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and

PROCEEDINGS OF THE GEMMOLOGICAL ASSOCIATION OF GREAT BRITAIN

GEMMOLOGICAL ASSOCIATION
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GEMMOLOGICAL ASSOCIATION OF GREAT BRITAIN

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INCLUSIONS IN DIAMOND

By W. F. EPPLER

THE two modifications in which carbon occurs, are diamond and graphite. Diamond as an inclusion in diamond has often been described. Graphite in diamond has also been mentioned many times.[1] But not every inclusion is a " carbon spot " of diamond or graphite. It is the high refractive index of diamond, from which results a small angle of total reflexion, which often causes a black appearance of the inclusions. Therefore, it is understandable that particles which look " as black as coal " are described by using the term " carbon spots ", even if they are quite a different material.

The mineralogical and gemmological literature mentions a great number of solid inclusions in diamond :

Particles of kimberlite, the mother rock of diamond
(a basic igneous rock, very rich in olivine)

Graphite	C	hex.
Garnet (pyrope)	$Mg_3Al_2(SiO_4)_3$	cub.
Magnetite	Fe_3O_4	cub.
Haematite	Fe_2O_3	trig.
Ilmenite	$FeTiO_3$	trig.
Chromediopside	$Ca(Mg, Fe, Cr)\ (Si_2O_6)$	mon.
Augite	$(Mg, Al, Fe, Ti)\ (Ca, Na)\ (Si, Al)_2O_6$	mon.
Enstatite	$Mg_2(SiO_6)$	orth.
Phlogopite	$K\ Mg_3(F, OH)_2\ (AlSi_3O_{10})$	mon.
Chromite	$FeO\ .\ Cr_2O_3$	cub.

Chlorite	Mg – Al – silicate	mon.
Pyrite	FeS_2	cub.
Olivine	$(Mg, Fe)_2SiO_4$	orth.
Quartz	SiO_2	trig.
Zircon	$ZrSiO_4$	tetr.
Diamond	C	cub.
Apatite	$Ca_5 (F, Cl) (PO_4)_3$	hex.

To the list, apatite must be added as it has been found recently. With every respect for the earnest ability of the authors, some doubt arises with regard to two of the crystal inclusions mentioned—graphite and quartz. It may be possible that a diamond crystal, which is embedded in another diamond, can be coated by a thin layer of graphite.[2] But, the independent occurrence of graphite in diamond is not yet confirmed with certainty. The original reports of graphite inclusions in diamond are dated back in literature for many decades, and no modern investigation has been made in this direction as, for example, by X-ray analysis.

The same argument must be taken into consideration with quartz. The mother-rock of diamond is a strongly basic (ultra basic) material from which no quartz crystals could be included by the diamond. The presence of quartz in diamonds from Brazil represents a particular kind of intergrowth between both minerals The only reference which could be found in literature is a communication of C. W. Correns[3] with the following conclusions (in translation) :

" The enclosures of quartz in (Brazilian) diamond consist of lamellae, mostly parallel to the octahedral plane and often limited by the same faces on their small sides.

" These quartz lamellae are not uniform crystals and, as could be found by X-rays, they have no orientation with the diamond or vice versa. From the border of the quartz enclosures it may be concluded that they must be of later origin than the diamond. It is shown that they can be regarded only as the fillings of etched cavities. Perhaps, these deeply trenched cavities originated from cleavage fissures, which have been caused by the tectonic movement of the mother-rock. Probably, these fissures have been gradually enlarged by the action of solutions of alkali carbonate or by overheated water. Both media are able to cause the sericitization of the rock and the recent formation of the quartz ".

Obviously, such diamond crystals with large intergrown quartz lamellae are not of gem quality, and they range among the boart of inferior quality.

Some of the solid inclusions which are listed above could be identified by testing industrial diamonds. Stones with interesting inclusions have been burnt subsequently by heating at 915°C for six hours. By this way, the crystal inclusions were separated and tested with conventional methods. Inclusions of diamond or graphite cannot be isolated by such a procedure as they are burnt and transformed into carbonic acid.

Garnet. In a small octahedron (Fig. 1), a red crystallized inclusion caused some perplexity by its form, which resembled the crystal habit of trigonal ruby (Fig. 2). The bewilderment was increased by its apparent anisotropic character which, as was found later, was due to the strongly developed tension—birefrigence of the host diamond. E. J. Gübelin took an interest in the problem. He found that the absorption lines, characteristic of ruby, were not present. Therefore he thought the interesting inclusion to be a garnet, which was confirmed after the separation (Fig. 3). This experiment was the cause of further investigations during which many garnets were found within diamonds. Sometimes, the garnet was found with its dodecahedron face parallel to the octahedral plane of the diamond, while in most of the cases no orientation of the garnets could be observed.

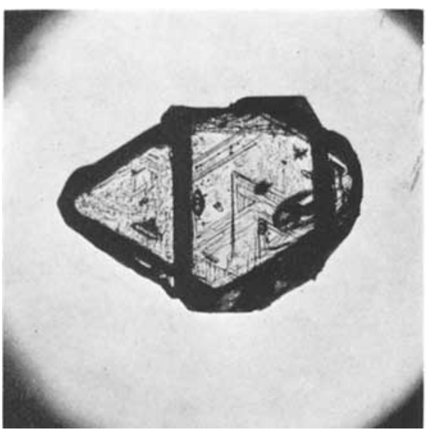

FIG. 1. *Garnet inclusion resembling crystal habit of trigonal ruby. 15 ×*

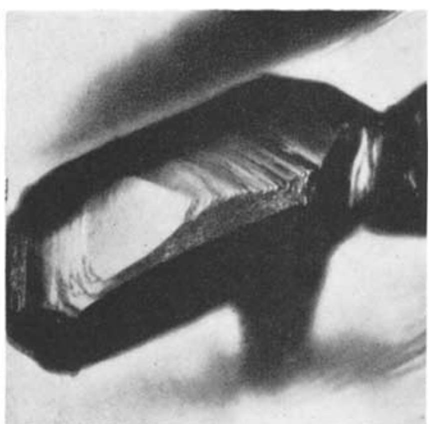

FIG. 2. *Garnet inclusion (see Fig. 1). 200 ×*

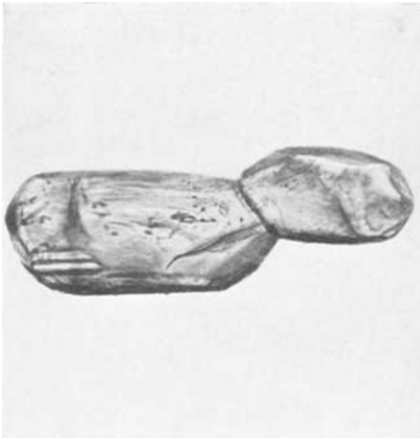

FIG. 3. *Garnet shown in Figs. 1 and 2 separated from host diamond. 120 ×*

FIG. 4. *Inclusion of Ilmenite. 65 ×*

S. I. Futergendler[2] found by X-ray analysis of garnet inclusions in diamond, that the lattice constants correspond to garnet of the almandine series, while judging by the refractive index, they approach pyrope most closely. Another property of many of the enclosed garnets is the fact that they are responsible for cleavage fissures parallel to the octahedron plane of the diamond. As can be seen in Figs. 1 and 2, little cleavage cracks surround the included heterogeneous crystal like a halo. In transmitted light they look like " carbon spots ".

Ilmenite. Fig. 4 shows an example of this interesting enclosed mineral. In transmitted and in reflected light, the ilmenite appeared black. Only the translucent thin edges exhibited a brownish colour, which is typical for this mineral. The orientation to the host crystal was deduced from the bright striation in Fig. 4, which indicates the direction of the octahedron edges : it is most probable that the basal plane of the ilmenite is parallel to the octahedron face of the diamond and, additionally, that a lateral axis of the ilmenite coincides with the direction of the octahedral edges of the diamond. Generally, inclusions of ilmenite in diamond seem to be relatively rare.

Olivine. R. S. Mitchell and A. A. Giardini[4] described oriented olivine inclusions in diamond. The orientation takes place in such a way that the prism face (010) of the olivine is parallel to the octahedron plane (111) of the diamond. S. I. Futergendler[2] describes the enclosed olivines as transparent and colourless in the form of isometric or tabular crystals. Fig. 5 shows such an elongated olivine with a smaller one in a parallel position. Both are surrounded by little cleavage cracks. It is the same group of inclusions which can be seen on the left side of Fig. 1.

It has been found that the forms of the enclosed olivines vary considerably. While Fig. 5 shows olivine crystals of a similar elongated habit as indicated by Mitchell and Giardini, more rounded crystal forms can also often be observed (Figs. 6 and 7). The olivine on the right side of Fig. 6 is encircled by strongly developed cleavage cracks. They look black in transmitted and in reflected light. The dark spots on the left side of the picture are also cleavage cracks, running parallel to another plane of the same octahedron. They are caused by other inclusions.

Fig. 7 exhibits the separated olivine which, on its part, contains tiny inclusions of an unknown nature. The formerly colourless enclosure turned into a reddish-brown colour, which is due to the various contents of iron, a characteristic component part of olivine. The burning process of the diamond—to cause the separation—

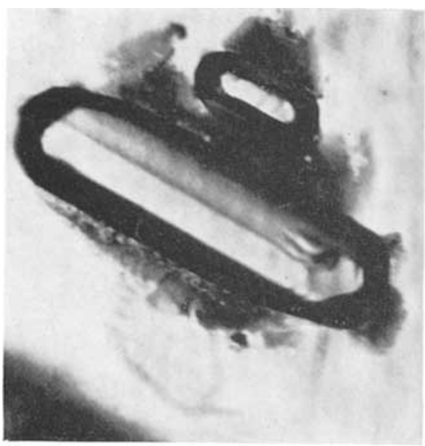

FIG. 5. *Elongated olivine inclusions in parallel position.* 200 ×

FIG. 6. *Olivine inclusion encircled by strongly developed cleavage cracks.* 65 ×

FIG. 7. *Olivine inclusion after separation (see Fig. 6) containing inclusions of an unknown nature. 120 ×*

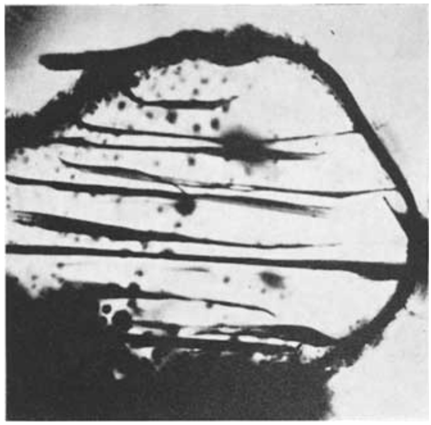

FIG. 8. *Tabular inclusions of olivine. 120 ×*

oxidized the iron content of the olivine and caused its change of colour.

Besides the elongated and rounded forms, tabular-developed crystals of olivine inclusions can be encountered, sometimes of surprising size. One of these is shown in Fig. 8 and 9. The dark rim of the olivine in Fig. 8 is due partly to the difference in the refractive indices between diamond and its enclosure. On the other hand, small cleavage fissures of opaque and black appearance broaden the border zone of the enclosed crystal. Fig. 9, a view of the separated olivine, exhibits the cracks which it had formerly. Its size is 0·6 mm, and its thickness only 0·03 mm. The refractive index was near 1·67, and the specific gravity was found to be approximately 3·27. Both values correspond with the properties of an olivine with a small iron content, so that the tablet appeared to be near to the forsterite member of the olivine group. A confirmation of the nature of this " exclusion " was obtained by an X-ray analysis made by H. Jagodzinski. Another tabular enclosure of olivine in diamond is shown in Fig. 10.

