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THE appearance of the Journal of Gemmology in its new and independent guise marks a definite turning point in the history of the Gemmological Association of Great Britain. Its examinations have long gained an international reputation, but it is now something more than an examining body ; more and more it is engaging in activities of value and interest to the Fellows and Members. The Council propose, in addition to chronicling their proceedings, to publish from time to time theses which have been successfully submitted for the Research Diploma and possibly other original work. The Association goes from strength to strength ; it is a privilege which I greatly value to have been connected with the movement from the very start, and I hope that it may be my good fortune to aid its progress still further. May the Association continue to flourish !

G. F. Herbert Smith

ALL PEARLS are not what they seem!

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IT has been six years since the writer published his first paper dealing with ways and means of differentiating Japanese cultured pearls from the genuine pearls of commerce ([1], [2], [3]).

Since 1939, several hundred thousand individual pearls have been fluoroscoped, radiographed, X-ray diffractioned and otherwise scientifically tested and examined.

To the layman, a pearl is a pearl. To the scientist, a pearl on examination may prove to be a pearl and then again it may turn out to be something quite different. Pearl testing is no job for an amateur jeweller, or even a retail jeweller who thinks he is an " authority " on pearls. The toughest synthetic ruby or sapphire is easy to determine by any standard when compared to **some** undrilled pearls that have come to the writer's attention.[4]

The Japanese cultured pearl is a good example with which to start. Mineralogists, as well as most dealers in pearls, have come to accept one very salient fact about Japanese cultured pearls, viz., that for the most part these biologically synthesized pearls contain a large, round mother-of-pearl head encased by pearl nacre not over a half-millimetre thick, and that this bead measures from 80-90 per cent. of the total linear diameter of the pearl ([5], [6]). The question has been asked: Are there any Japanese cultured pearls which do not contain round mother-of-pearl beads? Unfortunately for the pearl tester, exceptions do occur.

The writer uses the radiographic method almost exclusively to test pearls ([3]). The round, mother-of-pearl bead of a Japanese cultured pearl is usually well defined on the X-ray film. To cite a case: In 1946, two different pairs of fine quality earring button pearls, all cultured, representing 20 and 30 grains weight each, respectively, were found to contain not round mother-of-pearl beads, but large, **oval** shaped mother-of-pearl beads. Ordinarily, on the basis of the radiographic negative alone, these pearls would have been classified as " genuine." They " looked " cultured, however, and for that reason the request was made to have the pearls removed from the setting so that additional tests could be made. On the basis of non-radiographic tests, the pearls were positively identified as being cultured.

The Japanese use fresh water shell for manufacturing their mother-of-pearl beads. Mussel shells are found sufficiently thick to permit the extraction of large beads. This material has been found to fluoresce under X-ray radiation. The fluorescence is due to the presence of a trace of manganese associated with the calcium carbonate and organic matter of the shell. Until recently, of the thousands of Japanese cultured pearls subjected to X-ray radiation, none had ever failed to fluoresce, and similarly, no genuine Persian Gulf salt-water pearl had ever been found to fluoresce.

In the past several months, however, a few exceptions to this rule have been noted. The pearls in question weighed approximately 20 grains each and were undrilled. The writer had to resort to other tests to determine the cultured character of these pearls. If the Japanese were to use salt-water shell for mother-of-pearl beads, assuming that they could get shells of this kind in sufficient number and of satisfactory thickness, the phenomenon of fluorescence as an **indication** of a cultured pearl would not exist and the ingenuity of the pearl tester would be taxed still further.

And now for another case history. Some time ago, several undrilled fresh-water pearls of three and four grain size were brought to the writer's laboratory. These particular pearls had been pronounced genuine. The writer, using special techniques, found they had been cultured. Further investigation revealed that in truth they had been. The pearl culturist had taken a genuine, one grain fresh-water pearl and placed it in a fresh-water mussel, leaving it there for a period of years to grow. The final product

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[5] A. E. Alexander: *Sci. Am.*, *160*, 4, 228-229 ; 1939.

[6] A. E. Alexander: *Sci. Am.*, *160*, 5, 294-297 ; 1939.

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was a pearl of three or four grain weight. In this particular instance, radiography did not conclusively reveal the thin line of organic matter initially deposited on the genuine pearl insert.

In an earlier paper, the writer described the fine, undrilled fresh-water cultured pearls which were found to contain glass beads as nuclei (2). Pearls of this kind were found to have the same specific gravity of genuine pearls. An X-ray diffraction pattern characteristic of a genuine pearl was obtained from these pearls. Radiography, however, easily detected the glass bead.

Mention already has been made of certain genuine fresh-water pearls which will produce cultured-pearl X-ray diffraction patterns with reasons given for this anomalous condition (1). The problem becomes even more involved when Japanese cultured pearls having very small mother-of-pearl beads measuring 50 per cent. or less of the total linear diameter, yield genuine pearl X-ray diffraction patterns. (Such pearls are very much the exception to the rule, as has been stated before.) This condition results from the fact that the mass of genuine pearl matter greatly exceeds the mass of mother-of-pearl shell matter in pearls of this type.

A fine imitation pearl can cause trouble if a large number of genuine pearls are tested at the same time. Imitation pearls, made of glass, are generally composed of three types: (a) a solid glass sphere ; (b) a hollow glass sphere ; (c) a hollow glass sphere filled with some organic or inorganic material designed to give weight to the pearl. The sphere is covered with a substance usually organic in composition having the appearance of pearl nacre. On occasion, however, a remarkable simulation is achieved with the imitation pearl possessing the " life," lustre and look of a genuine pearl.

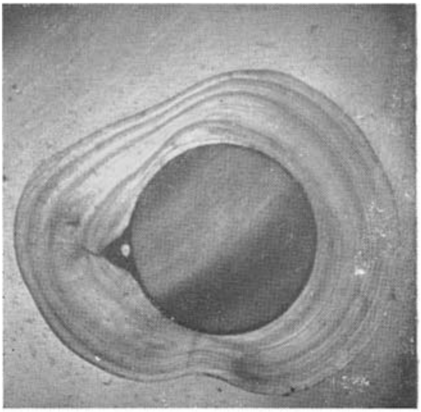
The solid glass bead may be of a variety of glass compositions. If the glass is a lead glass, the radiograph reveals this fact at once. On the other hand, some glass beads have a composition that will yield a shadowgraph identical or very close to identical with that obtained from pearl or mother-of-pearl substance.

Furthermore, if X-ray fluorescence is used as a preliminary test for cultured pearls, the tester must not be surprised to find some imitation pearls fluorescing, with equal intensity. Again, some imitation pearl necklaces that have been submitted to the writer for test produce no fluorescence whatsoever.

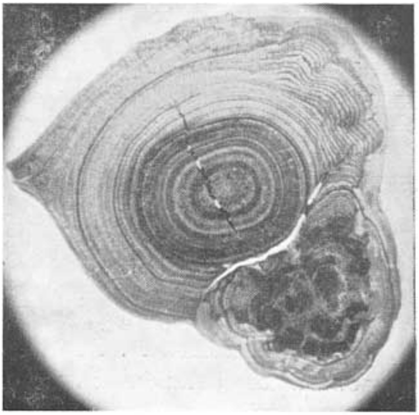
That still other simulations may be forthcoming, as from the field of plastics for example, can be accepted as a foregone conclusion.

SOME PHOTOGRAPHS FROM THE LABORATORY

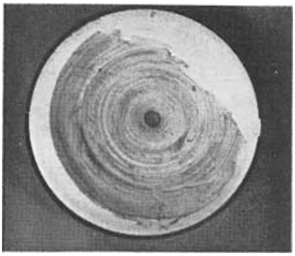
No. 1.—PEARL SECTIONS



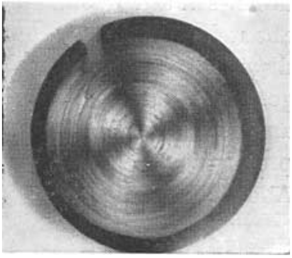
1. *Section of a baroque cultured pearl with an unusually thick skin.*



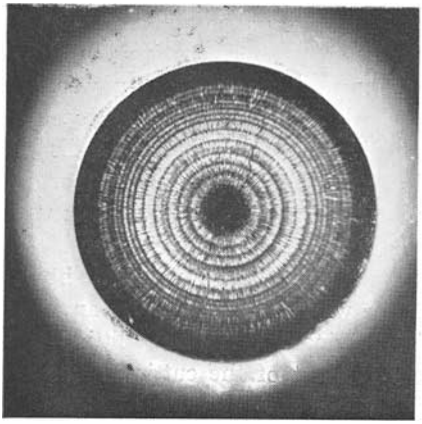
2. *Section of an irregularly-shaped fresh-water pearl.*



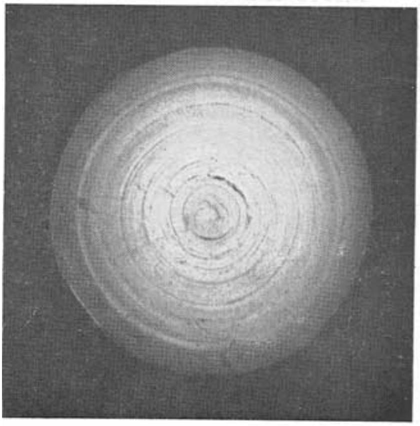
3. *Section of an oriental pearl.*



4. *Section of an oriental pearl viewed between crossed nicols showing the "extinction cross."*



5. *Section of a fresh-water pearl.*



6. *Section of an oriental pearl.*

(Photos by B. W. Anderson, B.Sc., F.G.A.)

Jade Picture

by ELSIE RUFF, F.G.A.

IT is easier to reconstruct a neolithic jade cutter's shop than it is to visualize accurately a contemporary one. And not because it is impossible to prove or disprove the ancient. One is the result of research . . . an aggregation of facts, a logical working out, a corroboration of this and that as experience progresses.

Generally our approach to jade has been a little theatrical. Its symbolism is so complicated and the authorities on the subject so few that we stand in awe of a jade figure. Any jeweller would rather sell a diamond than a piece of jade. He is not even clear about its mineralogy. And while there is hardly a question on diamonds he cannot deal with, there are many on jade that must go unanswered. Yet actually there is little difference between it and our early silverwork. Both the silversmith and the jade carver produced within a religious aura. It was the life of their day. And Buddhism is not much older than Christianity.

To go back-stage to the Chinese jade cutter's shop is to emerge feeling that another illusion has been destroyed and the way once more cleared for unbiased thinking. No limousine will take you there. A rickshaw coolie might jolt you down one of those thoroughfares that are a series of wide shallow steps. Finally you proceed on foot—along some gloomy alley where the cutter's shop will likely be in the dirtiest part. Unless it is exceptional, the shop's machinery will not be electrically controlled. Man-power, on the old treadmill principle, is still the custom. Wooden clogs standing empty—and rather pathetic—at the side of the treadmills proclaim that while bare feet do one job hands are free for another. Almost certainly the shop will be artificially lighted, for little enough daylight can penetrate a hole or two in the wall. If the holes are filled in with glass the glass will be grimy and light that much more reduced. Nor will the whitewashed walls be anywhere near their original white. The Chinamen will wear little—perhaps only slacks—for the climate in most of the cutting areas is warm and humid. A dozen or more men under such conditions, in a space just large enough to take two or three rows of treadmills side by side, is anything but agreeable. By comparison with our modern factories the jade cutting workshops might be described as a dungeon on the alley level.

