazuli, jasper and jade, the latter being a separate showing of magnificent oriental craftsmanship. The opals are well represented, and a concise natural history and display of the several kinds of pearls leads to a superb example of a necklet. One exhibit deals with birthstones for each month of the year, and another with rare and unusual gemstones that are but seldom seen.

Films in sound and colour about diamonds and the fabrication of jewellery will be shown during the luncheon hours of Mondays, Wednesdays and Fridays throughout the exhibition, and on these same days between 5 and 6.30 p.m. will be demonstrations of mounting and setting. Between 3 and 6 p.m. on alternative days there will be complementary demonstrations of stone cutting and polishing. In the Museum of Science and Industry, Newhall Street, there will be an exhibition concerning the industrial uses of diamond, principally the myriad needs and purposes of cutting, grinding and drilling most things from teeth and gramophone records to oil wells. This exhibition also will include practical demonstrations.

The ancient jewellery which will be shown at this exhibition ranges from Egyptian jewels and necklaces of 2000 B.C. to the rich Elizabethan Cheapside Hoard of about 1600 A.D. Primitive goldwork from America is also included. On the prehistoric side many of the major gold objects from Britain have been collected and will be shown together for the first time. These include the famous gold plates from barrows in Wiltshire.

Some magnificent examples of jewellery dating from the seventeenth to nineteenth century are also included.

One of the outstanding exhibits will be a Parure of jewels which belonged to the Empress Josephine and which were made for her in about 1805. An emphasis has been laid on quality of design from the seventeenth century to about 1914. It will be possible to follow most of the trends in jewellery in Europe during this period.

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No. 5
January, 1960

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Printed by F. J. Milner & Sons Ltd., Brentford and London