During the investigation of inclusions in diamond it was impressive to observe the great number of included olivines with widely varying sizes and forms. Olivine must be by far the most frequent heterogeneous crystal inclusion, whereas the complexity of

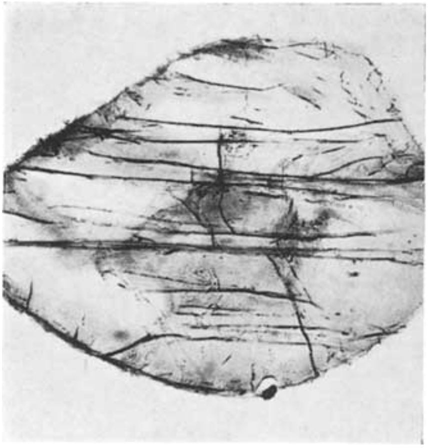

FIG. 9. *Olivine inclusion (Fig. 8) after separation, showing cracks. 120 ×*

FIG. 10. *Tabular inclusion of olivine in diamond. 65 ×*

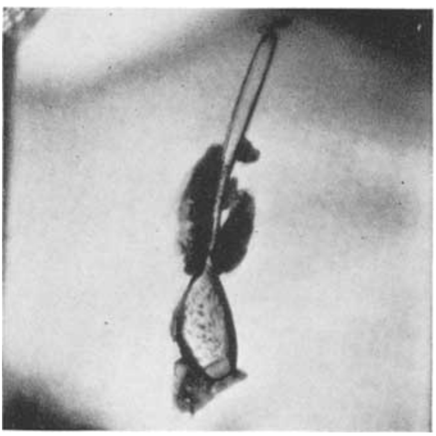

FIG. 11. *Olivine inclusion in diamond of unusual shape. 65 ×*

FIG. 12. *Apatite inclusion in diamond showing cleavage cracks. 220 ×*

its crystal habit may be the reason for its being confused with other crystals like quartz and zircon.

An extraordinarily formed olivine inclusion is shown in Fig. 11. This spoon-like formation is a single crystal of olivine, oriented to the host diamond. The dark areas near its narrowest part and at both ends are larger and smaller cleavage cracks in the diamond, which have been caused by the enclosure. The strange form of this particular olivine inclusion can perhaps be explained by the following hypothesis :—

Without any doubt, the genesis of diamond took place in a region of high pressure and high temperature. These conditions must have been above the stable state of the pre-existing olivine, so that its lattice suffered a breakdown, or the olivine crystal started to melt. In the situation of higher mobility, the liquified material, in some way or the other, followed the direction of decreasing pressure in the diamond, before it could solidify again. In the case of a greater difference of pressure, a certain flow could occur, as shown in Fig. 11. With less differences of pressure within the diamond, the olivine material became flattened or tabular, as demonstrated by Figs. 9-10. Such a hypothesis would mean that regular or euhedral inclusions of olivine crystals indicate little or no differences of pressure in the growing diamond.

Apatite. Although apatite is reported to be a primary constituent of kimberlite, the mother-rock of diamond, it had not yet been observed as an inclusion in diamond. It was fortunate, therefore, to find in a flattened octahedron of diamond a crystal of this species, unoriented to its host and characterized by its typical cleavage cracks (Fig. 12). The black parts, which, in the illustration, accompany the apatite, are cleavage fissures of the diamond, indicating the direction of its octahedral plane. The separation of this rarity failed in some way as, by reason of its marked cleavage, the apatite disintegrated during heating into tiny particles, from which the biggest, approximately 0·07 mm in diameter, was lost during immersion in alpha-bromonapthalene. It was just possible to find the refractive index of the splinter to be a little less than 1·6585 which is, together with the general appearance of the inclusion, sufficient to detect its nature (apatite has a mean refractive index of approximately 1·64). As this was the only apatite inclusion in a great number of diamonds under examination, it can be assumed that this particular kind of enclosure is very rare.

FIG. 13. *Gaseous inclusion in diamond.* 65 ×

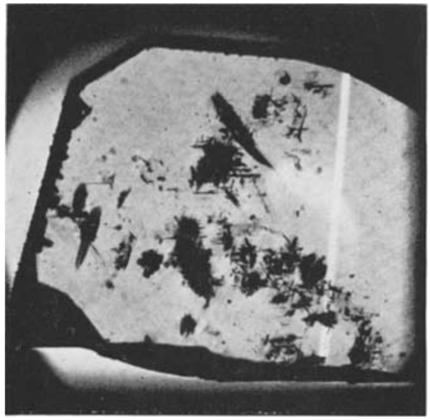

FIG. 14. *Cleavage cracks in diamond.* 22 ×

Gaseous inclusions in diamond are reported to form clouds of foggy patches which consist of minute gas-filled cavities (E. J. Gübelin[5]). Sometimes they indicate former growing planes of the host crystal. Fig. 13 shows an assembly of such gaseous inclusions. They are difficult to observe, as even with a high power magnification no particular details can be disclosed. The black inclusion on the left side of the picture represents a cleavage crack starting from a small crystal inclusion and following the direction of the octahedral plane of the diamond.

Cleavage cracks and fissures can be listed together with the gaseous inclusions as they contain air or gaseous carbonic acid. Most of the cracks must have been caused by tension of the diamond, as they follow the direction of cleavage along the octahedral plane. It is thought that formerly some of them have been considered as graphite, as they look black, especially in transmitted light. Fig. 14 gives a general view of several of those cleavage cracks. Some of them are broad patches, others appear in a needle-like form, and may be easily mistaken for solid material or crystallized needles. But they follow the plane of the octahedron of the diamond and its edges respectively.

Healing fissures in diamond are supposed to be present but not yet confirmed with certainty. It is necessary to observe the phenomenon with greatest care as otherwise some confusion may arise.

The cleavage crack in Fig. 15, which starts from an enclosed olivine crystal (right), is not a healing fissure in spite of the triangular etch figures (bright). Even the fissure in Fig. 16 is an ordinary cleavage crack. It reached to the outer surface of the diamond and was filled with a brownish material, imitating to some extend the pattern of a healing fissure.

With another cleavage crack parallel to the octahedral plane of a diamond (Fig. 17), it was not easy to make a decision whether it was a real healing fissure or not. Possibly the crack had absorbed some liquid, distributing the liquid material in tiny droplets over its area. It is very likely that such an interpretation is correct, as no signs of a healing process could be observed.

On the other hand, real healing fissures with all the significant peculiarities of the phenomenon can sometimes be encountered as inclusions in the diamond. Fig. 18 gives an example. A cleavage crack, parallel to the octahedral plane of a diamond, has been reduced to about one-third of its former extension by a healing process. Subjective examination under the microscope revealed the widespread healed area much better than a photograph. In spite of this, even Fig. 18 exhibits distinct differences in the texture of the healed and the unhealed part of the former cleavage crack.

Another healing fissure in a diamond developed similarly formed liquid inclusions (Fig. 19). They are well known in

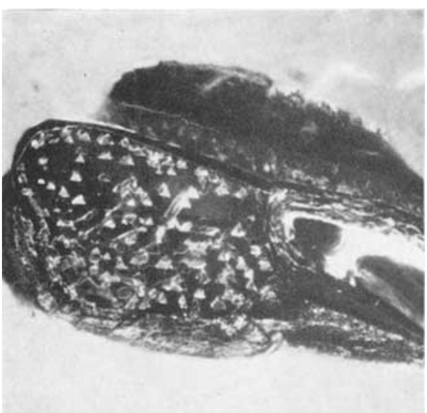

FIG. 15. *Cleavage crack in diamond starting from an enclosed Olivine crystal.* *220 ×*

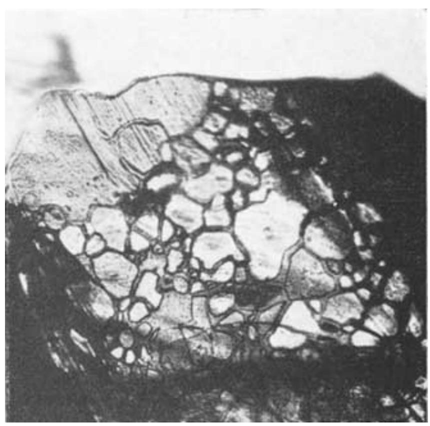

FIG. 16. *Cleavage crack in diamond.* *120 ×*

corundum and in the gemstones of the pegmatite series. There is little doubt that the liquid consists of carbonic acid. Fig. 20 exhibits details of the interesting former cleavage crack. It must be emphasized that the elongated or hose-like liquid channels follow the directions of the octahedral edges of the host diamond. The borderline of the former crack forms nearly a semi-circle. (Fig. 19).

FIG. 17. *Cleavage crack parallel to the Octahedral plane of a diamond. 110 ×*

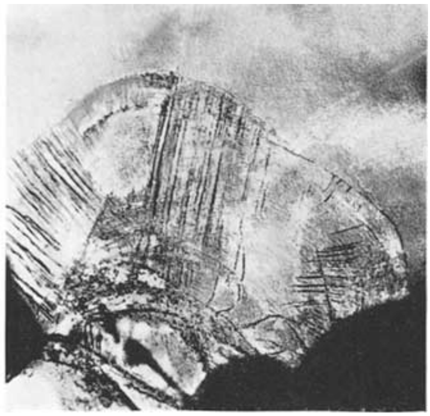

FIG. 18. *Healing fissure encountered in a diamond. 120 ×*

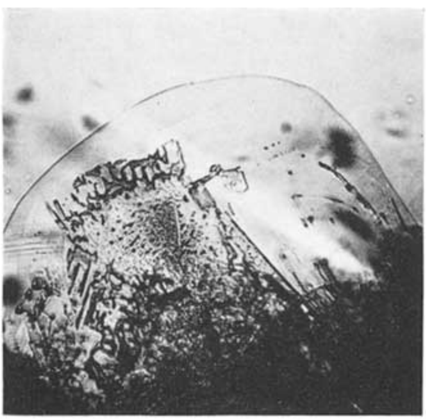

FIG. 19. *Healing fissure in a diamond. 65 ×*

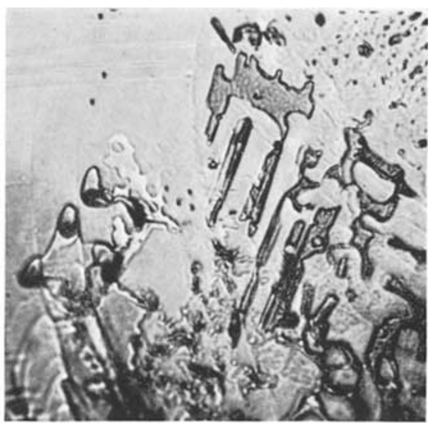

FIG. 20. *Part of the healing fissure in Fig. 19 with inter communicating liquid inclusions. The hose-like liquid channels follow the octahedral edges of the diamond. 240 ×*