For jade is a serious business and the Chinaman, if he gets half a chance, a good business man. And men must work and eat and sleep too. Some sleep on the premises of just such a workshop, with bunks, upper and lower, running round the top of the walls. There they breathe the abrasive and human laden air. And there, incredible as it seems, with the noise of the treadmills and the incessant chatter of his co-workers, the jade cutter does sleep. Perhaps it's his only chance of bed-space, a valuable commodity in the East. The workshop may be open from 8 a.m. to 12 p.m., and no trade unions control working conditions. During that period the workers doubtless have some time off and presumably take their turn in the bunks. Yet, despite conditions, the Chinese business man still has plenty of labour to draw upon, experienced and inexperienced only too anxious to learn.

The logical question to ask it: What can a man produce under these conditions? Well, there's a large slab of jade on one of the benches and an almost emerald green gemstone is being marked off for cutting. It is to come from a thin vein of green near the boulder's crust, separated only by a tapering ochre strip. But it will be valuable. The West has a taste for it. Large blocks will presently be marked off that will eventuate as jade figures. Variegated material should give the carver scope for some originality. But as likely as not he will draw on the past, particularly the Ming period (A.D. 1368-1644), for it was a time of great technical virtuosity, though not of spontaneous work. The Mings are credited with having imitated the earlier periods.

It cannot be denied that the jade carver has a realistic contact with the world in which he lives. He is up against it from birth. But good health and vitality—or at least phases of these—are also essential for creative work. And as a third factor there must be some degree of leisure in which to experiment and interpret. Most assuredly the contemporary jade cutter or carver sees his work in terms of rice. And the terms are not easy. An empty bowl is always imminent.

By Norman A. Harper, F.R.G.S., F.G.A.

SCIENCE or EMPIRICISM ?

INFORMED experience is a faculty of considerable value in any walk of life and knowledge gained by experience remains more firmly embedded in the minds of most people, than does knowledge culled from books or acquired at lectures.

Unfortunately, the human senses are not always capable of analysing their observations, with the result that experience is frequently ill-informed, and thus of little value.

For countless centuries men experienced the diurnal journey of the sun round the world, and, having a prejudice in favour of a geocentric universe, never suspected that in reality the rôles were reversed, it being the earth which was the " wanderer."* By means of the scientific method, the measuring, analysing and indexing of experienced observation, it was possible, however, to arrive eventually at this now almost universally known truth.

In every branch of knowledge the scientific method has proved its indispensability, and scientific instruments which measure and analyse human observations have become so numerous that a book† of some three hundred pages is required to describe briefly the forms and uses of the more important of them.

There is still, however, a remarkable disinclination or reluctance among many to use such instruments, or rather to acquire the technique enabling them to be used. This may be due to a mistaken idea that these instruments require a technique that can only be achieved by long and painful practice and study. If this is so, it had better now be stated that while such study is necessary to grasp thoroughly the scientific principles underlying the use, say, of the telescope, much valuable and accurate knowledge can be gained by anyone, completely unversed in the science of optics, who knows which end to place next to the eye.

Few advances in knowledge have had such beneficent effects upon humanity as those associated with medical science, and few sciences can equal it in the number of the instruments to which its practitioners have recourse. The instruments of physics, of optics, of chemistry, of electricity—to all these the physician turns for aid.

It is hard to imagine a doctor without a thermometer, a stethoscope, and a hypodermic syringe, yet it is possible for him purely by experience and the use of his hands to tell whether or not a patient is feverish, or by his unaided ear to hear the rhonchi or râles which mark successive stages of bronchitis ; it is also possible for him to introduce drugs into the body without a hypodermic syringe, but who will deny that the use of such instruments makes these operations so much more accurate and certain, besides their having other uses and a much wider application.

What, one may ask, is the object of this long preamble? The answer is contained in another question. Does the jewellery trade make sufficient use, in the hands of its numerous practitioners, of the scientific instruments which are available for the determination of the nature of the materials in which it deals?

The writer has within the past few weeks encountered three pieces of jewellery in which there were green stones which experience told him were emeralds, and not only his own experience, but the experience of three other jewellers of no mean capabilities, to whom they were shown. By the use of scientific methods and scientific instruments, however, these " stones " were proved to be extremely good imitations. As they were mounted in association with diamonds of considerable value, they might have escaped suspicion had not three very simple scientific tests been utilised to determine their true nature. Needless to say, the results of the investigations were a grave disappointment to their owners, who had vigorously asserted their genuineness.

In such cases the empirical method is generally employed, with the result that the truth is never discovered.

There are few trades where such mistakes can be more costly and few trades where accurate diagnosis is so often necessary. Every purchase from the public (and sometimes even from the " trade ") and every valuation, for whatever purpose, pre-supposes an exact knowledge on the part of the buyer or appraiser of the true nature of the constituent materials of the object to be bought or valued. Yet, in spite of the growing number of competent gemmologists, a census of the jewellery establishments in which a bottle of dilute nitric acid and a smooth faced file were the only instruments available (and in a few enlightened cases, one Chelsea colour filter), might engage a large number of enumerators.

In such establishments it is not possible to differentiate between unmarked platinum and unmarked white gold, or, for that matter, between either of those metals and stainless steel, and even an approximation of the quality of unmarked yellow gold would be with difficulty arrived at.

But when it comes to the determination of gemstones, the difficulties which beset such establishments would cause shivers of apprehension in a gemmologist.

Of course, jewellers in that position can always say that it is possible to " play safe " ; " when in doubt, don't buy "—or sell? " When not sure, allow nothing for the coloured stone." . . . " Buy it as 9 carat (or when it is obviously better than that . . . 15 carat)." But surely that is unethical and dishonest. What would be thought of a doctor who said " I can't be sure whether it is colic or appendicitis, so we had better operate "?

A knowledge of gemmology and the purchase of a little equipment would resolve most, if not all these doubts. In the case of precious metals, the expenditure of a few shillings and an hour of time with Selwyn's " Retail Jeweller's Handbook " are all that is necessary to banish them for ever. Precious stones require a little more attention, but the possession of a few scientific instruments and an easily acquired knowledge of the technique of their use constitutes all that is necessary to transform an empiricist into a scientist, or one who guesses into one who knows.

The cost of these instruments might deter the individual, as it is in the region of thirty to forty pounds, but it should not, under any circumstances, deter a business, or an individual if he happens to be the proprietor of a small business, as this equipment will in a few years pay handsome dividends if used with knowledge and imagination. In any case, the increased confidence to be gained from their use will manifest itself inevitably in more and more successful sales-talk.

" I don't want to turn my showrooms into a laboratory " is a remark occasionally heard, but a consultation in Harley Street will be conducted in the atmosphere of a cultured 18th century salon, with gastroscopes, cystoscopes, and even such a pleasant instrument as the microscope, kept well in the background. No one doubts their existence and possible proximity, however, and the certainty that the consultant will take every advantage in diagnosis they offer, makes his advice invaluable as compared with the advice of the greatest physician of medieval times.

What equipment will benefit the jeweller? Here is a list of instruments in the order in which they should be purchased, in the opinion of the writer:—

1. The Refractometer. (Tully, Herbert Smith, or Rayner.)
2. Heavy Liquids. (Bromoform, Methylene Iodide, Clerici Solution.)
3. Petrological Microscope.
4. The Dichroscope.
5. The Spectroscope. (4 and 5 can be in the form of Microscope accessories.)

The method of their use is fully explained in text-books written specially for the jeweller, but the first essential is a competent knowledge of gemmology.

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* *Planet : Greek.—Planētēs—Wanderer.*

† Scientific Instruments: *Edited by Herbert J. Cooper, B.Sc., A.R.C.Sc.I., A.M.I.E.E. Hutchinsons.*

The Gemmological Association Exhibition

By Gerald Carr

GEMS from every part of the world, many of them so rare that they had seldom or never been seen by the ordinary person, were on display in all their beauty and with all their interest at the first Gemmological Association exhibition to be held in the Hall of the Worshipful Company of Goldsmiths.

On January 8th and 9th, the two days of the exhibition, these gems, some unique, many rare and others costly, delighted the expert eyes of the gemmologist. They looked their best in the settings which had been designed for them as they glittered or revealed their fine markings beneath the twin lighting of electricity and the hundreds of candles in the great candelabra of the Hall. From the spoken comments of the less expert of the visitors it was clear that the exhibition had aroused their enthusiasm, given them a glimpse into new fields of knowledge and almost converted them on the spot to take up the study of gemmology.

Apart from gems and instruments of the Association, leading organisations and firms associated with gemmology contributed their own well presented displays and notable, too, were some of the displays and collections of the Fellows of the Gemmological Association. Many important members of the trade travelled far to visit the exhibition, and I understand that the members of the Design and Research Centre who visited it on the second day were impressed by its scope and variety.

Amid the filled Hall with beauty everywhere, it is difficult to know where to start in reporting the exhibition. But perhaps the diamond, still holding pride of place in value if not in rarity, gives the clue, and this display caught the eye first. Two cases told the story of this and its associated gems with a liberal display of fine diamonds ranging from gems of several carats to mixed melee.

There was a piece of Kimberley blue ground with a diamond embedded in it, and from that the visitor could see the future stages in the production of a brilliant from the rough. They were shown by models, mathematically correct ; by photographs showing stages of the work and by the diamonds themselves.

The models showed the diamond in its perfect octahedral form as mined, then sawn in half and then " bruted " into its round shape. Then the polishing began and following models showed the successive stages from the polishing of the first two pavilion and top facets until all 56—or 57—facets had been done.

Above this were pictures of some of these stages being carried out by the workers, while at eye level where vision could be aided by a magnifying glass, was a wonderful example of this craftsmanship carried out on a fully-faceted gem of only .07 cts. While for contrast by its side was a £7,000 diamond of 7.3 carats.

A section of the Exhibition from balcony

Then in the second case the visitor found that a diamond mine was not wholly composed of diamonds. Many other useful minerals and semi-precious stones were mined, such as bronzite, gypsum, limonite, molybdenite, garnet, olivine and zircon. Examples of these and others were given, but again the attention of most visitors was caught by the groups of diamonds of different varieties, lit from below and including a fine 72 ct. large cape and a 90 ct. large maccle stone in which the lateral division line marking these " two-in-one " stones could be noted.

Neat little piles of diamond wealth made up the other varieties. There were yellow stones and blue, small extra blue maccles, green stones, sand and brown stones and mixed melees.

And naturally, the world's two remarkable diamond finds, the Cullinan and the Jonkers, the latter found only three miles away from the site of the former and both bearing a common resemblance, were not left out of this exhibition. Glass models of the two diamonds were on view, together with models of some of the stones which were cut from the rough.

The Geological Survey and Museum presented a good display of mainly semi-precious stones which included an attractive one of sphene in its different colours and also tourmaline in its multicoloured form. There were also some fine quartz and opal specimens and a lovely blue topaz. The contrast between the rough and polished stones was also underlined with specimens of each.

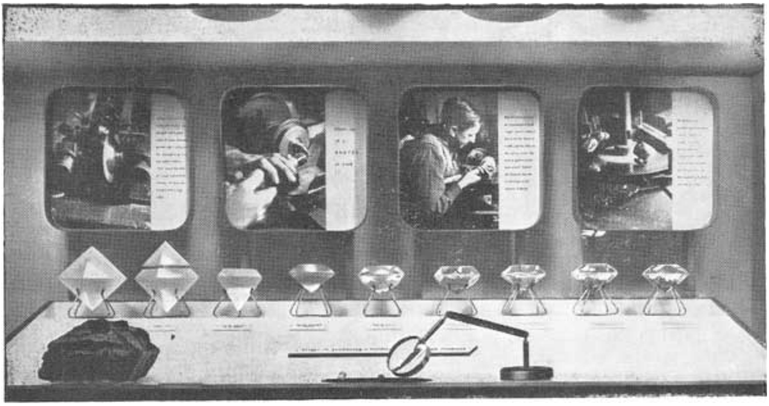
A fine 76 ct. scapolite was also among the display together with a large peridot and a number of those always attractive zircons. Other lesser known stones—as far as the jeweller, but not the gemmologist, is concerned—were danburite, spodumene, orthoclase, apatite and phenakite.

For even more unusual gem stones, however, the gemmologist had not to seek far. They were presented in a profusion which almost seemed to give the lie to the comparative scarceness of many. There was the most recently discovered, Brazilianite, of a yellowish colour and named after the country in which it was found. There was a case of different varieties of sphene and examples of phenakite, cyanite, idocrase and cassiterite.

An exhibit prepared by Thorold Jones, F.G.A.

Here again there was rivalry between the popular and lesser known stones, and the fine 100 ct. " Queen of Australia " opal, glowing with deeply contrasting lights in the forefront of the case, captured a lot of attention. This opal, reputed to be the finest found at Lightning Ridge, had been loaned to the exhibition by the Duke of Devonshire. A number of water opals also made a nice display here, as did a 114 ct. aquamarine. A varied collection of rough and cut stones from the Moguk Stone Tract in Burmas was pleasing and admired by the many Fellows present.

Another case which told the story of the manufacture of synthetic sapphires was greeted like an old friend by many gemmologists who had heard an Association lecture on this subject in the same hall last year. Here, among the modern exhibits, was an historic one of a synthetic ruby made by Fremy in 1890.



Stages in producing a brilliant from a rough diamond

Memories of the Stalingrad Sword were evoked by the stand of Gregory Bottley and Co., who supplied the quartz crystal for the Sword, and who exhibited some lovely varieties of minerals. Here the jeweller and gemmologist met the scientist, for quartz has a new use to-day in timekeeping and radio control. Here, too, the gemmologist was again reminded of the resources, now so much diminished, of his own country. Quartz from Cornwall was there, but in greater quantities was quartz from Brazil.

Another glimpse into the romance of gemmology was afforded by an exhibit of scapolite, discovered by an expedition that tried to find the missing Amazon explorer, Col. Fawcett. An exhibit of cassiterite from Uganda gave visitors a chance to see a very rare stone.

Yet, as if the beauties of these minerals were not sufficient on their own, Mr. Bottley made them take on a new charm as he displayed their fluorescent qualities under ultra-violet light.

This exhibition presented almost as many facets of gemmology as there are to be found on the cut diamond. So it was not surprising to find that Mr. Thorold Jones, F.G.A., showed yet another facet in his presentation of gemmology at war.

Here he showed how gemmology helped to give us the finest sparking plug in the world, adopted by the United States for all their war planes. Corundum insulation was an important secret in these plugs and his exhibit showed by actual examples, by photographs and microphotographs, just how success was gained in this field in producing the now well-known " Corundite " plug.

The visitor, impressed by these microphotographs showing the structure of the material, was even more impressed when he turned from this exhibit to another and realised that such pictures might be taken by a 5s. camera. That was the theme of the display by one of the Fellows, Mr. J. Vincent. They were fine pictures of gems that had been taken with a " Brownie " camera and a 60-year-old microscope. Certainly, as the exhibit suggests, they hold out the prospect of enabling the " thumb print " of gems to be taken for a few pence and the gemmologist is likely to want to know more about this avenue of study.

The evolution of pearl testing was shown with many of the early and original instruments by those leaders in the field, Mr. B. W. Anderson, B.Sc., F.G.A., who has helped so many gemmologists to gain their degree, and his able co-worker, Mr. R. Webster, F.G.A., and Research Fellow of the Association.

R. Webster, F.G.A., demonstrating at the pearl testing stand

The principal of the majority of the testing instruments lay in differentiating between the radial structure of the real pearl and the layer structure of the mother-of-pearl bead in the cultured pearl. Many different means were used in the past to do this, methods which seemed as ingenious as they were practical. Thus there was the magnetic method which registered the interference caused by the bead to the magnetic lines of force. Another used the differing heat conductance of the real and cultured pearls to denote which was which and there was a complicated one using mercury to observe the inside of the pearl through a microscope.

Visitors could try all these and, of course, the modern endoscope instrument, or the inexpert could look at two pearls fluorescing under ultra-violet light and guess which was the real and which the cultured.

It might be thought that the ramifications of gemmology had by then been exhausted, but a new one, " medico-gemmology," to coin a fresh word, was introduced in the exhibit of Sir James Walton, K.C.V.O., F.R.C.S., F.G.A., whose exhibits of fluorspar specimens revealed that some of them had been given him as a result of an operation upon a man who was doing research work on lesions of the lung experienced by quartz workers. The gemmological knowledge of this famous surgeon was of aid in clearing up the difference in the crystalline structure of the quartz. The exhibit, made interesting by the surgeon's notes, included crystals, cut stones and manufactured articles.

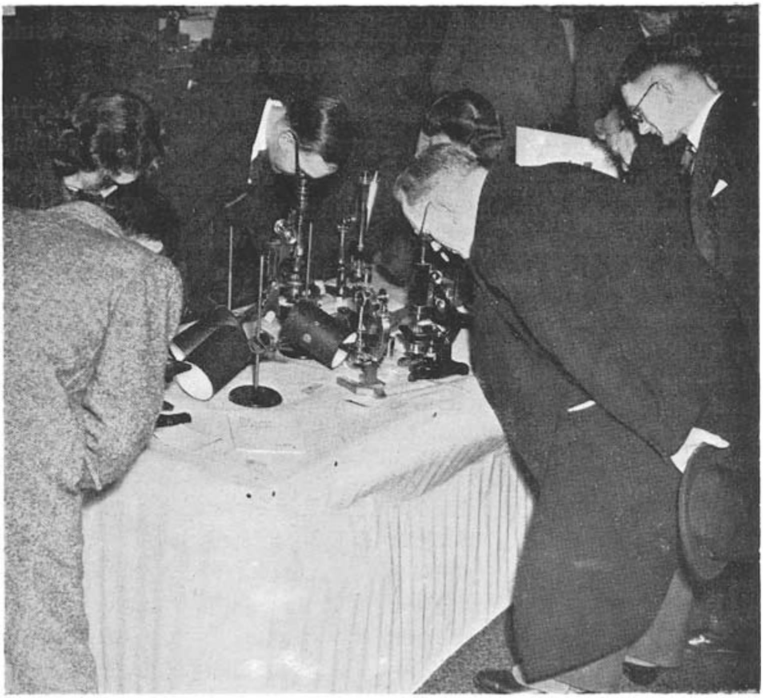
More home produce in the form of the famous Scottish jewels of cairngorm and Scotch peeble agates was to be seen in another display of silica in its various forms, where there were also glass models of the crystal systems of a number of gems, including the rhombic topaz and peridot and the hexagonal corundum, quartz and sapphire.

Nor was ivory and its related materials forgotten. Mr. M. T. Hindson and Mr. E. R. Levett showed a display from the Netsuke collection of finely carved ivories, many of mammoth origin, and there was also carvings on walrus, elephant, hippopotamus and vegetable ivory. This led gradually from some finely fashioned pieces in bone, to celluloid, buttons and modern plastics.

Books on gemmology dating from the 17th century made an interesting display, one especially catching my eye that was dedicated to Cæsar Borgia.

Finally, there was a good display of the tools of the gemmologist—the well-known series of Rayner refractometers ; of spectrometers and dichroscopes, spectroscopes and microscopes, which must have caused a buying urge in many.

Did I write finally? There was one exhibit that seemed to be out in the cold and overlooked by many. It was of a jadeite boulder and it was in the entrance hall, downstairs. Maybe the hard-working gemmologists who were responsible for the finest gemmological exhibition that has ever been seen in Britain were too tired to carry it upstairs!



Viewing inclusions in natural and synthetic stones

By Robert Webster, F.G.A.

Some Aspects of Fraud

VALUE is an essential concomitant of that type of criminal offence which the legal mind terms " stealing by false pretences," and the jeweller trading in precious stones is a fitting target for this type of trickery. The following notes, based on factual reports and personal experiences, may make interesting and informative reading, and may in some measure prevent others suffering loss through the same pitfalls. Although all the episodes mentioned may not have been fraudulently conceived, most would have, or had, the stricture of the law upon them.

Perhaps it would be wise to remark that no trick of this nature would be effective unless some preparation in the way of the gaining of confidence were first engendered. To walk into a shop, place a four carat zircon on the counter and say " I want £700 for this diamond " would not get a rogue very far with the hard-headed business man of to-day ; but with confidence established suspicion is lulled and almost anything may happen. Indeed, it can be given as an axiom that one is never caught except when haste is the " jade," a " breezy " type of personality or a pretty face and a trim figure be the distraction, or when the desire for profit overcomes common sense.

It is fitting that the diamond be the first stone to consider, for that is the gem most handled by the jeweller and the most likely to be the stone whose simulation leads to chicanery. The substitution of a diamond by a paste imitation does not, at first sight, appear a likely cause of loss, for only an **imitation** jeweller would come to grief with this fake ; it is the amateur who falls for a piece of glass. What member of the trade has not heard of the wonderful bargain bought in a public house for a song? Inevitably it is the jeweller who has the unenviable task of supplying the denouement.

Most jewellers have encountered false diamonds which they glibly term " jargoons," " doublets " or " white sapphires," often totally unaware of the correct interpretation of the names they use. In most of these cases the fake has been the colourless zircon which owes its lack of colour to heat treatment and has a high dispersion. Exhibited in a " half-light," such stones do show an appreciable resemblance to diamond—providing one does not look for the strong double refraction. Time and time again these zircons have caught the unwary, often the same operator working the same fraud for months on end until Nemesis finally overtakes him.