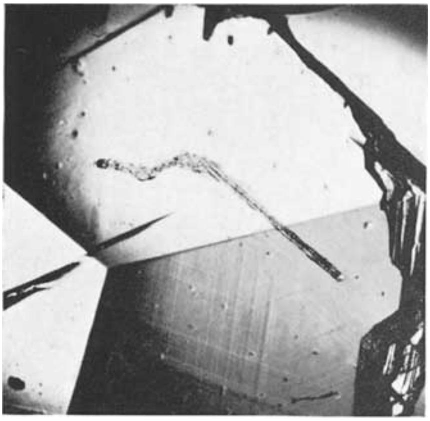

FIG. 21. *Worm-like inclusion in a diamond. 22 ×*

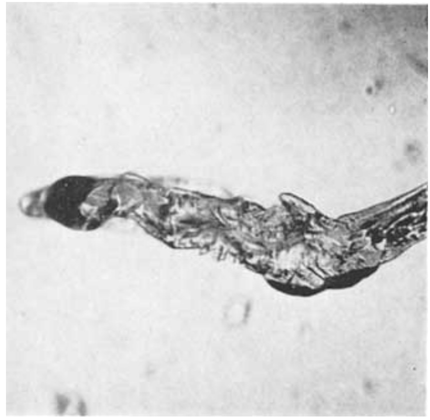

FIG. 22. *Enlargement of part of Fig. 21 showing gas bubble termination. 120 ×*

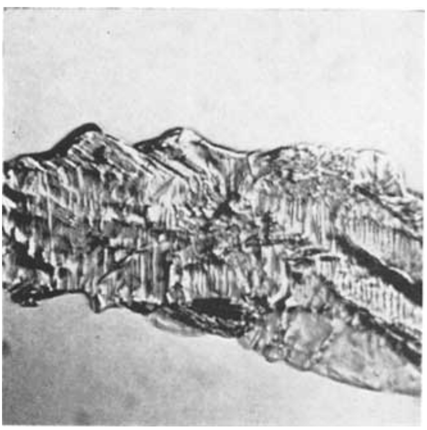

FIG. 23. *Middle part of hose-like inclusion (Fig. 21). 240 ×*

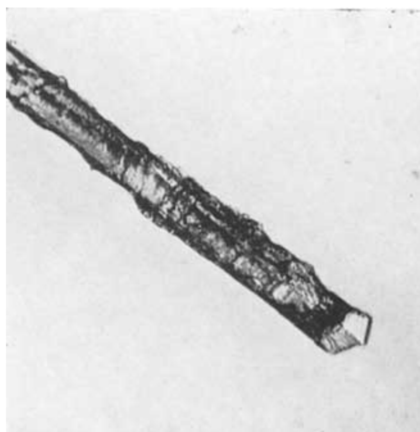

FIG. 24. *Octahedral termination of other end of hose-like inclusion (Fig. 21). 120 ×*

An unusual inclusion in diamond is shown in Fig. 21. Within a rose-cut stone, there was a worm-like enclosure, a longer part of which was rectilinear. By comparing its direction with the rough (or broken) girdle of the stone, which exhibited growing lines, and by using a higher magnification, a coincidence of this and other preferred directions with the edges of the octahedron was found (Fig. 22-24). Additionally, the left part of the " worm " ended in a gas bubble (Fig. 22), while the end of its right part exhibited two crystal faces which belong to an octahedron (Fig. 24). The middle part (Fig. 23) revealed a rough surface with marked lines. They coincided with the direction of the growing lines of an octahedron plane. It is not unlikely that this unusual formation represents a negative crystal, which is filled with a liquid (carbonic acid). The gas bubble as well as the transparency of the crystal are in conformity with such an explanation, while its isotropic character supports this explanation.

Summary. Garnet, ilmenite, olivine, apatite, gaseous inclusions, healing fissures, and an extraordinary negative crystal have been observed in diamonds. The solid inclusions have been tested after their separation from the host crystal. It is certain that a number of other crystal inclusions occur in diamond, as has been reported by some authors. During this study, however, no evidence could be found that graphite and quartz were present, a result which should not be overestimated as only industrial diamonds were examined, the exact occurrence of which was not known.

ACKNOWLEDGMENT

The author is indebted to Messrs. Ernst Winter & Sohn, Hamburg, for having supplied the suitable diamonds and to Prof. Dr. H. Jagodzinski, Max Planck Institut für Silikatforschung, Würzburg, for the X-ray analysis of an olivine inclusion. Most of the industrial diamonds were obtained by the courtesy of Messrs. Ernst Winter & Sohn, Hamburg.

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NEW STAR-STONES AND THEIR ANTECEDENTS

By FREDERICK H. POUGH

A DURABLE new " star-stone " for the jewellery trade is the latest comparatively inexpensive stone to be offered in the United States of America in the past year. Since American acceptance of star-sapphires and rubies has always been better than that of the rest of the world, it is not surprising that these stones are assembled in the U.S. and that the cutting is done abroad to obtain the precision, production and lower cost expected of German lapidaries. Basically the stone is a doublet, with in one case a cement that might justify the term triplet for the finished product. The top of the stone is transparent synthetic sapphire or spinel. The star appears to be produced by minute scratches that spread reflections into a bar.

Before describing the new stones, it might be interesting to follow the rise of star-stones to their current popularity. The stars that could be disclosed in natural sapphires and rubies by the combination of cabochon cutting and proper orientation were popularized on the American market many years ago by some of the more aggressive tradesmen. Slightly cloudy sapphires and rubies, which could have produced a star if properly cut had been faceted and sold in the past without any attempt being made to take advantage of the rutile " silk " ; allowing it, in fact, to be a detriment to the stone. Some of these early stones have been profitably recut into star-stones in the West. Usually they are stones with weak stars, but they are also often unusually deep in colour.

Once stars had become popular, there was naturally a desire on the part of artificers to provide more and cheaper stones for this market. Numerous attacks on the problem were made before Linde finally solved it for the better class market. Human nature, of course, still provided a reason for a cheaper solution, and the new stones will appeal to this regrettable character defect, and look much better than any previous aspirants. One of the earliest synthetic " star-sapphires " must have been intended for buyers who had heard the name but who had no conception of its appearance. It was synthetic all right, and it showed a star. But the star was engraved on the back : a sort of upside-down intaglio. Similar stones were made of glass, with a star that was fixed and motionless on the back of the stone. From these imitations the " experts " then adduced an edict: that the star moved about, depending on the viewing angle, only in genuine stars. This test soon fell down, but surely no-one was ever deceived by the carved imitations: their only resemblance was verbal. They are said to have been made about 1930.

Shortly before the 1939 war a far better substitute was found : one that promptly gave the lie to the idea that a fixed star was a characteristic of all imitations. This material is now well known, and still being made, but is neither synthetic nor sapphire.

The presence of star-like reflections or dispersions of transmitted light was known to be an uncommon, but characteristic, property of a number of crystallized substances. Star-garnets, with 4 and 6-rayed stars, were found among the Indian carbuncles. Star-quartz, from pale rose to almost slightly grey, was every bit as pronounced in its stars as sapphire. Someone, probably in England, since the very first stones came from London to New York, got the brilliant idea of colouring the back to make the pale quartz opaque and coloured. These were quite effective, though few people were probably deceived by them. If the back could be seen, it was at once obvious that it was a painted or an enamelled back. Generally the colour on the back was the colour the stone showed, and when one looked sideways at the stars one could easily see the pale, nearly colourless nature of the star-material.

The star-quartz imitations had their limitations. The colouring material had a disconcerting habit of coming off after a time, not being as impervious to water and wear as one might wish. Then, too, some men's perpetual lifetime goal (to make something cheaper than the other fellow, with no heed to quality) achieved something like perfection by making the stars so frightfully bad that they lost all their appeal to buyers, who had earlier found some merit in the initial products when price was not quite so much of an object. They are still on the market but seldom seen in jewellery.

The lack of hardness, in comparison with real star-sapphires, was no great factor in leading the ingenious imitators to turn to corundum material as their next raw material for the star-imitations.

It is more likely that the colour, and possibly the name, suggested that the new imitations should be made from synthetic boule material. Someone got the idea of scratching the back of a ruby or sapphire cabochon with three sets of fine lines. A very bright light shining on the top of the stone showed a weak coloured star radiating from the centre of light reflected back from the bottom of the stone. To intensify this an attempt was made to mirror-plate it, or to cement a mirror surface to the bottom of the cabochons. It helped, but the housewife's dishwashing soon took it off and the sale of the stones collapsed. Another error was in cutting the stones in very high cabochons, which made them thick and dark, so that the star, at best, was very weak.

At about this time, or soon after the War, an American, Louis Moyd, had a bright idea that was inspired by a familiarity with a Canadian phlogopite (magnesium mica) which also showed a star by transmitted light (Fig. 1). As in the quartz and the corundum, it is caused by the presence of innumerable microscopic crystals, oriented by the mica into the same sort of three-rayed pattern as in the former two minerals, for its crystals, though monoclinic, are almost hexagonal in their symmetry (Fig. 2). A glass or ruby hemisphere, laid on a piece of phlogopite, focuses the light into a spot and reflects back to the viewer as a star. If the mica is really saturated with the inclusions, possibly rutile, possibly some other material, it becomes very bronzy and opaque. The best results

FIG. 1.

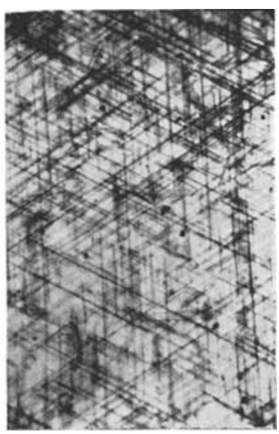


FIG. 2.

were found with this type of mica, but the star was not as brilliant as could be wished, little better than that of the scratched-back synthetics. At the time, too, no good cement was known and nothing could be found that would not separate after a time.

New cements, particularly the plastics known as the Epoxy resins, which have been introduced in the past few years, have made cemented stones more practical. Coming as two separate viscous liquids, they are mixed in equal proportions and allowed to set : a hardening process which can be hastened by mild heating. Once hardened they cannot be dissolved with any of the simple solvents and are little affected by water. They have greatly simplified some forms of jewellery making, for with " Epoxy " one does not have to drill tumbled stones for mounting : they are simply cemented into a cap.

Naturally this remarkable material revived an interest in the star-doublets, and two makers at least are now producing synthetic stones with stars. Though they sell for about the same price, one is very much better than the other in appearance (Fig. 3). It would be hard to guess about their respective durabilities. Their names are in need of some clarification, for while synthetic sapphire and ruby are the basis of some stones, synthetic spinel is also used, glass is seen occasionally, and not all of the stones are stars. If one puts a single set of scratches on the stone, then one gets a cat's-eye in place

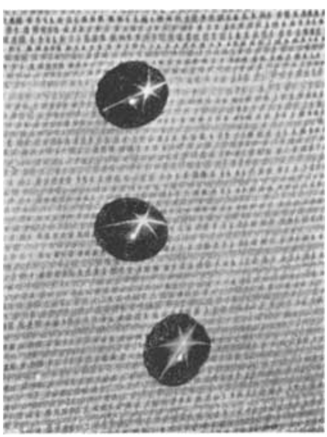


FIG. 3.

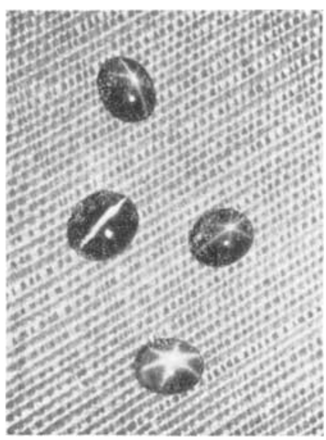


FIG. 4.

of the star. The manufacturer of the plastic-resin cemented stones makes cat's-eyes as well as stars. (Fig. 4.)

The star, or cat's-eye, can be made to appear in a stone in three different ways. The star-causing reflecting surfaces can be in the stone, as they are in natural star-stones. They can be scratched on the back of the stone, as they were in the first synthetic ruby imitations, or they can be on or in the backing material, as they were in the phlogopite-backed doublets.

The plastic-cemented doublets (double doublets one might say, since there are four layers) belong to the latter group. (Fig. 5.) The maker of these stones starts with low cabochons, one might almost call them " buff tops ", probably cut in Germany in calibrated sizes from any sort of material ; synthetic sapphire and ruby, synthetic spinel in blue or green, emerald-green glass and a sort of an opal glass. The " epoxy " cements this to a clear glass back, less than a millimetre in thickness. However, from the back this glass back seems first to have been scratched with one, or three, sets of scratches, and then plated with a mirror surface. The plating is so thin that the scratches show on the metallic surface.

This is a better product than any of the earlier substitutes because the top is thinner and paler than the first deep cabochons were, permitting brighter reflections. The colour is rich and approximately right (though the star is very highly coloured in comparison with the real or Linde stars). An epoxy cement can probably take any normal sort of abuse without separating. From the back one sees a silvery moonstone-like surface.