The diamond doublet, although so often mentioned, does not appear to be so prevalent as is generally supposed. Of three authentic cases known to the writer, one consisted of a crown of true diamonds and a base of glass ; in another the base was probably rock crystal ; the third, a stone with a two carat spread and mounted with " roman " or " gipsy " setting in a heavy gold ring, caused the jeweller who bought the ring (at dusk, when the light was bad) to lose many pounds. This stone, which the leaders of the jewellery trade considered to be such a dangerous fake that they instituted a " broadcast " caution, was found to have a base of synthetic white spinel.

It is doubtful whether the synthetic white sapphire has ever caused much difficulty, but mention must be made of the artificially produced colourless spinel, if only to comment on the journalistic enthusiasm which caused the " diamond scare " of 1935. These " Jourado diamonds," generally " emerald-cut," a style which was then beginning to be favoured for diamonds, did momentarily cause confusion, but only for the few hours before the report of the Laboratory Experts was published by press and radio. That these synthetic white spinels have not been entirely neglected by the unscrupulous is recalled by the recent conviction of the Dutchman, Winnser, but this was probably more in the nature of substitution than in direct simulation.

Comparatively early in the writer's career he met with the " painted " diamond. Shown a single-stone diamond ring which had been pledged by a gentleman prominent in the theatrical profession, he noticed something " not quite right " about the stone, but lack of experience precluded a definite reason. The opinion of an experienced diamond broker confirmed this suspicion ; he washed the stone in hot water, thereby removing the dye from the rear facets, and returned an off-coloured yellowish diamond instead of the " white " stone submitted to him. The method used to restore the stone to a white colour need not be considered here.

It is questionable whether the inducing of a green colour in a diamond by radium emanations, so easily detected by autophotography and spinthariscopic observation, can be called fraudulent, for, in the case of the heat treatment of zircons and topazes and the staining of agate, the alteration of hue is not considered to be wrong providing the stone is sold as such ; but how often is the radium-treated diamond so sold?

Although having little application to the retail jeweller, the imitation of diamond crystals goes to show to what length the crook fraternity will go in their endeavour to make money by fraud. There have been three authentic cases of " diamond octahedra " which had been found to have been artificially shaped from base material. In two of these cases the material used was synthetic colourless corundum, and for the third case colourless quartz was used.

Most jewellers, knowing all too well the synthetic production of the corundum gems, ruby and sapphire, are wary of dealing with such stones unless they have sound reasons or are backed by a laboratory report, and it is rare that loss is occasioned by such an artifice. That fraud can occur, even with an experienced trader, was made apparent recently when a three-stone ruby ring was bought for some hundreds of pounds, it being discovered later that the most important centre stone was a synthetic.

With respect to emerald, the most likely cause of trouble is surely the composite stone better known as the soudé emerald, but, despite the undoubted fine effect of this counterfeit, the writer cannot recall a single case of fraud involving this stone. The true synthetic emerald which is now being made in America has as yet not invaded this country, and when it does, as surely it will, more care still will be required by the members of our trade.

The painting of the rear facets of pale rubies, sapphires and emeralds in order to enhance their colour is too patent and too well known to cause much difficulty, and the same may be said for the older type of garnet-topped doublets. The imitation of the alexandrite by the synthetic version of corundum and spinel does not now appear to worry the trade as it has done in the past, nor, for that matter, do the opal doublets ; on the other hand, the orange-red synthetic corundum, sometimes called the " padparadscha," is still confused with the fire opal by some people less informed than their neighbours.

Before bringing these few notes to a close, reference must be made to gem pearl, for, although the cultured pearl is so well known and so difficult in some cases to detect at sight, that risk is rarely taken. It is with the black pearl that trouble may occur, for artificial colouration may be particularly good, and, rather surprisingly, that hoary text-book fake, the polished haematite sphere, has quite recently shown itself. What probably was the most unusual fake that the writer came across was a necklace of pink beads, bought as coral, which turned out to be vegetable ivory appropriately stained.

With the spread of the science of gemmology, most, if not all of these tricks should never succeed, and those enemies of society who perpetuate them be for ever put out of their nefarious business —but for the frailty of human nature.

AMERICAN GEM CONCLAVE

The first American Gem Society conclave since the war will be held at the Hotel Stevens in Chicago on March 30th, 31st, and April 1st. Arranged by the International Committee of the A.G.S. under the leadership of Carleton C. Broer, International Chairman of the Society, the three-day session will include instruction in gemmology as well as business meetings of the Society.

The educational programme will, as in previous conclaves, be conducted and planned by Robert M. Shipley, Jr., formerly educational director of the Gemmological Institute of America. Lecturers and instructors will include many prominent educators and Certified Gemmologists, and a special session of advanced gemmological instruction may be arranged for the latter on the day preceding the opening of the conclave.

This conclave will be an innovation in that it will be the first wholly national and international meeting of the Society. In previous years two conclaves have been held each spring, one for members of the Eastern Division and another for members of the Central Division. Because of the greatly increased membership of the American Gem Society, an attempt is being made to provide educational accommodation for 500 members, which is twice as many as pre-war.

American Gem Society, 541, So. Alexandria Avenue,
Los Angeles 5, California.

A Lecture, illustrated by a film, delivered to Fellows and Members of the Association by R. P. Rooksby, B.Sc., F.Inst.P., of the G.E.C. Research Laboratories

SYNTHETIC CORUNDUM

INTRODUCTION

I SUPPOSE the manufacture of precious stones has been an attractive proposition for centuries. Certainly there are several records during the nineteenth century of attempts to make both sapphires and diamonds. I think we have to distinguish these attempts to synthesize crystals, chemically and physically similar to natural ones, from efforts directed merely in imitation of the genuine article.

For a crystal to be valued as a gem stone it should have other properties besides rarity. Rarity is, of course, a prime reason for valuing crystals, but the mineral must have certain other attractions as well.

Clarity, hue, high refractive index for light, and hardness stand out as properties desirable in a gem stone. Of these, hardness is important, because, once cut and polished, or otherwise finished, a jewel should not be easily scratched or blemished. Of natural minerals diamond is the hardest known. Sapphire, though much less hard than diamond, is nevertheless near the head of the list.

For industrial applications we must have chemical stability, but a high value of hardness is a quality that will make a crystal of considerable practical utility. So that, besides the original objective to produce diamonds and sapphires for the gem trade, we have another strong incentive to produce for use in industry. It was not until the beginning of the century that the problem of manufacture of sapphire was solved, and we shall be discussing some of the developments that have taken place since that time.

THE NATURE OF SAPPHIRE

First of all, let us examine the nature of the material we call sapphire. Sapphire, ruby, corundum are all chemically and structurally similar, consisting of the α-crystal form of aluminium oxide. Originally the term sapphire described the characteristically blue and clear natural crystals of alumina valued as gem stones. Corundum was at one time used to describe the less attractive white or opaque forms, but it is now customary to refer to single crystals of alumina of a high standard of perfection as white sapphires.

In the applications with which we are concerned the single crystal character of sapphire stones, whether natural or synthetic, is important. For satisfactory working of the material the perfection of the crystal structure must be high, and stones that comprise a heterogeneous assemblage of crystal fragments are unacceptable.

Blue sapphires and rubies are similar to white sapphires but coloured by the presence of certain specific impurities which enter the crystal lattice.

We find that the hardness of sapphire or corundum is put at 9 on Mohs' scale, higher than, say, quartz at 7, but lower than diamond at 10. One must be clear, though, that this does not mean that sapphire is nine-tenths as hard as diamond, for Mohs' scale is not quantitative, and is simply an old accepted means of placing materials in order of hardness.

Diamond would naturally be the ideal material to use for instrument and meter bearings. However, the hardness of sapphire is adequate for a very long life, and sapphire jewels have an enormous advantage in cost over diamonds. To-day the jewels of watches and the bearings of all good-quality instruments are cut from sapphire, synthetically grown to be crystallographically and chemically similar to the best examples of the natural mineral.

THE VERNEUIL PROCESS FOR THE SYNTHESES OF CRYSTALS OF SAPPHIRE

Our aim, then, is to manufacture homogeneous single crystals that can be subsequently cut and fabricated as required. At first glance we might imagine that the process would not be very difficult. Could we not simply melt the alumina at high temperature in a suitable container and allow it to crystallize slowly during cooling? This does not work. Too many points of crystallization occur, and it is found impossible to prevent the development of a number of crystal nuclei. Then on solidification we obtain a multi-crystalline agglomerate, which, although it may be suitable for some purposes, is certainly unsuitable for the preparation of jewel bearings.

We must endeavour to confine the crystallization to a single point or nucleus, if the product of crystallization is to be a good homogeneous single crystal. It was Verneuil in 1902 who discovered the solution to the problem.

He dropped finely powdered alumina through the flame of an oxy-hydrogen torch on to a refractory support rod. The contact with the rod was reduced to the minimum possible area consistent with mechanical strength. From this point contact, the single crystal was built up very slowly by feeding the powder through the flame in small increments, which were individually melted and merged with the parent crystal.

The basic form of Verneuil's apparatus has not been modified to any great extent to this day. Improvements have been made, so that the crystals that can be grown now are much larger than the small ones with which Verneuil was content, but the principal features are unchanged.

The crystals are called boules, from the French word for " ball," because the original specimens made by Verneuil were spherical in shape.

The finely powdered raw material is held in a canister whose bottom is a 40-mesh sieve ; the container is like an inverted pepper-pot. When the apparatus is in action, taps from a hammer above the canister give it a periodical shake, so that puffs of powder pass through the sieve. Oxygen is fed into the annular space surrounding the container by means of a pipe, and the gas stream carries the powder downwards through a long tube to the furnace. Hydrogen is fed in lower down through a concentric tube and mixes with the oxygen at the jet.

The furnace itself is formed of two specially shaped refractory bricks, small portions of which are cut away to form an inspection window. The powder falls on to a refractory rod or candle entering the lower end of the furnace. This support can be raised or lowered by turning a handwheel.