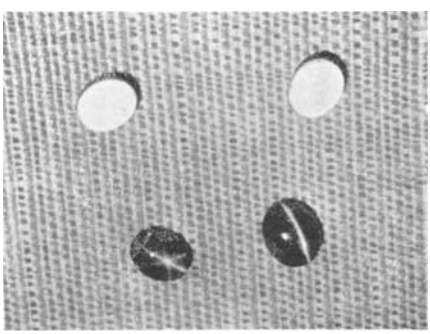


FIG. 5.

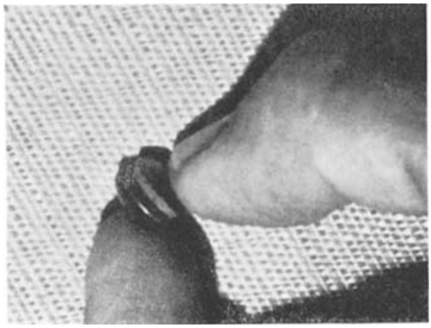


FIG. 6.

Over-heating could destroy these stones : the sort of heat that might be applied in careless sizing. Other than that they seem to be satisfactorily permanent, but one obviously cannot expect any plastic material to withstand really high, burning, temperatures. The glass backing too would be likely to crack in too much heat.

The second manufacturer of synthetic star-sapphire doublets doubtless produced a stone even less susceptible to disruption by heat. This doublet can only be described as soldered (a term with which the jeweller is familiar through the unsoldered " soldered emerald "). This new star stone is, literally, soldered together. (Fig. 6.) It is a triplet, the top layer is a buff-top, German-cut synthetic ruby or sapphire, just like the other. The back, which fits perfectly, is made of blue or red sintered corundum, an opaque deeply coloured material. In the case of the blue stones it looks just like the sintered synthetic spinel imitation of lapis-lazuli. X-ray tests indicate that it is a corundum, however, or at least the red material was.

The buff-tops, as imported, are polished all over. The first step is probably scratching the surface in a series of microscopic grooves, in the three different 60° directions. The greater hardness of the synthetic corundum may be in part responsible for the better appearance of these stones, creating on sapphire weaker and sharper scratches than are made on glass. The two halves, of almost equal thickness, must then be soldered together with some relatively low melting point metallic solder, which adheres strongly to the corundum. The solder provides the reflecting surface, holds the two parts together and appears unaffected by most of the normal hazards. The stones were found to separate under extreme heat, an abuse to which they would never be subjected under normal conditions.

As loose stones there is no difficulty in recognition, and even in a mounting the sintered corundum back is quite unlike that of any natural stars : the colour is far too deep. Just why this material was used as a backing is not clear, except that possibly it was felt that a metal that would adhere to the corundum on one side might just as well be backed with equally durable material. Probably a metal plate would do as well.

The star is very fine, coloured of course, but sharp and bright. The finer, better defined lines that are made, presumably by rubbing the corundum on a coarse diamond dust studded surface in three precise directions, give a sharper star than that produced by the metal-plated scratches on glass. The soldered sandwich is probably slightly more durable under extreme conditions than the glass-backed stones, but the testing conditions are not likely to be encountered by either of the stars under normal wear and handling.

The new stars have considerable merit because of their beauty and their durability. One can also confidently predict a poor future, for their manufacture is too easy. Glass imitations which have had poor acceptance till now would soon ruin the appeal of the star-stones and cat's eyes once a good demand had been created by the more attractive synthetics.

I am indebted to the Wm. V. Schmidt Company and the International Gem Corporation for their co-operation in providing samples of the assembled synthetic sapphire-ruby-spinel stars for the illustrations and tests.

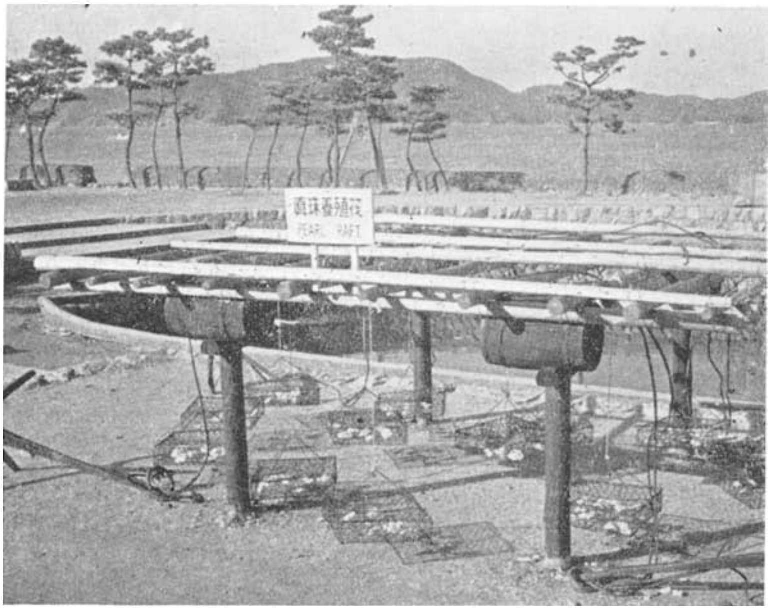
THE JAPANESE CULTURED PEARL INDUSTRY

By JUDITH BANISTER

FORTY years ago, the London gem market was startled and alarmed by the appearance of " pearls " from " a new fishery in Japan ". At first, it seemed feasible enough, for the pearl-bearing *pinctada martensi* is a native of southern Japanese waters, and in the north island, Hokkaido, the *unio margaritifera* still produces freshwater pearls. But it was quickly discovered that these new " pearls " were the result of man's interference with the abnormal ability of the oyster to produce nacreous substances. Mikimoto's persistent experiments to cultivate pearls had borne fruit. To-day, almost all the world's cultured pearls come from Japan, about 80 per cent of them from Ise Bay, in the Mie Prefecture, where Mikimoto lived and first produced his man-assisted pearls.

The history of cultured pearls, as most things Japanese, starts in China. There, it is said, the ancients used to insert small objects into living mussels so that they might be coated with the shimmering nacre. But it took centuries for the idea to cross the China Seas, and only at the end of the last century were the shellfish-abundant waters of Ago Bay exploited by men of Mikimoto's enquiring genius in order to copy the ancient Chinese skills. As long ago as 1893, Kokichi Mikimoto achieved the reasonably successful culture of semi-spherical pearls, but his new round ones in 1921 were an advance indeed. His " whole-wrapping method " entailed the destruction of one oyster, by removal of the nacre-producing mantle, so that another might be " injected " with a bead wrapped within this tissue and tied with fine silk. For this Mikimoto has generally, and justly, been acclaimed the father of the cultured pearl. But others were also at work, and at the National Institute for Pearl Research at Kashikojima, due credit is given to a gallery of gentlemen whose pioneer work helped to build up Japan's now vast cultured pearl industry.

Second to Mikimoto was his son-in-law, Tokichi Nishikawa, also known as " the cultured pearl man ". He, with his two assistants, Tsuguyo Fujita and Masaya Fujita, developed the " piece insertion method " that has revolutionized cultured pearl production. Others studied the best materials for the composition of the bead nucleus. In 1907, experiments were made with lead nuclei.



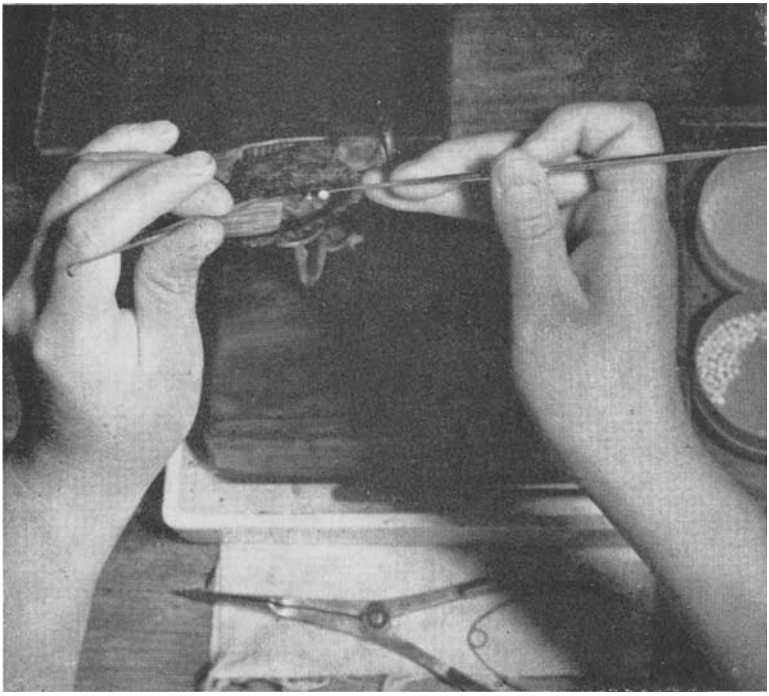
Section of one of the rafts, exhibited for tourists.

From 1907 to 1909 Tatsuhei Mise was using silver particles for insertion, and, indeed, is said to have produced round cultured pearls at the same time as Mikimoto. Nishikawa also used silver pellets, and other experiments were made with stone, marble and glass. But it was Kikutaro Konishi who established the use of Gamanose, clam shell from the Yangtse river, which, until China's doors were closed to trade, provided the best nucleus for the beads. To-day, Pig's Toe Shell from mussels in the Mississipi is used, and cut and ground into spheres in special rotating cast-iron discs. As the years went on, the size of the nucleus or nuclei inserted has been generally increased. About 1913, very tiny beads were used. To-day, large pearl oysters (*pinctada margaritifera*), inhabiting the warm southern waters off Australia, can take beads even up to 60 mm in diameter, though in Japan the *pinctada martensi* cannot really accommodate a bead larger than 12 mm.

Japanese pearl cultivation has become a highly skilled laboratory process. Dental instruments for the operational work were suggested many years ago by Mikimoto's dentist friend, Otokichi

Kuwabara, and certainly look more workmanlike than some of the earlier tools used. But there are still picturesque features at the pearl farms, most of which are situated in the wooded inlets of Ago Bay. The ama, or diving women, wearing long-sleeved white bathing dresses, still collect oysters from the rocks, remaining seemingly endless minutes beneath the surface. But there are fewer than there used to be, as most oysters used in pearl cultivation are raised from spat. The long serried rows of rafts which carry the cages of oysters give a strange Klee-like pattern to the waters of the Bay, their flatness relieved here and there by the little roofed pavilions where the cages are sorted out of the sun. But for the rest, pearl farming is a business, organized and tabulated, with profits and losses gauged by oyster mortality or health, by natural

Lifting oyster cages for cleaning.



Insertion of mother-of-pearl bead.

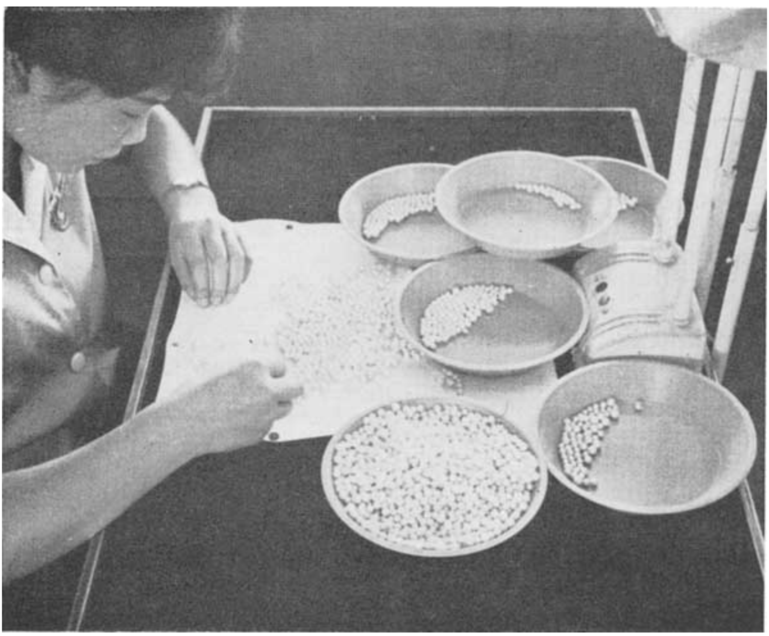
enemies and by the luck of successful production of nacre within the host oyster.

Some idea of the size of the industry to-day can be gauged from the fact that one good operator can insert between 200 and 300 beads in her eight-hour day, and that on one farm alone approximately 50 million oysters are reared, so that some 20 million can be operated on every year.

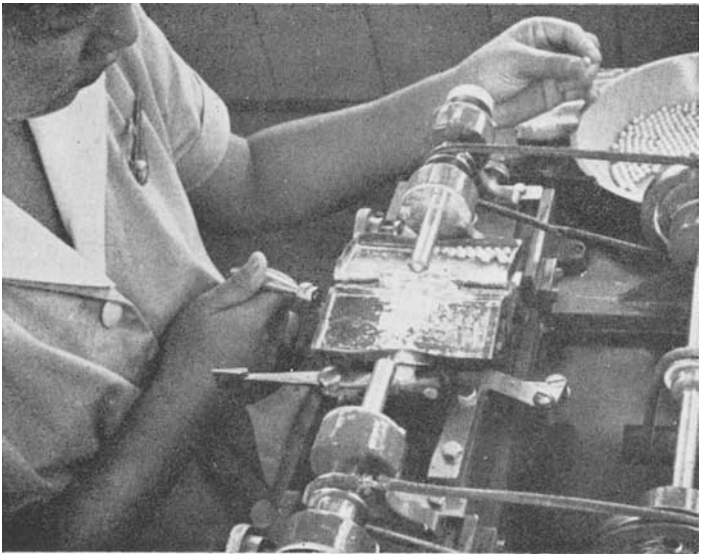
The " piece insertion method " attributed to Nishikawa and the Fujita brothers has revolutionized cultured pearl production. Instead of destroying one oyster to operate on another, the mantle of a single oyster is cut into several dozen sections. The tissue is gently scraped—it will live for several hours in favourable conditions—and is cut into tiny rectangular slivers. The oysters on which the operations are to be made are kept in salt water. The operation is a quick and skilled one : the oyster is lifted out of the water, and a wooden peg slipped in to keep the valves apart. A slender tool, like a gingevectomy knife, is used to make a tiny slit within the epithelium sac of the living oyster, a sliver of the grafting tissue inserted, and then a bead placed in exactly the same slit. Four or five small beads may be placed within a single oyster of about three years old. Another advantage of this piece method is that large beads can be inserted, whereas with Mikimoto's wrapped method the slit to be made would have been so large that the oyster would inevitably die.

The raising of oysters from spat helps to ensure a constant supply of healthy young oysters for the pearl operators. It is most important that the oysters should be healthy and strong, and though small nuclei can be successfully inserted when the oyster is only a year old, it is better to wait another year, and even better if the pearl cultivator can afford to wait until the oyster is three years old before the bead is inserted. The pearl oyster usually lives about 10 years but its pearl-bearing life is over by the time it is seven years old. In a good-sized oyster, as many as five or six small nuclei can be inserted, or two of 4 mm in diameter. A large nucleus does tend to weaken the host, and losses of oysters carrying large beads are legion. Careful study of the oyster has helped to cut the death rate, however. It was found that the Japanese pearl oyster hibernated during the four coldest months of the year and was therefore very weak during the immediate period afterwards, producing nacre of very poor quality then, even if it survived at all. So large nucleus insertions are now made in July and August, so that the oyster becomes accustomed to the bead within its mantle for 40 or 50 days before the winter sets in. So simple (though skilled) an operation has the insertion of small beads become that these can be inserted at any time of the year, with very little loss of life, providing always that the oyster is in a healthy condition and that health is maintained for the rest of its life. Health also, claim the Japanese, helps to promote a good layer of nacre on the beads. This layer is said to be at least 1 mm thick on 3 mm and 4 mm nuclei, and rather more on larger ones. A law of 1957, the Cultured Pearl Enterprise Law, was designed to regulate production and to prohibit the export of inferior quality pearls.

Immense precautions are taken to ensure the health and safety of the oysters. They are housed in wire cages suspended by ropes below the bamboo rafts—sometimes nylon mesh is used, but wire is generally considered a better protection. Between 30 and 50 oysters are kept in each cage—the fewer the better, as more air and food can penetrate. The oysters are never artificially fed, but rely on the plankton that is carried by the tide. It is thought, however, that the oyster's food may affect the colour of the nacre, and experiments are being made to probe this theory. It has been found that suspension of the cages at various heights is better than placing them on the seabed, and careful readings are taken to ensure that the cages are suspended at the height most beneficial to the oyster. When the waters are too warm in summer, the cages are lowered ; in winter they may be raised or moved to more sheltered parts of the Bay, and again, during the rainy season, they must be moved to saltier depths as too much fresh water will suffocate the oysters. In emergencies, the ropes holding the cages must be cut, and then the ama will dive down later to retrieve them. The oysters are also regularly inspected to see that they have not been subject to disease, and they are scraped of marine growths, shells and other parasites



First sorting of cultured pearls.



Drilling of cultured pearls.

about five times a year. Another precaution taken against wasted work is the X-raying of oysters every year ; by using weak X-rays it can quickly be detected whether the oyster has ejected the bead nucleus—a large percentage of larger beads are spat out by the oyster within the first year.

Besides watching for water and temperature changes, constant guard must be kept against the depredations of the oyster's enemies. Marauding fish that attack the oysters include the octopus and the starfish, both of which choke the oyster and then eat it. The sea-eel, globefish and the black snapper all prise open the shell as the oyster breathes and then eat the flesh, and barnacles, the hiro worm and other smaller oysters tend to batten on the shell and cause the oyster to suffer from malnutrition. Day and night watch is also kept on the rafts against human thieves, and to give ample warning of natural disasters.

The terror of the *akashio*, or red tide, that comes several times a year to the southern coasts of Japan is much less of a danger than once it was, for early warning is usually given and the pearl cultivators have time to move the precious rafts and to scatter lime to eliminate the red tide. Hazards of wind and water are more difficult to contend with, and the typhoons that in summer sweep across the China Seas from the equatorial regions present an annual threat. The severe typhoon two years ago destroyed over a million oysters in Ago Bay and caused thousands of pounds worth of damage to the rafts and farm installations.

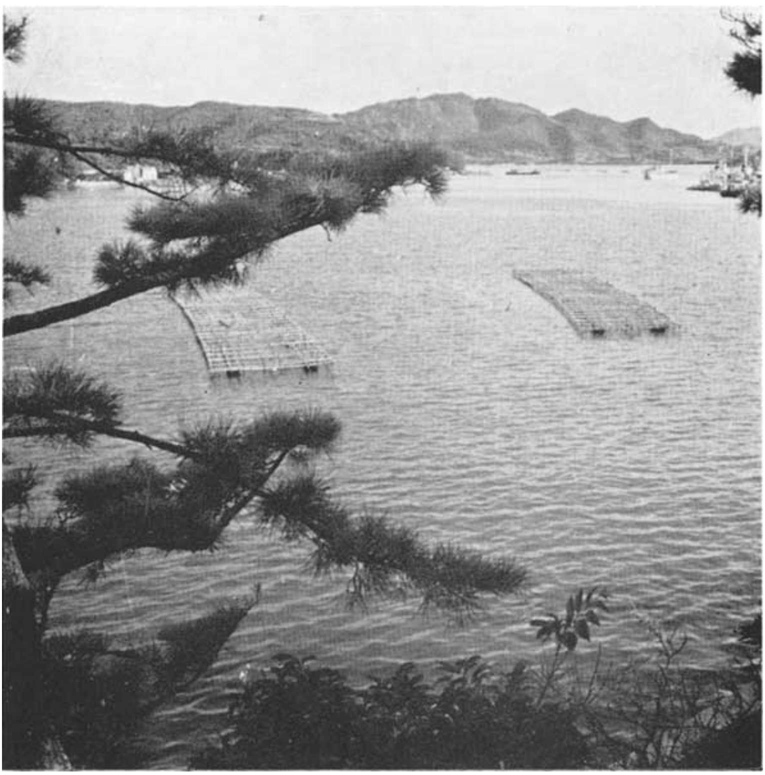
I was staying in Kashikojima on Ago Bay last May when the tidal wave set off by the Chilean earthquakes hit Japan. The waters surged into the Bay and receded, an almost silent dawn destruction that seemingly peaceful 23rd May. Raft was swept against raft, a tangle of bamboo spars, floats and cages. Pavilions were swept down, motor boats piled on the shore. At first the farmers feared that they had lost about a third of their oysters, but though damage was estimated at about 100 million Yen (£100,000), a large majority of the oysters were recovered by the diving girls.

But despite every precaution, there is at least a 10 per cent mortality of oysters every year, whether from disease, age or disaster. In addition, of course, there are large losses when the oysters are opened. A considerable number of cultured pearls are of qualities inferior to those laid down by Japanese law, and must be destroyed. However healthy the oyster, the pearl cultivator has no guarantee that the coating of nacre will be even, of good thickness or of an acceptable colour, and continued demand for large cultured pearls, especially from United States markets, means a higher death rate and a lower percentage of good cultured pearls.

Up to 5 mm in size, losses are less extensive, and about 15 to 20 per cent of oysters produce good quality cultured pearls of A grade. However, increase the size to 7 mm, and the yield will only be between 5 and 10 per cent, to 8 mm, and the yield is between 2 and 3 per cent, and to 10 mm, and it will be less than 1 per cent.

The first grading of the pearls is to separate gem quality from pebble. Badly shaped and lustreless pearls are rejected, to be used for throwing back into the seat at ceremonies, or to be skinned and the nucleus re-used for insertion. From the small percentage of good quality pearls recovered, there must be further grading according to colour and size. Some baroque shapes are accepted—

baroque cultured pearls are usually due to the nucleus having remained in the oyster too long. Occasionally, of course, natural pearls are also found in the shells, but on the whole the Japanese do not bother to distinguish between them. The operator can, of course, detect them when the shell is opened, because the natural pearl will lie along the outer membrane, and not within the mantle where it has been found the oyster will best produce the nacre to coat the inserted bead. Recent developments have also been made in Japan in the culture of pearls in freshwater mussels in Lake Biwa, near the old capital of Kyoto.



Pearl rafts in Ago Bay.

Gemmological Notes

ELUSIVE CHROMIUM

A. E. Farn

The abundance of minerals—metalliferous and gemmological—ensure that we have plenty of solid gold and real gemstone jewellery (although not all will stand up to etymological exactitude).

Nature, in scattering the earth prolifically with silica, corundum, carbon and beryl has been slightly less liberal in dosing her gems with chromic oxide—it makes such a difference ! It's like forgetting to put the salt in the potatoes—they are edible but do not whet the apetite.

The chromium content of the important gemstones is very critical indeed and it is necessary for optimum quality of colour and hue that it should be not too little, and not too much. Pale pink sapphires and pale emeralds obviously suffer from chromium starvation, whereas too dark and saturated green emeralds and almandine-red rubies have too much. These latter are often termed Siam stones when in fact they are chrome-rich Burma stones. On the other hand it is very difficult to take over from nature the dietary deficiencies of these important gemstones—even in their synthetic counterparts. Witness the all too familiar shocking raspberry-red of the synthetic ruby and the strong blue-green of the Chatham synthetic emerald, both cases of excess chromic oxide. In the case of the synthetic Verneuil ruby it is often the random cutting of the stone which causes it to " look " wrong, but it is a fact that it has a far stronger fluorescence under the ultra-violet lamp or X-ray set and a visible persistent phosphorescence sometimes easily seen to last a few minutes—all characteristic of an excess of chromium.

Even the correct or optimum amount of chromium in these important stones does not necessarily ensure that they will exhibit the ideal colour, because the presence of too much iron in the chemical composition of the stone has a quenching effect upon chromium and this causes the less commercially attractive colour of Siam rubies and *pro rata* affects the price per carat accordingly.