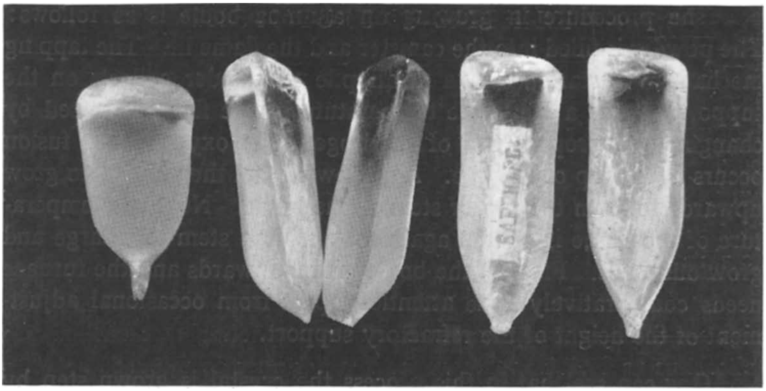


FIG. 1.—*Typical sapphire boules, showing "splitting."*

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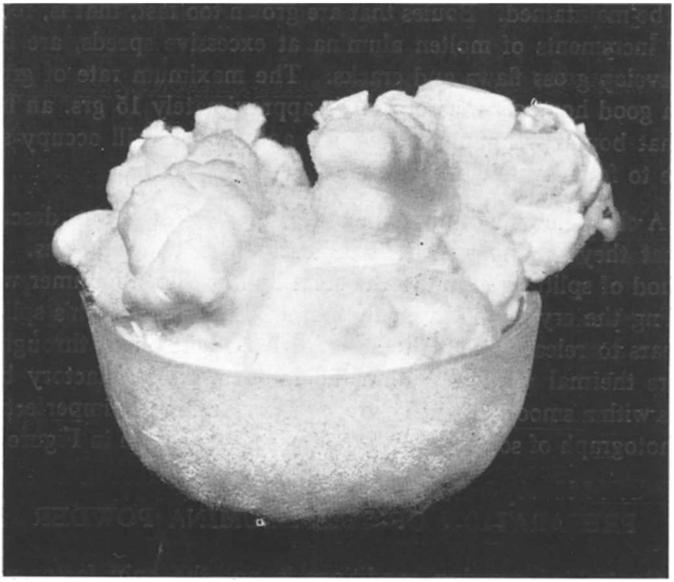

FIG. 2.—***Dish containing γ alumina prepared by decomposition of ammonium alum at 1000°C.***

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The procedure in growing an alumina boule is as follows: The powder is filled into the canister and the flame lit. The tapping mechanism is started and a small pile of powder collects on the support. After a while the temperature of the flame is raised by changing the proportions of hydrogen and oxygen until fusion occurs at the top of the pile. A narrow crystal then begins to grow upwards to form the pip or stem of the boule. Next the temperature of the flame is altered again to cause the stem to enlarge and grow outwards. Finally, the boule grows upwards and the furnace needs comparatively little attention apart from occasional adjustment of the height of the refractory support.

One can see that in this process the crystal is grown step by step by the addition of small increments of molten alumina. As each increment falls on to the growing surface there is an interval before the next increment arrives for the thin layer to assume the structure and crystallographic orientation of the underlying material. Experience shows that there is a maximum rate of growth which must not be exceeded if the homogeneity of the boule crystal is to be maintained. Boules that are grown too fast, that is, receive their increments of molten alumina at excessive speeds, are liable to develop gross flaws and cracks. The maximum rate of growth for a good homogeneous crystal is approximately 15 grs. an hour, so that boules weighing between 45 and 60 grs. will occupy some three to four hours' furnace time.

A characteristic of alumina boules grown in the way described is that they readily split longitudinally into two portions. One method of splitting is to tap the stem lightly with a hammer whilst holding the crystal firmly in the palm of the hand. This splitting appears to release strain in the crystal brought about through the severe thermal gradient within the furnace. A satisfactory boule splits with a smooth surface showing the minimum of imperfections. A photograph of some of these split crystals is shown in Figure 1.

PREPARATION OF THE ALUMINA POWDER

Control of growing conditions is not the only factor which has to be considered in the preparation of good white sapphires. The quality of the powder used has a most profound influence on the quality of the boule.

A powder of irreproachable purity is naturally required, but it must also have special physical properties. For instance, it has to be of low bulk density, and it should have free flowing properties, so that it does not pack down solidly in the container.

The alumina is prepared from ammonium alum crystals by firing in an electric or gas fired muffle furnace at 1,000° C. The charge swells up during firing to a meringue like cake. Figure 2 shows the typical appearance of the fired product. This is anhydrous alumina in the γ crystalline form, and it has a sponge-like texture. The fired product is broken up to powder by a tumbling process.

PROPERTIES OF THE SAPPHIRE BOULE

I want now to refer to some of the characteristics of the sapphire crystals prepared in the way you have seen. We have to consider, for example, such items as crystallographic orientation, perfection of crystal structure, and the presence or absence of flaws.

Dealing first with orientation, this is of importance because of the influence on the wearing properties of finished jewels. As will be mentioned later, the direction of the crystal axes with respect to the bearing surface have a significant effect on the rate of wear. If the orientation of the boule is known, cutting can be devised so as to avoid unfavourable orientations in the finished jewels.

The crystal structure of sapphire can, for our purposes, be thought of as being based upon the hexagonal system. Hexagonal crystals have four axes. Three of these are equal and intersect at 60° to define the base of a hexagonal prism, whilst the fourth is at right angles parallel with the height of the prism. The prism axis is commonly referred to as the optic axis, and it has three-fold symmetry. Its direction in a crystal of unknown orientation can be found by optical means, using polarized light, or by X-rays. The direction of the other axes, which have only two-fold symmetry and are therefore described as diad axes, can only be determined conveniently by X-ray methods. A hexagonal crystal would be completely defined by specifying one of the diad axes and the optic axis.

We have seen that sapphire crystals grown in the Verneuil furnace split longitudinally. It does not appear that this is a crystallographic cleavage ; a principal crystal plane is not normally involved. The split occurs because of strain in the crystal resulting from the manner of growth.

But we do find that the split surfaces invariably contain the three-fold or optic axis. The optic axis lies in the plane of splitting, but, on the other hand, its direction does not bear any steady relation to the growth axis. All angles between 0° and 90° with the direction of growth seem to be found when a number of boules are examined.

It is a particularly lucky freak of fortune that the optic axis is located in this way, since it is this direction that we need to know when we come to make jewel bearings. We shall come back to this point in a moment.

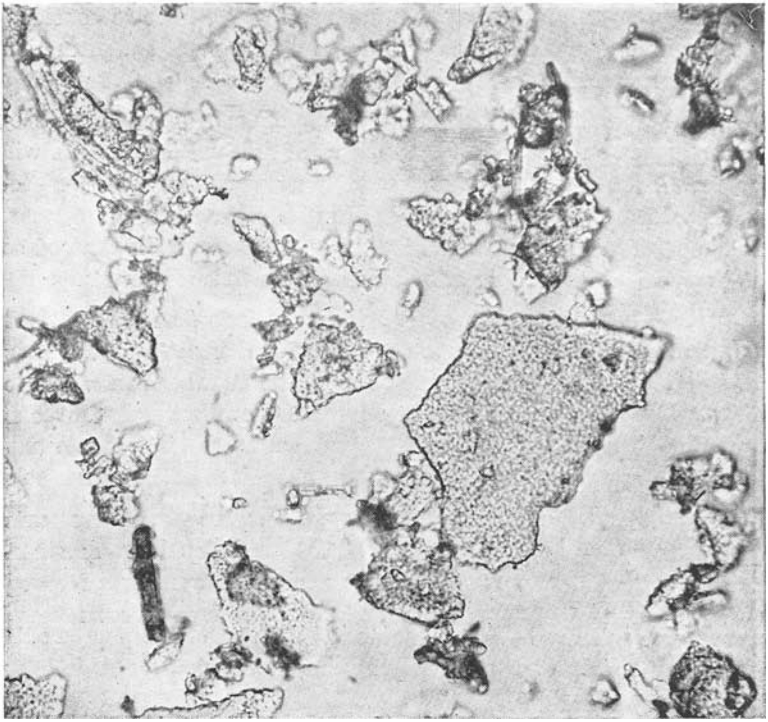

FIG. 3.—*Photomicrograph (x 275) of alumina powder used for synthetic sapphires.*

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The next aspect of the synthesized crystals we have to consider is the perfection or homogeneity of structure. How well does the synthetic boule conform with the single crystal ideal? It is difficult to devise scientifically based criteria of quality, and what is usually done is to base acceptance largely on the perfection and smoothness of the split surface. When the surfaces are rough or irregular and striated the crystals seem to have a greater tendency to develop cracks or other flaws during subsequent processing than when the splits are smooth and even. In bad cases, of course, the boule does not split regularly at all, and is cracked in several places, so that it is quite unsuitable for cutting. This may happen if the rate of growth is excessive, when presumably some discontinuities in the steady development of the single crystal structure have been introduced. Figure 4 shows several half boules in which the varying nature and degree of perfection of the split surface may be observed.

The only other flaws that are troublesome in the synthetic crystal are small bubbles that sometimes develop in parts of a specimen. Gases may be trapped either in the powdered particles passing down on to the growing surface or as the particles merge with the surface. Insufficient refining of the molten alumina before solidification, then, means that a few bubbles may become permanently fixed in the crystal. Although a few bubbles may be tolerated, large numbers are very objectionable as they may lead to flaws in the bearing surfaces of the finished jewels.

CUTTING AND SLICING BOULE FOR INSTRUMENT JEWELS

Now let us pass on to the cutting of the boule for practical use.

The boule is first of all sliced either parallel or perpendicular to the long axis. The slices are then cut again to give pieces of square section. A third cutting operation gives segments of the required thickness. By turning on a centre, rondels or discs are obtained.

The bearing surface now has to be prepared. Originally the recesses or cavities were made by hand, but to-day complete mechanization of the recessing and finishing processes is effected. A wide range of dimensions and shapes is required. For instruments the Vee jewel and the cup jewel are mostly employed, but other designs are utilised for watches.

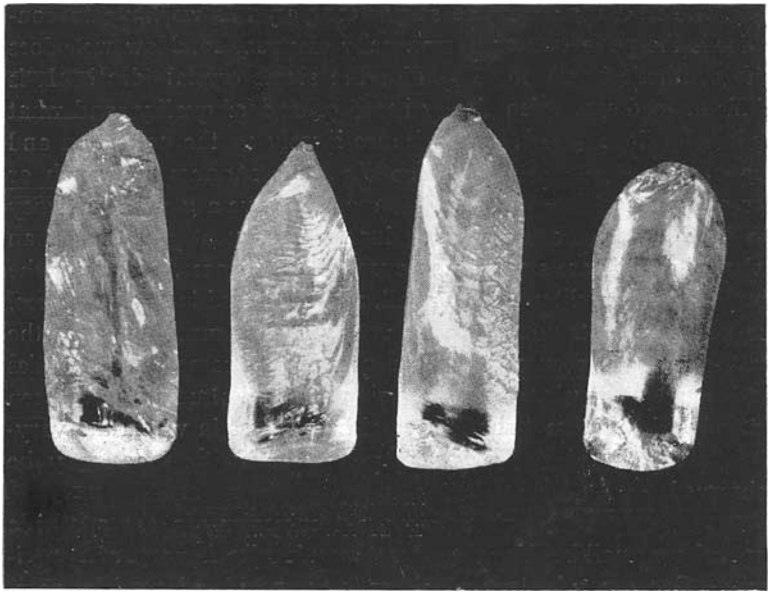


FIG. 4.—*Half boules of synthetic sapphire, showing variations in character of split surface.*

(Reproduced by courtesy of Royal Society of Arts)

One of the most important parts of the recessing operation is the final polishing of the surface on which the pivot runs. The preparation of a highly polished cavity has a profound influence on the wearing properties. Polishing is usually done with diamond dust, which is carefully selected and graded for the purpose.