The most striking example of the importance of the balance of colour, sensitively displayed in a chromium-coloured gemstone, is that of a well cut Alexandrite. Here the price per carat rockets astronomically (not surprising in a Russian stone).

The reaction and excitement caused to even biased people such as Hatton Garden dealers in London are quite remarkable when the magic word alexandrite is mentioned. Although green chrysoberyl is a very pleasant stone and perhaps a little rare in occurrence of any sizeable pieces, it does not command prices per carat in any way comparable to its brother who was fortunate enough to inherit a trace of chromium.

Thus the small green stone becomes fabulous and sought after because it exhibits a colour-change effect when taken from daylight to artificial light and is the rarest of precious stones carat for carat of quality.

There are of course many brown-hued chrysoberyls which do in fact show some difference in tone of colour when taken from one light source to another—but it is the green/red colour change which is truly alexandrite. A true alexandrite must be therefore a stone which is green in daylight and a tone or hue of brown-red or pink-red in artificial light. It has chromium in its chemical composition, which can be seen clearly in the absorption spectrum when viewed by a spectroscope. This seems a hair-splitting test and a stone exhibiting a colour change from pale green or dark green to a hint of pink hue or deeper muddy colour can prove to have chromium in its physical make-up and must therefore be termed alexandrite. The limiting factor of its poor appearance and barely discerned colour change will be portrayed adequately in its price per carat, a most sensitive factor which has a very sobering effect on gemmological enthusiasm. Even so, the latter specimen still commands a price out of all contrast to its normal green type.

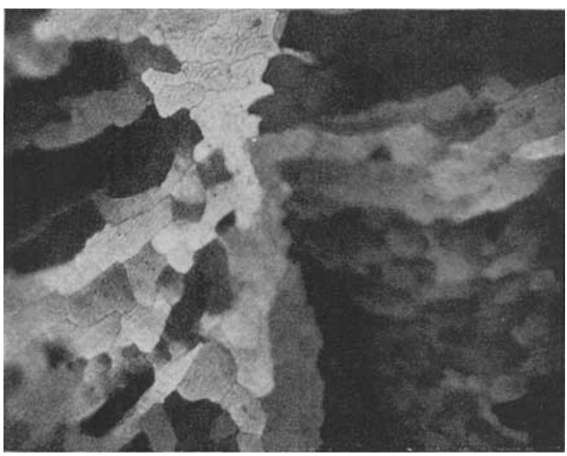
Fairly recently I had a parcel of alleged green chrysoberyls literally, metaphorically and almost physically thrust upon me—not by some philanthropic gemmophobe, but by a dealer, who, not desirous of my further education or commercial progress, was interested in the settlement of some previous transaction in which I was theoretically making a profit.

However, it is part of an education especially when transactions affect the pocket, so, in search of some good basic reason for a come-back, I decided to examine and test the parcel. On sorting, I found that several (including the largest) were paste, some were peridot and one a peculiar hue of brown-green quartz—a very flat shallow oval stone. The remainder, by far and away the smallest stones, were green chrysoberyls. Later, when placed between crossed filters, one glowed a cheerful cherry-red and when checked by spectroscope gave a faint but distinct chromium spectrum and thus achieved a distinction in gemmology by qualifying for the term alexandrite, albeit a very wan specimen. Now, of course, the stone became reasonably interesting and although not destined for the highest American market will, it is hoped, fill a long felt want in someone's gemmological drawers.

UNUSUAL STRUCTURES IN A "PEARL" R. WEBSTER

A brownish non-nacreous spherical object recently examined was said to have been removed from a shell—from its description maybe one of the *Avicula*—which was fished in Greek waters.

The object, which presumably could be called a pearl, was calcareous and had a density of 2·53. When examined microscopically, using a very strong transmitted light, the colour was golden brown and a most intriguing internal structure was revealed. This structure was in the form of radiating prisms showing different shades of brown and the terminations were attractively marked with scales or striations. The monochrome picture fails to do justice to the beautiful view seen through the microscope.



Gemmological Abstracts

ESPIG (H.). *Die Synthese des Smaragds.* The synthesis of emerald. Chem. Techn., Vol. 12, No. 6, June 1960, pp. 327-331.

Single crystals of synthetic emerald (Igmerald) which were suitable for cutting, were first made 30 years ago by I. G. Farben, Bitterfeld. The process was kept secret. This left room for the assumption that a hydrothermal method was used, especially as microscopical inclusions seemed to point in this direction.

Production has ceased since 1942 and the reasons for secrecy have disappeared. H. Espig has now disclosed an interesting mineral synthesis, which might lend itself also to other applications.

By melting the components BeO, Al_2O_3 and SiO_2 a glass results, due to the low crystallization speed of emerald. For this reason the use of Verneuil's process was ruled out. Instead the components had to be united by means of a flux. Hautefeuille and Perry found in 1877 that alkaline vanadates, tungstates and molybdates were suitable for the synthesis of silicates. In 1888 they reported a successful synthesis of emerald using lithium molybdate. They used a mixture of BeO, Al_2O_3 and SiO_2, in the ratio indicated by genuine emerald, and heated it with a five-fold amount of lithium molybdate for a fortnight at 800°C (1472°F) in a platinum vessel. A great many emerald crystals were obtained but only up to the size of 1 mm (0·040″).

These experiments were repeated and varied. Many seed crystals and mineralizers were tried. In Bitterfeld work had been carried out since 1911; the experiments of the author himself, which started in 1924, aimed at crystallizing emeralds from oversaturated solutions.

The first success was obtained when it was recognized that the process was not just a simple crystallization but a chemical reaction depending on the fact that emerald was formed in lithium molybdate and was less readily soluble than its components. Temperature and concentration were critical conditions. When these were given, the three components BeO, Al_2O_3 and SiO_2 crystallized from the solution. However, when the three components were evenly distributed, an oversaturated solution resulted and a great many small crystals were obtained. The oversaturation, therefore, had to be reduced to a minimum by separating the components in the melt. To achieve this, BeO, Al_2O_3 were placed on the bottom of the platinum vessel. Next came the flux and on top of this a disc of molten quartz. The densities are such that the quartz floats on the melt, BeO and Al_2O_3 remaining on the bottom. Through diffusion and currents the oxides and their reaction products with the molybdate reached the zone near the quartz disc where SiO_2 dissolved in the melt. Crystallization began in a comparatively narrow zone as soon as the saturation point for emerald was surpassed. The emeralds grew in nice single crystals on the quartz disc. This arrangement allowed for the gradual joining of the components necessary when crystal material is grown which is not readily soluble. After having established the method in principle, optimum conditions with regard to raw material, temperature, concentration, influence of other substances and arrangement of apparatus had to be found in numerous tests. Growth of the emerald crystals on a quartz disc led to inclusions and fracture on separation. Therefore a platinum wire mesh was placed horizontally underneath the quartz disc. The seed crystals were floated under the platinum wire mesh. A vertical platinum cylinder in the centre allowed for feeding in the components BeO and Al_2O_3. All the quartz for a growth period of two to four weeks was added in one amount, the oxides BeO and Al_2O_3 in small portions every two days. Crystals of up to 1 cm size resulted, but they grew through the wire mesh. When the mesh was replaced by a holed platinum sheet (2mm holes), the emerald crystals were not attached any more. With sufficient supply of the oxides, emeralds with sharp edges and glossy prism faces and bases resulted. When the melt became deficient in oxides the emerald crystals began resolving. Pyramidal faces resulted, the edges became rounded and the surface matted with etch marks. Over-rapid growth led to needle structure at the base. Emerald formation started at 640 to 750°C. At 770 to 800°C the seed crystals grew best, at 800 to 850°C new crystals appeared and at 900°C emerald formation came to a halt, existing emerald crystals were resorbed and other crystals formed. These are listed by the author. Also listed are several of the mixtures of the initial melts. The finally established figures were (1) a minimum of 6·55% emerald ($BeO + Al_2O_3$) had to be contained in the melt to saturate it; (2) an additional feed of 0·25%, representing very slight oversaturation, was required. Practical details were as follows:

A platinum vessel of about 7″ diameter and 3½″ in height was used; in it was suspended a horizontal circular holed platinum sheet to which the vertical feed tube was permanently attached. The distance of the circular disc from the bottom of the vessel was about 2″ (55-60mm). On the bottom of the vessel was placed the $BeO-Al_2O_3$ mixture in the theoretically indicated ratio, altogether 80 grammes including a few grammes of lithium chromate as colouring agent. Over this was the melt consisting of acidic lithium molybdate, which had been prepared by melting MoO_3 together with lithium carbonate and by pulverizing the cooled melt. The platinum vessel contained 2·8 kg of the melt. On top of the melt were placed 80 grammes of emerald seed crystals, which had been obtained in previous test runs. Next came the holed platinum disc and on top of that 250 grammes of quartz fragments from 8 to 10 mm thickness. The vessel was placed in an electric furnace, which had been heated to 800°C and this was kept at that temperature (+ 10°C) during the whole growth period of 20 days. Every two days $BeO + Al_2O_3$ was fed in through the platinum cylinder. This resulted in a weight increase of 20% of the seed crystals during the 20 days period. An improvement was achieved by using prismatic seed crystals. These were obtained by sawing off pyramidal ends with a diamond saw. Eventually 12 furnaces were in operation and single crystals of 2 cm (over ¾″) length were grown during a period of one year. Chromium oxide as colouring agents resulted in a bluish-green colour and other additions had to be found to produce the desired grass-green colour. The production in Bitterfeld came to an end in 1942. According to W. F. Eppler the inclusions in Chatham synthetic emeralds resemble those in Igmerald to such an extent that in all probability the production methods can be assumed to be similar.

The described method of synthesis was not entirely restricted to emerald. Other minerals—especially silicates—were produced, namely phenakite, willemite, zircon, garnet, titanite and rutile. 11 illus., 2 tables. W.S.

GROSS (H.). *Suesswasserperlen.* Fresh water pearls. Deutsche Goldschmiede-zeitung, Vol. 58, No. 5, 1960, pp. 260-261.

Short article describing fresh water pearls, especially those found in central Europe, i.e. Germany, Bohemia and Austria.

These pearls take 20 to 25 years to grow to a diameter of 4 mm and perhaps 40-50 years to grow to 6-7 mm. A photograph shows a pearl of 5·76 mm with 39 rings, i.e. of an age of about 39 years. With the increase of impurities in rivers the fresh water pearls also decrease. X-ray radiography and diffraction pattern show the difference between salt- and fresh-water pearls.

E.S.

HOHENESTER (G. W.). *Bernstein.* Amber. Deutsche Goldschmiede-zeitung, Vol. 58, No. 7, 1960, p. 371.

Five photographs showing insect inclusions in amber. There is a growing difficulty in finding amber with insect inclusions as most of the raw material comes from E. Germany. Only pieces free of insect inclusions seem to be exported.

E.S.

EPPLER (W. F.). *Wachstumserscheinungen am Aquamarin.* Growth phenomena in aquamarine. Deutsche Goldschmiede-zeitung, Vol. 58, No. 5, 1960, pp. 258-259.

Usually growth phenomena are shown by the external habit of a crystal. The internal growth phenomena are more difficult to observe. This article deals with the internal signs of growth phenomena in Brazilian aquamarine. There are often irregular lines in the stones, which look like swirl marks ; these lines were caused by periodic and irregular variations in the mother-solution. It could be seen that the aquamarine had grown from a small crystal via various intermediary stages to the final stone. Photographs illustrate various intermediary stages, i.e. intermediary crystals within the final aquamarine.

E.S.

EPPLER (W. F.) *Aetzroehren im Aquamarin.* Etch tubes in aquamarine. Deutsche Goldschmiede-zeitung, Vol. 58, No. 7, 1960, pp. 368-370.