There is probably quite a deal to be learnt about the structure of the polish layer. For instance, there may well be a difference in structure between a polish layer produced by " flowing " the surface and that produced by mere abrasion. However, there is general agreement that the surface of the recess must be perfectly smooth and free from all flaws and imperfections that can be detected under a microscope.

Another question with which we have to be deeply concerned is the crystallographic orientation in the jewel crystals. Verney Stott, working at the National Physical Laboratory, first drew attention to its importance in connection with the wear on meter jewels. Stott indicated that for maximum wear the orientation selected should be such that the optic axis of the sapphire crystal lay in or near to the tangent plane to the bearing surface. It is a common practice to specify the orientation of meter jewels by the angle between the optic axis and the normal to the tangent plane. Stott's work showed that 90° jewels were the best. 0° jewels would be expected to give a rather poor account of themselves in comparison.

Now why should this be so? Remembering our earlier remarks about the crystal structure of alumina the optic axis is, of course, the C— or prism axis of the hexagonal form. Now it appears that crystal planes parallel to the prism base, i.e. perpendicular to the optic axis, are planes of weakness in alumina. Alumina exhibits what is sometimes called basal parting. This is the most prominent parting. Because of the relatively weak bonding across these parting planes, crystals of alumina tend to fracture along the basal plane rather than along any other crystal plane.

We could thus regard sapphire crystals as having a laminated structure, the laminas being perpendicular to the optic axis, Some diagrams illustrating the form this laminated structure might take in meter jewels of varying orientations are shown in Figure 5. In the 0° case, with the optic axis vertical, the weak planes are in an unfavourable orientation, as the revolving pivot may well tear laminated fragments out of the surface. In the 90° case, on the other hand, the weak planes intercept the bearing surface at a steep angle, and consequently fragmentation is not so likely to occur.

Another aspect of the laminated structure is illustrated in the photograph, Figure 6, of some wooden models representing meter jewels of similar orientations to the above. The form of these models is due to Mr. Shotter, of the North Metropolitan Power Supply Co.

More evidence has been collected since Stott's early work, and it does seem that a specified orientation has to be envisaged as an essential item in meter jewel selection. As it happens, the specification in the case of boule is not really very difficult to meet. This is because it has been found that the optic axis invariably lies in the plane of splitting, and with this as a known consistent direction cutting procedure can be devised so as to ensure a favourable orientation in the finished jewel.

SYNTHETIC SAPPHIRE IN OTHER FORMS

So far we have thought of the synthesis of sapphire in terms of the boule form. But it has to be admitted that for jewel bearings much material is wasted in the cutting processes and these processes themselves are most expensive on such a hard material. If a single crystal of small circular cross-section could be synthesized, the cutting might be reduced to a relatively simple process. A great economy of labour and material would be effected by slicing rondels or discs of the right thickness.

These considerations have influenced development work in both this country and America, with the result that sapphire crystals can now be produced in the form of rod. I must emphasize the point that these rods are just as much single crystals as are boules. It may seem a little strange if we still cling to the conception of crystals with regular external faces and symmetry. But we have to accept the idea that the external form is of little moment, provided the internal make-up in respect of atomic configuration is that of the single homogeneous crystal.

Single crystal rod is grown in much the same way as the boule, furnace size being scaled down to confrm with the narrow cross-section of the crystal being synthesized.

One may ask what about the orientation of the crystal? There is a technique for controlling the orientation aspect of the structure. This is by seeding with a small crystal of the desired orientation and growing the rod on to this. The method has been developed particularly in America, where it is claimed that, with the seed-crystal technique, rods can be grown consistently with the same predetermined orientation.

Not only is the rod form of synthetic crystal an economic form to use for jewel bearings, but, remarkably enough, it can be shaped and bent under controlled heat treatment conditions. It has been demonstrated in America, for example, that the sapphire rod can be drawn to quite small diameters, provided the conditions are carefully controlled. Proper deformation and working of the sapphire rod can, for example, only be done for a limited range of crystal orientations.

Bending and twisting of sapphire rod open up a variety of applications in which the hardness of the sapphire would be a practical advantage. It has been reported that hooks and rings are made for use as fibre or thread guides, these having a much longer

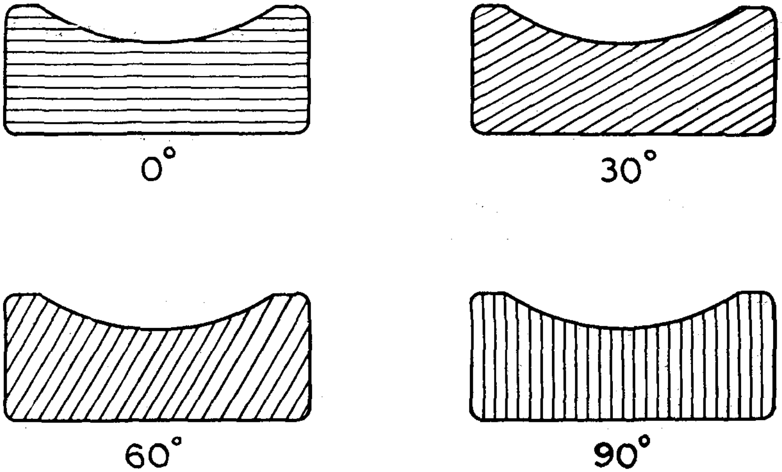


Fig. 5.—*Diagram illustrating "laminated" structure of sapphire jewels of different crystallographic orientations.*

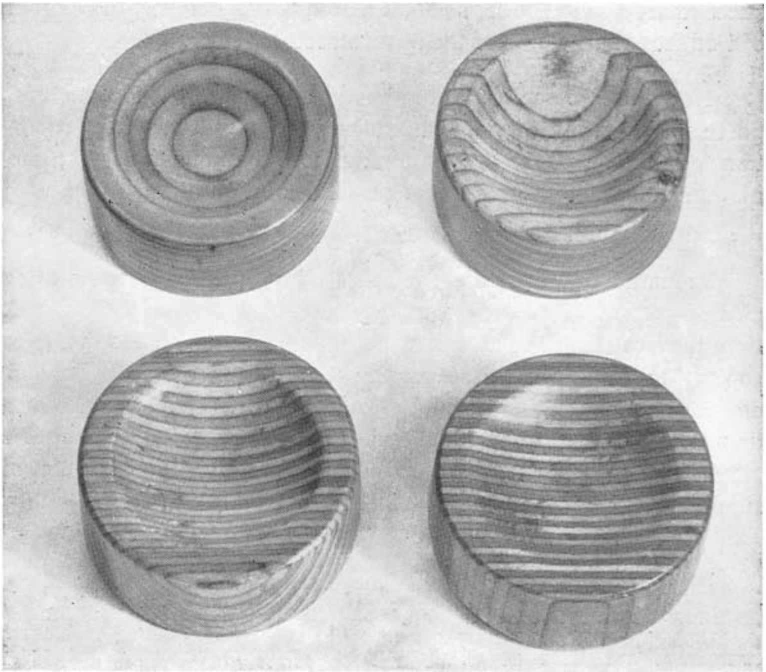


Fig. 6.—*Wooden models of sapphire meter jewels, illustrating changes in direction of "laminated" structure with crystal orientation. The orientations correspond with those in the diagrams of Fig. 10.*

(Reproduced by courtesy of Royal Society of Arts)

life, and less deleterious effects on the fibres than materials previously used.

THE MANUFACTURE OF SPINEL CRYSTALS

There is another crystal that can be prepared by a similar method of growth to sapphire. This is the magnesia/alumina compound known as spinel. Ideally spinel crystals contain equimolecular parts of magnesia and alumina, but, since spinel and alumina are to some extent mutually soluble in one another, the term spinel, when used to describe synthetic crystals, does not necessarily refer to the one-to-one molecular composition. In fact, it is quite common to make spinels containing three or four molecular parts of alumina.

The structure of spinel differs from that of alumina. It is a cubic crystal and magnesium aluminate is the analogue of a whole series of crystals of similar structure. Magnetite, the magnetic oxide of iron, for example, is of the same structural class.

Now the γ form of alumina has ideally a spinel-like structure. So this is probably why we can make spinels with varying proportions of alumina. A spinel containing more than one molecular part of alumina can be looked upon as a solid solution of γ alumina with the conventional $MgO.Al_2O_3$.

Preparation of powder for spinels involves the incorporation of an appropriate amount of magnesia with the alum. One finds that the growth of good spinel boules is a little more difficult to control than the growth of sapphires. Boules tend to become opaque or crack if grown too fast or too large. Spinel boules also do not split as do sapphires. The shape tends towards a rectangular cross-section, instead of the round cross-section characteristic of sapphire.

As regards applications, spinel is appreciably less hard than sapphire, but because of this it is more easily worked. When lower hardness can be tolerated the advantage of ease of working might be worth while. It is also possible that use can be made of a relatively tough crystal which has a complete absence of the crystallographic basal parting characteristic of synthetic corundum.

COLOURED BOULES

Both alumina and spinel can take impurities into solid solution which confer attractive colours upon the crystals. Coloured boule is perhaps mainly valued for gem stone purposes, but there are some practical industrial uses for coloured jewels. For instance, the colour may be wanted because it leads to simple distinction and differentiation between jewels to be used in different parts of an instrument. Watchmakers, too, have a preference for rubies because they are more easily seen than white sapphires.

For gem stones we would want to be most careful and precise about our selection of the exact shade or hue of colour. The gemmologist has very definite notions on the precise hue which is going to be acceptable and attractive. In industrial applications one is, perhaps, less influenced by these considerations, but a good depth of colour is desirable. Red or ruby, and blue, are the most usual colours, though by altering the ingredients it is possible to make alumina and spinel with a whole range of colours, to include red, orange, green, and blue.

In red corundum or ruby the colouring ingredient is chromium oxide, and amounts from about one half of 1 per cent. to 5 per cent. may be incorporated in the alumina powder. We can follow what happens to the chromium oxide by X-ray analysis of the resultant crystal. The chromium oxide forms a solid solution with the alumina, and one measures an expansion of the average interatomic distances.

The method of growth of synthetic rubies follows much the same course as for white sapphire, but generally speaking the size of boule is rather smaller. The best blue sapphire is made with two added impurities, namely, iron oxide and titania. Iron oxide alone gives a green crystal.

Cobalt oxide gives a very strong blue colour in spinels, but gives disappointing patchy effects in alumina. In practice it seems generally easier to make coloured spinels than sapphires, and this is probably attributable to the differences in crystal structure.

CONCLUSION

There, I think, we shall have to leave the story of the syntheses of sapphire and spinel crystals. It is worth remarking that before 1940 synthetic jewel production seems to have been largely in the hands of Swiss, German and French manufacturers. It was following the break with the Continent that we had to ensure the supply of jewel bearings by developing the process quickly. Only by careful co-ordination of research and manufacturing experience was progress made, and it can now be justly claimed that British sapphire boule is the equal of that of Swiss origin.

Manufacture under controlled conditions ensures a consistency of quality and predictability of physical characteristics which would be difficult to obtain in a natural product. This is one of the important features we can claim for the synthetic material, and for practical use in industrial work this is naturally a property of great importance.

Finally, I would like to make perfectly clear to you that I am merely the spokesman of a group of people who have been working on this subject. Without their assistance and generous help this talk could not have been given. May I mention particularly the names of my colleagues Mr. Dauncey and Mr. Chirnside, and for the preparation of the film I have to thank Miss Hobbs and Miss Anthony.

NEW GEM TESTING METHOD

An exact and conclusive method of identifying gem mineral species which is a major advancement in the field of determinative gemmology has been discovered as a result of an intensive research project conducted by staff members of the Gemmological Institute of America in their laboratory.

In the science of gemmology, this discovery is comparable to the introduction into mineralogy of the X-ray powder method which gave to the mineralogist his final and conclusive test. The new X-ray technique of identification of gemstones will determine with absolute accuracy the nature of opaque to transparent gems, whether they are mounted, unmounted, faceted, cabochon, carved or rough, regardless of size.

By a revolutionary departure from old techniques which required reduction of the specimen to a powder, the new X-ray method produces the same results without harming the gem in any way. The discovery will be used especially as a deciding test in cases where previously known methods do not yield conclusive results.

Gemmological Institute of America, 541, So. Alexandria Avenue,
Los Angeles 5, Calif.

Synthetic Sapphire & Spinel Production in Germany

(Extracted from the Final Report No. 355 of the Office of Military Government for Germany (U.S.). The Final Report written by Mr. H. Barnes of the Joint Intelligence Objectives Agency)

1. There are two plants in Germany which produced synthetic sapphire and spinel boules during the war, the I. G. Farben plant at Bitterfeld and the Wiedes Karbid Werke at Freyung. Both plants employ the basic Verneuil process. The details of German apparatus and process have been revealed for the first time, since this information was always held as a strict trade secret before the war.

2. The German sapphire plants depend on highly skilled, low wage labour for their successful operation. The boule growth process is considered an art, and little or no attempt has been made to mechanize the process or to introduce production aids.

3. The Wiedes Karbid Werke boule plant has a capacity of 60,000 carats per day. This plant specializes in the production of spinel boules.

4. While it was not possible to visit the I. G. Farben plant at Bitterfeld, information from other sources indicates that this plant has about 300 burners with a boule capacity substantially greater than that of the Wiedes Karbid Werke. The I. G. Farben plant specializes in the production of clear sapphire and ruby boules.

5. There was never a shortage of synthetic sapphire boules in Germany during the war, but there was a shortage of diamond powder for cutting them. This led to the development of a process for hardening spinel bearings such that their performance approached that of sapphire, and only one-quarter as much diamond was needed for fabrication. Except for this spinel bearing development, no new applications for sapphire or spinel were found that were not known before the war.

6. The German synthetic sapphire and spinel boules are considered inferior to those made in France and Switzerland by the gem cutters at Idar Oberstein.

The only process known for the production of synthetic corundum and spinel crystals of appreciable size was invented by Verneuil about 1902. It is an oxy-hydrogen flame process in which the crystals, or boules, are produced by a layer on layer growth. For 25 years before the war, the world production of synthetic corundum and spinel was centred in Switzerland, France, and Germany. Before the war, the United States imported millions of jewel bearings annually for watches, watt-hour meters, and precision instruments of all types. In addition, the market for semi-precious gem stones of corundum and spinel in America was considerable.

While the general process for the production of synthetic corundum and spinel was known in the United States, details of European plant equipment and process control were closely guarded trade secrets. It was the purpose of this investigation to learn these details of equipment and process as practised in German plants.

It has been found that there were only two plants in Germany producing corundum and spinel by the Verneuil process. They are the I. G. Farbenindustrie plant at Bitterfeld and the Wiedes Karbid Werke at Freyung. The Wiedes plant is in operation and was visited by this investigator. It was not possible to observe the operations of the I. G. Farben plant, but a number of people were interrogated who had access to information concerning the Bitterfeld operations.

DEFINITIONS AND BACKGROUND INFORMATION

Before discussing the specific detailed information gained on this investigation, for purposes of completeness, it appears appropriate to set down here the following definitions and well-known background information relative to the production of corundum and spinel crystals by the Verneuil technique.

A corundum boule is a single crystal of alpha aluminium oxide (Al_2O_3), normally produced in diameters between ½ and 1 inch and lengths from 1 to 2½ inches, usually weighing between 100 and 200 carats (20 to 40 grams). If the boule is coloured red by the addition of .5 to 3.0 per cent. chromic oxide, it is ruby with essentially the same chemical composition as the natural stone. The addition of small amounts of titania and iron oxide results in a blue sapphire crystal. The clear, uncoloured corundum crystal is usually designated as clear or white sapphire.

Synthetic spinel ($MgO : 3.5\ Al_2O_3$) is clear, but may be coloured a wide variety of tints and shades by the addition of small percentages of the oxides of cobalt, chromium, titanium, nickel, iron, and vanadium. Perhaps the most popular coloured spinel stones for gem purposes are the blue and aquamarine, for which the principal colouring oxides are cobalt and nickel, respectively. Other oxides are often added in small quantities to give more desirable shades of these colours.

The basic process for growing corundum and spinel boules is essentially the same in the I. G. Farben and the Wiedes Karbid Werke plants. The powdered oxides are held in a hopper with a fine mesh screen bottom. Tapping the hopper causes the powder to be fed intermittently into the oxygen stream and carried down through the central tube of a diffusion type oxy-hydrogen burner. Hydrogen is fed to the flame through an annular passage surrounding the central oxygen-powder tube. The tip of the oxy-hydrogen burner discharges the flame into a cylindrical ceramic furnace, usually split down the middle for easy opening and with a small rectangular slot in one side for viewing the boule during the growth process. The boules are grown on a ceramic pedestal, centred in the refractory furnace, and supported by a table with vertical screw adjustment.

At the start of the boule growth process, the powder feed rate is adjusted somewhat higher, and the flame intensity lower than for steady boule growth conditions. A fritted mass is built up on the end of the pedestal, and soon a single crystal begins to emerge from the mass if the flame conditions are favourable. By careful control of flame intensity, this single crystal is made to grow out of the sintered mass until it is about the diameter of a matchstick and $\frac{1}{4}$ to $\frac{1}{2}$ inch long. At this point the flame intensity is increased and a small ball is made to form on the end of the rod, which is progressively broadened to resemble a mushroom. When the diameter is increased to that desired for the boule being grown, the growth conditions, including powder feed, flame intensity, and boule lowering rate, are adjusted to give a uniform diameter cylindrical section. These steady conditions are maintained until the boule is of the desired length, and then the growth process is abruptly stopped. As a general rule, the clear stones are easier to grow than the coloured ones ; and the greater the amount of colouring agent added, the more difficult is the fusion and the greater probability of the boule cracking when the flame is shut off at the end of the growth cycle.

WIEDES KARBID WERKE—PLANT ORGANIZATION

The boule plant of the Wiedes Karbid Werke is located at Freyung in the Bayrischer Wald. Hydroelectric power is available, and an electrolytic plant consisting of two 250 KW cells furnishes the necessary oxygen and hydrogen for boule production. The hydrogen capacity was said to be 4,000 cubic metres per day. Boules have been produced in this plant for 20 to 30 years. The plant was shut down by the Allied Forces on April 27th, 1945. Operations were resumed on a limited scale on October 27th, 1945, by a contract agreement between American and French Military Governments. This agreement provides that aquamarine spinel boules be grown at Freyung and shipped to Idar Oberstein in the French Zone for cutting into gem stones.

POWER PRODUCTION

The alumina and alumina-magnesia spinel powders used as starting materials in the boule process are prepared by the calcination of aluminum ammonium sulphate and magnesium ammonium sulphate. These alums are purchased from Merk in Darmstadt and usually are of satisfactory purity as received. However, occasionally it is necessary to wash the alum crystals in a centrifuge with distilled water before they are sufficiently pure for boule purposes. No purity standards or tests are applied to the alum except the actual making of a boule from a calcined grab sample of the material.

Spinel powder is prepared by the mixing by hand of 729 grams of magnesium ammonium sulphate with 6,075 grams of aluminum ammonium of sulphate. This was said to give a ratio of $MgO:3.5$ Al_2O_3 in the finished powder. The mixed alums are calcined in quartz dishes in the same manner as the sapphire powder except at a slightly higher temperature. As in the case of the ruby powder, the spinel colouring agents are added to the alum in each quartz dish just prior to calcination.

The calcining furnace in the Wiedes plant is coke fired and contains six full muffles made of silicon carbide. The muffles have a hearth space of 78 cm. x 44 cm. and an arched roof with a maximum height of 25 cm. A single thermocouple in the back wall of the central muffle is used for temperature control. Each muffle will accommodate a charge of 8 quartz dishes.

After cooling, the alumina in the quartz dishes is in the form of a light friable cake which is dumped into steel drums for transfer to the screening room. The powder is brushed through brass screens (approximately 65 mesh per cm.) with rotating bristle brushes. Wooden hoppers feed the powder to the screen. The powder is then ready for use in the boule burners. No special aging or humidifying treatment is given to the powder to improve its flowing properties.

BOULE APPARATUS

A concentric two-tube diffusion-type burner is employed with a water-cooled skirted tip, having an inside diameter of 3 cm. The oxygen-powder tip has a diameter of 4 mm., and the water-cooled cast iron skirt extends beyond this tip for a distance of 6 cm. The overall length of burner is 30 cm.

The powder hopper is 8 cm. in diameter and 20 cm. long with a 30 mesh per cm. brass screen on the bottom. The hopper is supported from a phosphor bronze diaphragm, which is sufficiently flexible to transmit the tapper blow to the hopper. The casing enclosing the hopper is 10 cm. in diameter and 42 cm. long, the bottom half being in the form of a conical approach to the central oxygen-powder tube.

The bottom of the water-cooled burner tip is just flush with the top of the high alumina refrectory furnace in which the boules are actually grown. This furnace is split into two halves with tongue and groove joint to permit opening for easy access to the finished boule. A vertical slot 5½ cm. long and 1 cm. wide is provided for viewing the boule during the growth process. The furnace is 16½ cm. high with an outside diameter of 14 cm. and an inside diameter of 4 cm. The life of these furnaces was said to be about 18 boule growth cycles, after which they are too badly cracked and the inside wall is melted down. The furnaces are purchased from Marktredwitz at a cost of 1.30 Reichsmark per pair of furnace halves.

The boule burners and furnaces are mounted with clamps to an angle iron frame, 17 burners in a row with a space of about

18 inches between burners. There are twelve such banks of 17 burners each in the plant, making a total of 204 burners. When operating at maximum capacity, only one-half these burners are actually used to grow boules at any one time. The remaining burners are in the process of cooling down from a previous run or are being serviced. Powder is added to the hoppers after each three boules. The individual tapping hammers for dispensing the powder from the boule hoppers are actuated by a camshaft running the length of the burner bank. This camshaft is driven by a variable speed DC motor with rheostat control. Individual mechanical adjustment of the tapper height, and hence the powder feed, is provided for each boule burner. A simple manual screw adjustment is employed to raise and lower the boule in the furnace.