Among the various inclusions in aquamarines, long thin tubes or channels are the most frequent. They are filled with either a liquid, a gas or with both. These tubes are always orientated in the same direction, parallel to the c-axis. It is probable that these tubes were produced by etching. The tubes can be of various thicknesses. Apart from the long, thin tubes, there are some shorter tubes, also parallel to the c-axis. Their contents are usually one or more doubly refractive crystals, a liquid and a gas, i.e. they are typical three-phase inclusions. Sometimes resorption phenomena can be observed on these growth tubes.

E.S.

HEGEL (C.). *Einschluesse von Diamant in Diamant.* Inclusion of diamond in diamond. Zeitschr. d. deutsch. Gesell. f. Edelsteinkunde, 1960, No. 32, p. 23.

Photomicrograph of diamond octahedron in small brilliant.

E.S.

PICHL (M.). *Edelsteine in der Goldschmiedewerkstatt.* Gems in the workroom of a goldsmith. Zeitschr. d. deutsch. Gesell. f. Edelsteinkunde, 1960, No. 32, pp. 21-23.

Includes table of 46 gems and how they could be affected mechanically, chemically and by heat.

E.S.

SCHLOSSMACHER (K.). *Die Entstehung der Achate.* The formation of agates. Zeitschr. d. deutsch. Gesell. f. Edelsteinkunde, 1960, No. 32, pp. 16-20.

A new theory has been put forward by the Carnegie Institute in Washington. This suggests that magma from which stones solidify can in its liquid form house two types of melts at the same time. These two types do not mix, but one swims in droplet form in the other type, one being acid, the other alkaline. The basis put forward is that the lava from the eruption of a volcano is not homogeneous, but that these alkaline melts included drops of acid melt, forming a kind of suspension.

E.S.

MIRTSCHING (A.). *Die Diamantlagerstätten Ostsibiriens.* Diamond occurrences in east Siberia. Zietschr. d. deutsch. Gesell. Edelsteinkunde, 1960, No. 32, pp. 11-16.

The north-west part of the Republic of Jakutia in East Siberia seems to be one of the parts of the earth richest in diamonds. A map of the district is shown, with photographs of the general landscape and two of the stones produced.

E.S.

Benson (L. B.). *Testing black pearls.* Gems and Gemology, No. 2, Vol. X, pp. 53-58. Summer 1960.

Two basic types of treatment are mentioned, surface and centre treatment. Some cultured pearls have their nuclei treated before insertion in the mollusc. Silver nitrate at one time extensively used and X-radiography may detect. Most natural black pearls fluoresce reddish to rays of approximately 4000Å—usually by the " crossed filter " technique. Dyed pearls do not fluoresce, but care must be taken as centre dyed pearls may fluoresce from the normal glow of the whitish nacreous outer layers. Coated pearls may be detected by using a small swab moistened with a 2% hydrochloric acid solution, which on being rubbed over the surface of a coated pearl will show on the cotton wool a slight brownish coloration. This test will also detect pink and bronze dyed pearls. Fluorescence experiments were carried out by using a 100-watt mercury spot lamp.

1 illus. R.W.

Crowingshield (G. R.). *Development and highlights at the Gem Trade Laboratory in New York.* Gems and Gemology, No. 2, Vol. X, pp. 59-63. Summer 1960.

Comments are made on some American misleading advertisements using the names " Diamond-ite ", " Trulite ", " Brillight " and " Vespa gem " for synthetic white sapphire, and giving incorrect hardness values for this material. Synthetic emeralds are reported which have inclusions of platinum and the author points out the danger that these metallic inclusions can influence the density. A number of unusual specimens tested in the New York laboratory are mentioned and these include a citrine-coloured soudé-type stone. The absorption spectrum of a brownish willemite is mentioned.

3 illus. R.W.

Benson (L. B.). *Developments and highlights at the Gem Trade Laboratory in Los Angeles.* Gems and Gemology, No. 2, Vol. X, pp. 45-52. Summer 1960.

Three diamonds showing a bluish adularescent effect, said to be due to a combination of minute inclusions, and the fluorescence are reported. A diamond is mentioned which had an elongated internal fissure, upon the surfaces of which crystal growth marks could be seen. It is suggested that these marks indicated that the fissure is an elongated negative crystal. Reference is made to a string of purple beads sold as " purple jade ", which proved to be dyed aventurine quartz. Other stones examined were a chatoyant golden-brown kornerupine and a blackish-green gahnite having a density of 4·50 and a refractive index of 1·79. A pearl-like formation of orange-brown colour, which was represented as a black pearl, showed that light was readily transmitted parallel to the prismatic crystals but was opaque at right angles to that direction. The object was thought to have been fashioned from a section of a large shell. There is a report of turquoise beads imported from Japan which had been treated with paraffin or other wax. The method is said not to be permanent. Another strand of turquoise beads (S.G. approx. 2·71) was too dense to be impregnated with wax, and a process involving etching the beads in presumably hydrofluoric acid had been used to impart myriad pits on the surface. The beads are then coated with blue-coloured epoxy resin. References are made to the new modified polaroid jewellers' camera, and to the Custers audio-electric-conduction apparatus and to the meter type devised by the Gemological Institute of America.

11 illus. R.W.

HOWE (E. L.). *North America's only diamond field.* Australian Gemmologist, No. 1, Vol. 3, pp. 16-17. July 1960.

A short article on the diamond field at Murfreesboro which was first found in 1906. It is now open to tourists.

1 illus. R.W.

ANDERSON (B. W.). *Gem testing by non-destructive testing methods.* Non-Destructive Testing, No. 2, Vol. 2, pp. 3-8. August 1960.

A general description is given of the methods of testing gemstones and pearls. Gems are precious and any testing must be non-destructive. The use of the jeweller's refractometer is explained and also the method of refractive index estimation using immersion fluids (immersion contrast methods). The absorption and fluorescence spectra methods of gem testing are discussed. The use of the microscope in the detection of synthetic stones is explained. The article concludes with notes on density methods and the use of X-rays in the testing of stones and pearls.

11 illus. R.W.

SCHLOSSMACHER (K.). *Modern diamond grading.* Diamant, No. 23, July 1960. (Reprinted in Gemmologist, November 1960).

The grading of diamonds by colour is discussed and an International Colour Classification appended. It is pointed out that some names occasionally used by dealers are not mentioned. Some notion of percentage prices from Top Wesselton is given. Purity from inclusions and some of the typical inclusions seen in diamond are mentioned. An International scale of cleanness grading with some remarks on accuracy of cutting as a price factor are given.

R.W.

POUGH (F. H.). *The Spanish topaz mines.* Gemmologist, No. 351, Vol. XXIX, pp. 183-186. October 1960.

The Margarita mine near Vilas Buenas in north-western Spain was discovered about 100 years ago. This is the source of all the brownish-yellow quartz erroneously known as " Spanish topaz ". Some comments on the reason for this misnomer are given. The mine, which supplies rock crystal as well as citrine, is again being worked to some extent.

3 illus. R.W.

RAMSAY (A. M.). *Scottish gem localities.* Lapidary Journal, No. 4, Vol. 13. October 1959. (Reprinted in Gemmologist, November 1960).

An account of the gem minerals which have been found in Scotland. It is disputed whether diamond has ever been found in Scotland, despite the reports of finding isolated diamonds in Sutherlandshire. Pearls from Scotch rivers are mentioned and the sapphire from the island of Mull. Beryl, topaz, garnet and zircon are found in a number of counties but not necessarily of gem quality. Prehnite is recovered from Boylestone quarry, Barrhead, Renfrew and has been cut into cabochons. Thomsonite is found at the same locality. The chief gem minerals found in Scotland are those of the silica group. Rock crystal is common and there is much brown quartz (cairngorm). Amethyst is recovered from a number of localities. Agates are common and the places where they may be found are given. Jaspers, aventurines and bloodstones are also found in Scotland.

1 map. R.W.

CHALMERS (R. O.). *Kalgoorlie—El Dorado of the west.* Australian Gemmologist, No. 1, Vol. 3, pp. 5-9. July 1960. (Reprinted from the Australian Museum Magazine).

The story of the Kalgoorlie goldfield of Western Australia. The geology of the goldfield is discussed and the production figures given.

2 illus. R.W.

WIRTH (A. A.). *The noble opal of Australia.* Australian Gemmologist, No. 1, Vol. 3, pp. 6-7. July 1960.

A general article on what constitutes a fine quality opal.

R.W.

WEBSTER (R.). *Testing for electro-conductivity.* Gemmologist, No. 350, Vol. XXIX, pp. 161-169. September 1960.

Reports the results of experiments carried out on various types of detecting apparatus for the electro-conductivity of gem materials. A simple circuit consists of a source of current, two electrodes for the specimen to be tested and a detecting device. Various types and voltages of current were tried and the efficiency of meters, neon lamps and telephones was examined. A neon lamp screwdrived circuit tester was found to be very efficient. The results on a number of tests on gem materials are mentioned. Natural blue diamonds, but not irradiated blue diamonds, were found to be conductive. Other gem materials which experiment showed would conduct electricity were hematite, much chalcedony (but not jasper), pyrites, marcasite, pseudophite, synthetic blue rutile, verdite, some serpentine and most turquoise.

6 illus. P.B.

FRANCO (R. R.). *Pequeno glossario gemologico.* Gem glossary.

A glossary of 180 gem minerals in Portuguese.

S.P.

BYKERSMA (R.). *A trip to Rubyvale.* Australian Gemmologist, Vol. 3, p. 2, 1960.

A short account of a visit to the Anakie sapphire field, Queensland, Australia. S.P.

CAMPOS (J. E. de S.). *Safiras do Rio Coxim, Matto Grosso.* Gemmologia, 1960, No. 21, pp. 1-8.

An account of the sapphire crystals found in the Rio Coxim area of the Matto Grosso.

S.P.

RAO (A. B.) and SOUSA (M. S.). *Gahnita do nordeste e variedades de espinelio.* Gemmologia, 1960, No. 21, pp. 9-18.

This paper deals with the general classification of the spinel group. Chemical composition, physical and optical properties and X-ray data are enumerated, and occurrences in general, and localities in Brazil are cited.

Special reference is made to spinels occurring in Borborema pegmatites, where the presence of possible gahnite-hercynite spinels is noted. Theur properties are detailed, and X-ray powder patterns and spectrochemical data are given. Paragenetically they are in association with cassiterite deposits. These spinels are sporadic in occurrence and lack transparency.

S.P.

McKAY (H. C.). *Elementary optics for the lapidary.* Lapidary Journal, 1960, Vol. XIV. No. 5.

A well-illustrated article which considers problems of reflection and refraction encountered by the lapidary.

S.P.

ASSOCIATION NOTICES

PRESENTATION OF AWARDS

There was an international flavour about the presentation of awards held in the Livery Hall of the Goldsmiths' Company on 15th November 1960. Not only had Dr. Edward Gübelin come from Lucerne to present the prizes, but also members from Germany and Ceylon. Altogether two hundred members and friends were present. Later in the evening they had Ceylon brought to them in "glorious colour" through the film made by Dr. Gübelin of the gem industry of the island.

Mr. Norman Harper, the Vice-Chairman, described the occasion as the crown of the year, yet marking only the beginning of the gemmologist's career. This was emphasized by the fact that during the evening they would also be presenting Research Diplomas for the first time.

Dr. Gübelin in presenting the prizes and diplomas also said that this was the evening to which many had been looking forward for two years. Their knowledge was wide. As gemmologists they were also acquainted with mineralogy and other aspects of the science of nature. The jeweller who was also a gemmologist had a most useful hobby. Yet gemmology was also an art. The splendour of gem stones and the pleasure that could be derived from their colours and vivid brilliance could enrich our lives. Some of them would want to know more about gem stones. Others would use their knowledge to help them in their careers. They all had a new talent of which they should make good use.

Mr. B. W. Anderson proposed a vote of thanks to Dr. Gübelin, which was enthusiastically given.

Mr. Harper, also thanking Dr. Gübelin, said he was glad that they could do this by giving him something in return, namely one of the Research Diplomas for his work on inclusions. His name would always be associated with this aspect of the subject and he led the world in this study, though he covered a much greater field.

There was to-day an even greater need for gemmologists. They had to keep the trade and true gem stones in the exalted position which they had occupied through the centuries.

Mr. Harper then presented the following research diplomas :—

1945 August — M. D. S. Lewis, B.Sc.
Some surface properties of gemstones.

1946 October — Robert Webster
An investigation into the properties of ivory : the materials used in its simulation, and the methods whereby they may be severally distinguished.

1953 August — G. Frank Leechman
The origin of the colours in precious opal.

1957 June — Edward Gübelin, Ph.D.

A contribution to the genealogy of gemstone inclusions.

1959 June — Leonard C. Trumper, B.Sc.

The measurement of refractive index by reflection.

Before the presentation there was a reunion of just over 100 members held in the Exhibition Room of Goldsmiths' Hall.

Dr. Gübelin's fascinating film about gem mining in Ceylon opened with a dinner party, at which various questions about gems were asked. Then a pearl drop at the end of an Indian lady's ear-ring faded into the island of Ceylon. Animated drawings showed the formation and occurrence of the gem gravels and, after a few scenes of the exotic plant life of the island, the two methods of obtaining stones from the gem gravels were shown. The primitive methods of cutting and polishing the gems and the method of selling the finished stone were most interesting. A cloth is placed over the hands of buyer and seller and by grasping one, two, three or four fingers, and by means of other signs, a bid for the stone is made and acceptance, strangely enough, is indicated by a shake of the head and not a nod. The onlookers to such a transaction receive one rupee each. At the end of the film the various gems which are found in Ceylon were shown, some of the most outstanding being ruby, sapphire, cat's-eyes, zircon and spinel.

Details of the making of a piece of jewellery were shown and at the end the film returns to the dinner party with a further display of articles of jewellery.

This excellent film is most suitable for showing to a lay audience, and it is hoped that the Association will have a version with English dialogue sometime during the year.

MIDLANDS BRANCH

Mr. Robert Webster gave a talk to members of the Midlands Branch on 11th October, 1960. His subject was " Diamonds and some of their problems ", and he dealt with the many problems that are met with in the jewellery trade. The meeting, which was attended by an unusually large audience, was an excellent start to the Midlands Branch winter programme.

On 25th November, Miss Judith Banister gave an illustrated talk about her recent visit to Japan and the cultured pearl fisheries there.

A visit to the Severn Wildfowl Trust at Slimbridge and to adjoining historic Berkeley Castle provided a pleasant ending to the Branch's summer programme. Slides of this outing were shown to members by Mr. Clay and Mr. Deane at the November meeting.

The Midlands Branch Annual Dinner and Dance will be held at the Medical Institute, Edgbaston, on 22nd March, 1961.

WEST OF SCOTLAND BRANCH

The first meeting of the winter season for the West of Scotland Branch was a film show, held on 20th October, 1960, when the films " Diamond Coast " and " Stars that shine forever " were shown to an audience of members and friends.

TALKS BY MEMBERS

WEBSTER, R. : " Diamonds and some of their problems ", Midlands Branch of the Gemmological Association, 11th October, 1960.

BLYTHE, G. A.: " Diamonds and their substitutes ", Inner Wheel Club, 3rd October; Marlborough Conservative Association, Southend-on-Sea, 13th October; Conservative H.Q., Southend, 16th November, and Southend Business Luncheon Club, 17th November, 1960.

BOWDEN, A. : " Gem Stones ", Plympton Townswomen's Guild, 11th October; Pelynt (Cornwall) Women's Institute, 13th October ; Plymouth Y.W.C.A. Luncheon Club, 2nd November ; R.N. Young Wives, H.M.S. *Thunderer* Plymouth, 22nd November, 1960.

CAFFELL, E. W.: " Gemstones ", Guild of St. Andrew and St. John, Cobham, 11th November; Bracknell Townswomen's Guild, Easthampstead Community Centre, Bracknell, Berks., 6th December, 1960.

VISITORS FROM AMERICA

A welcome visitor to the Association's offices in October last was Richard Liddicoat, Jr., Director of the Gemological Institute of America. His visit gave great pleasure and further cemented the friendship that has existed between the two organizations over the years.

Other welcome visitors were Dr. F. H. Pough, of New York, who kindly presented the Association with a new type of synthetic star-stone and Mr. W. E. Kelley, Lakeland, Ohio, who added to the Association's collection by a generous gift of various opal specimens found in the U.S.A.

GIFTS TO THE ASSOCIATION

The Finnish Gemmological Society has presented the Association with a collection of gems and gem minerals, all of which were found in Finland. The specimens were donated by various members of the Society and some were faceted by them. The Council of the Association is greatly indebted to the Finnish Gemmological Society for the presentation.

The Council also acknowledges the following gifts :—

From De Beers Consolidated Mines Limited a new film about diamonds entitled " The Eternal Gem ", a valuable addition to the Association's film collection.

Mr. J. R. Funrbach, B.Sc. has sent a further collection of gem minerals for student use and Mr. A. V. G. Rao, an article on the Panna Diamond Mining Industry.

Samples of Dallasite, a peculiarity of Vancouver Island, Canada, from Mrs. Rhoda Blyth.

From Mr. R. Webster, a large piece of lapis-lazuli.

Mr. W. E. Kelley, of Lakewood, Ohio, specimens of black opal from Humboldt County, Nevada, including a sample in vesicular basalt, various common opal specimens from the same county and specimens of silica glass " cat's-eyes ".

DIAMOND DICTIONARY

The Gemological Institute of America has just published a comprehensive, profusely illustrated dictionary of the diamond industry.

The Diamond Dictionary represents an effort by the teaching and research staff of the Institute to define every important term relating to the gem diamond. Unlike the usual brief definitions of a dictionary, however, most of the terms are given an expanded explanation and discussion, thus ensuring a full understanding of the subject. Important subjects such as grading and evaluation, market controls, fashioning and cutting styles, properties, mines and mining methods, and grading and testing equipment are explained in detail.

One of the many outstanding features of this 317-page book is the careful consideration that has been given to describing more than 250 of the world's large and notable diamonds, many of which are illustrated, a far greater number than have been treated in previous books. In addition, many industrial-diamond terms and foreign words and phrases are defined and discussed. There are numerous photographs and line drawings illustrating diamond imperfections and cutting discrepancies. It is the conviction of the authors that it will fulfil a long-felt need of jewellers and diamond men in all branches of the industry.

The book is priced at $8.75 (65/-) and may be ordered through the Association of Great Britain.

CORRESPONDENCE

Dear Sir,

Mr. Stores in his " Strange Case of W. J. Lewis Abbott " in the October, 1960, issue of the *Journal of Gemmology*, asks for a few more details about this pioneer of gemmological training. He may be interested to learn that Mr. Abbott was writing regularly for the Watchmaker, Jeweller and Silversmith from 1890 onwards. The issue for 1st December, 1890, contained the following note :

" Mr. W. J. Lewis Abbott, who for some months past has been contributing a series of articles on gems to our paper, has begun a course of lectures on the science of gems at the Horological Institute, on alternate Tuesdays to last through the winter months. . . ." It was added that the hall was full for the first two lectures in November, and that many people " lingered " afterwards to ask questions and to see further demonstrations.

On 1st June, 1891, the name " W. J. Lewis Abbott, F.G.S." appears on the masthead of the W. J. & S. as editor, when he presumably officially took over from Mr. David Glasgow, whose untimely death at the age of 34 was reported in the same issue. Mr. Abbott continued as editor until 1897, and continued writing for the journal even after Mr. Augustus Steward became editor in that year.

Yours faithfully,

Judith Banister.

The Editor,
The Journal of Gemmology.

COUNCIL MEETING

A meeting of the Council of the Association was held at Saint Dunstan's House on Tuesday, 29th November, 1960. Mr. F. H. Knowles-Brown presided and specially welcomed Mr. J. M. McWilliam, representing the West of Scotland Branch.

The following elections took place :—

Fellowship

Beach, Michael L., Twickenham
Burwood, James R., Coventry
Chalcroft, Pamela, Edinburgh
Christophersen, Einar E., Sandnes, Norway
Haigh, David E., Lincoln
Hamara, Pauli, Helsinki, Finland
Heikkila, Heikki S., Helsinki, Finland
Jarvis, John Clifford, Calcutta, India
Kaskimies, Keijo L. K., Helsinki-Munkkivuori
Kraus, Pansy D., San Diego, U.S.A.
Lee, Kenneth A., London
Masters, Christopher R., Blackpool
May, Peter G., Coventry
McMillan, Archibald, Edinburgh
McTurk, George L. C., Edinburgh
Mikkola, Toini A., Otaniemi, Finland
Mortimer, Frederick, Loughton
Norman, Michael S. J., Bath
Nyman, Yrjö, Helsinki, Finland
Øiesvold, Arild, Arnes, Norway
Øiesvold, Odd, Jessheim, Norway
Clay, John J., Leicester
Collins, Christine D., Wolverhampton
Cook, Peter B., Birmingham
Coward, David E., Matlock
Gritzkewitzh, Boris, Helsinki, Finland
Orkomies, Lotta, Roihuvuori, Finland
Parker, George E., Birmingham
Paronen, Tauno K., Helsinki, Finland
Pettersson, Ulf J., Helsinki, Finland
Ranta, Olavi A., Helsinki, Finland
Riley, Philip W. T., Chester
Rufli, Jean C., Stockholm
Scorer, Brian, London
Springall, John Edward, London
Stoodley, Simon A., Alton
Sundqvist, Jalo A. M., Helsinki, Finland
Taylor, Peter G., Hounslow
Turton, George G., Bromsgrove
Waddington, Alfred M., Scarborough, Canada
Wilding, Peter, Liverpool

Ordinary Membership

Bradley, Robert C. W., Didcot
Capps, A. E., Plymouth
Georgiadis, Jack C., London
Goldin, R., Johannesburg
Gould, Henriette, Johannesburg
Keller, Jean P., Lucerne
Kern, Edward E., West Hartford, U.S.A.
Liebman, Arnold, Johannesburg
Lister, John G. C., Uganda, E. Africa
Maunton, Frederick J., Bromley
McChlery, George M. A., Glasgow
Mullen, Joseph, Glasgow
O'Connell, Sean, London
Piper, Robert W., Guernsey
Preston, Iris W., Iver
Rose, Thomas D., Hove
Winner, Frank E., Warner Robins, U.S.A.

Probationary Membership

Angell, David J., Tonbridge
Butler, June I., Waltham Abbey
Butler, William C. F., Paisley
Jones, David W., Sanderstead
Lee, Raymond G., Torquay
Paterson, Andrew, Paisley

Cropp, Alan R., Cambridge
Dayal, J. P., Hong Kong
Halpern, Carlos J., Lisbon, Portugal
Heasman, David J. A., Colchester
Hill, George R., Salisbury
Ranger, Clive J., Bromley
Sealey, Roger M., Totton
Stanley, Edward, Manchester
White, John A., Frome

Transferred from Ordinary and Probationary Membership to Fellowship

Burwood, James R., Coventry
Lee, Kenneth A., London
Masters, Christopher R., Blackpool

The Council gave consideration to a report of an examinations committee on proposed revision of the syllabus of examinations. The committee were requested to present a further report which would take into account the views expressed by members of the Council, instructors and examiners.

The Chairman recalled that recently the National Association of Goldsmiths had congratulated Mr. H. J. B. Wheeler upon completing twenty-five years with that organization. Mr. Wheeler had also served the Gemmological Association and its predecessor for a similar period and the Council placed on record their appreciation of Mr. Wheeler's long service.

HERBERT SMITH MEMORIAL LECTURE

The 1961 Herbert Smith Memorial Lecture will be given by Professor W. F. Eppler, of Munich, at Goldsmiths' Hall, Foster Lane, London, E.C.2, on Monday 24th April, at 7 p.m., instead of 12th April previously announced.

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