Oxygen and hydrogen are fed into the individual burners from a gas header made of 3-inch pipe running the length of the boule bank. Each burner is provided with needle valves on the oxygen and hydrogen lines for individual adjustment of gas flows. However, it is the present practice to control an entire bank of 17 burners by master valves on the gas headers rather than by the individual burner needle valves. The needle valves are used only as metering orifices for balancing the gas flows of the various burners. The oxygen and hydrogen are supplied to the boule banks at a pressure of approximately 10 cm. H_2O by means of belt-driven rotary compressors.

BOULE PRODUCTION

The operations in the Wiedes boule plant are dependent upon highly skilled, low wage labour. The entire process is manually controlled with practically no effort being made to mechanize any phase of the operation. For example, no metering devices are used for setting the burner gas flows which are regulated manually by a rather crude valve on the gas headers for each bank of 17 boules. The adjustment depends on the judgment of the " melter " as he looks at the boules being grown. Balancing of the gas flows to individual burners by the small needle valves to make all boules grow under identical conditions is also left to the judgment of the melter without the aid of any gas metering device. About one year is required to train a boule melter, provided he is capable of learning the art at all. Each melter develops his own individual system of control, and no two melters employ the same.

When operations were at their best, the capacity of the plant was 60,000 carats per 24-hour day. This figure, which includes cracked boules as well as first quality ones, is considered poor by this investigator for a plant with 204 burners. At the present time, because of the lack of skilled operators and an insufficient quantity of alum, the plant is making only about 40,000 carats per 24-hour day. On aquamarine spinel (90 per cent. of the production now), the following data on growth conditions were provided:—

Boule size	150 to 200 carats
Boule growth time	4 to 5 hours
Cooling time in furnace ...	$\frac{1}{2}$ to 1 hour
Tapping frequency	60 to 80 per minute
Hydrogen consumption ...	4 cubic meters per hour
Hydrogen-oxygen ratio ...	2 to 3
Overall powder utilization ...	60 per cent. approximately

The average size of the ruby and sapphire boules made in this plant is only 80 to 125 carats. The growth time for boules of this size was said to be about $2\frac{1}{2}$ hours with a first quality yield of 50 to 60 per cent. The above yield figures apply only for 1.3 per cent. Cr_2O_3 ruby and clear sapphire.

INSPECTION, GRADING AND SELLING

Boules are inspected with a bright incandescent lamp in a darkened hood. No liquid immersion or other means is used to minimize surface reflection. All boules are placed into one of three grades with no special regard for boule size. Corundum boules are always split before inspection by pinching the foot with a pair of pliers. Boules are graded in the Wiedes Karbid Werke corundum plant according to the following standards:—

First Quality—Boules which show no major cracks and which are free from cores, feathers, and large bubbles. Minor cubic foot cracks in spinel boules are common and acceptable in this classification.

Second Quality—Boules which exhibit cores, feathers, and bubbles, but which do not have major irregular cracks.

Third Quality—Badly cracked boules irrespective of their internal quality.

In normal good operation, the yield of boules is 60 per cent. first quality, 20 per cent. second quality, and 20 per cent. third quality. At the present time, the entire production of the plant, about 40,000 carats per day, is being sold to Gebrüder Kaucher, the plant representative in Idar-Oberstein. Since resuming operations two weeks ago, the wholesale price of boules (lots greater than 25,000 carats) has risen 50 per cent.

I. G. FARBENINDUSTRIE AT BITTERFELD— PLANT OPERATIONS

Fortunately, Dr. Konrad Schad in Höchst was using a boule burner from the Bitterfeld plant for a special research which will be discussed in detail later. This burner is quite similar to the Wiedes burner, the principal difference being that the I. G. Farben burner does not employ a water-cooled skirt. The ceramic furnace used experimentally by Dr. Schad was improvised from an ordinary clay crucible and obviously did not represent boule plant practice. The ceramic boule support for the I. G. Farben apparatus was mounted on a rotating table. However, Dr. Schad insisted that this feature was used only for centring the ceramic pedestal at the start of the operation and the boule was not rotated while being grown.

Alum for calcining to alumina is purchased from Merk in Darmstadt. The purity of this material as received is satisfactory for making ruby and clear sapphire, which are the principal products of this plant. Very little spinel is produced. The alum is calcined in two-litre fused quartz dishes at a temperature of 1,000° C. for eight hours, according to Dr. Schad. While ruby boules can be grown from powder containing as much as 5 per cent. Cr_2O_3 in the alumina powder, the standard ruby powder contained between 1.2 and 1.5 per cent. C_2O_3. The Cr_2O_3 was added to individual dishes of alum in the form of a sulphate solution just before calcination.

The best information indicates that the Bitterfeld plant has approximately 300 boule burners with a production several times that of the Wiedes Karbid Werke. According to Dr. Konrad Schad, boules of about 200 carat size are grown in four to five hours.

It was the opinion of Mr. Richard Bohlenger that the ruby boules made at Bitterfeld were not equal in quality to those made in the Swiss and French boule plants.

SPINEL JEWEL BEARINGS

The most interesting work on jewel bearings found in Germany was related to this investigator by Dr. Wilhelm Eppler. Since 1942, Dr. Eppler has been working with Dr. Maucher and Prof. Kaden at the University of Strasbourg on the problem of minimizing the use of diamond powder in the production of jewel bearings.

Since spinel has a Mohs hardness of 8 as compared with 9 for sapphire, it is much easier to work and requires considerably less diamond powder to fabricate than sapphire. However, the lower hardness makes spinel somewhat less satisfactory for jewel bearings than sapphire. Dr. Eppler has developed a process for hardening the synthetic spinel after the spinel bearings have been fabricated through all the steps except the final polish.

The spinel hardening process depends on the fact that synthetic spinel contains a considerable amount of excess alumina held in solid solution " in the gamma form," according to Dr. Eppler. On heating the spinel to a temperature of 950 to 1,050° C. for 12 hours, " part of the excess alumina is precipitated and converted to an alumina form intermediate between gamma and alpha." The clear spinel stone is made quite cloudy by this treatment, and at the same time the hardness is measurably increased. Heating to a higher temperature (above 1,075° C.) was said to result in conversion of the excess alumina completely to the alpha form accompanied by a weakening of the stone structure and the destruction of all the desirable properties obtained by the lower temperature treatment. After the jewel bearing is heat treated, the final polishing of the bearing surface is effected with diamond powder in the usual manner. While coloured spinel can be used for bearings and can be improved in performance by the heat treating process, it is considered inferior to the clear material and is not recommended by Dr. Eppler.

According to Dr. Eppler, he has made extensive comparative tests on sapphire, spinel and glass bearings. A sand blast wear resistance and hardness test was devised from which the following comparative performance index was obtained, based on loss of weight of a standard polished sample:—

Quartz	100
Clear Spinel	400— 600
Heat Treated Spinel	1,400—4,500
Sapphire	2,000—3,800

Vibration tests made on instruments with sapphire, heat treated spinel, untreated spinel, and glass bearings gave results which indicated that the heat treated spinel bearings were equally as satisfactory as the sapphire ones ; the untreated spinel bearings were not acceptable but were better than the glass bearings. The elasticity of spinel was said to be 30 to 40 per cent. greater than that for sapphire.

The heat treated spinel bearings were tested by Paul Backes and Degussa. Both companies found the bearings satisfactory and comparable with sapphire, according to Dr. Eppler. However, only the Paul Backes company actually made the bearings in production. About 900,000 heat treated spinel bearings were made for airplane instruments in the last year of operation of the Backes plant. A diamond powder saving of 75 to 80 per cent. was made by the use of spinel instead of sapphire. Dr. Eppler indicated that Degussa would have produced heat treated spinel bearings had it not been for pressure by I. G. Farben, who make sapphire and practically no spinel boules.

Dr. Eppler stated that all of his records and reports on this development had been taken from Strasbourg by the U.S. Army in May or June of this year.

GEM STONES

Before the war, gem stones of synthetic corundum and spinel were cut in large quantities at Idar Oberstein and at Hanau. However, according to Dr. Willi Holstein, who is head of the Chamber of Commerce at Idar Oberstein, no gem stones have been cut there in the past four years because of the lack of boule stock and diamond powder. Diamond powder is still very scarce, and for this reason, the limited gem stone cutting now being done is confined to spinel, which requires a minimum of diamond for cutting. Spinel can be rough cut with silicon carbide and can be finished polished with aluminum oxide. Diamond is required only for grinding the facets on the stones and rough polishing them.

It is interesting to note that a large part of the production of the Wiedes Karbid Werke boule plant during the war was in coloured boules for gem stones. This would indicate that there was never a shortage of sapphire for jewel bearings in Germany during the war. Why the major part of the coloured spinels made by Wiedes were cut in Czechoslovakia instead of at Idar Oberstein or Hanau could not be ascertained.

As far as could be learned, there have been no major improvements in the methods of fabricating gem stones from corundum and spinel. The stones are all cut by hand and the quality depends entirely on the artistic ability of the worker. Most of the facet work is done by eye, requiring the development of a high degree of manual skill. Diamond impregnated horizontal copper laps are used almost universally for shaping and faceting the stones. Tin and other " secret alloy " soft laps with very fine diamond powder or alumina are used for the polishing operations.

NEW SAPPHIRE AND SPINEL APPLICATIONS

Except for the heat treated spinel jewel bearings, no new applications for synthetic sapphire or spinel were found in Germany which were not known before the war. As far as could be learned, sapphire has not been used for plug or ring gauges in Germany. While the value of sapphire and spinel as a thread guide material was recognized, practically none of these guides were fabricated in Germany. No new applications for corundum as a wear resistant surface or for optical uses were found.

No evidence was found that the German plants had developed corundum or spinel in rod form, such as is now being made in the United States. It was the opinion of all persons interrogated, including Dr. Wilhelm Eppler, that corundum in rod form in small diameters would be of no value because it would always split down the middle and lose its cylindrical shape. The Germans apparently are not aware that a corundum rod in the order of one-tenth inch in diameter has been developed in the United States which does not split.

A Summary of the
RESEARCH THESIS

by Robert Webster, F.G.A.

Entitled: "AN INVESTIGATION INTO THE PROPERTIES OF IVORY ; THE MATERIALS USED IN ITS SIMULATION, AND INTO METHODS WHEREBY THEY MAY BE SEVERALLY DISTINGUISHED."

IVORY is described as the body substance of the teeth of all mammals, and, for commercial purposes, that material obtained from the tusks of the elephant ; from the hippopotamus ; from the walrus ; from the narwhal, and to a lesser extent from the tusks of the boar and the teeth of the cachelot whale.

The structure shown by visual inspection and by the examination of thin sections, illustrating the undulatory character of the fine canals, were found to give some evidence of the origin of the ivory. The hardness (about 2½ Mohs) was ascertained by scratch and hardness indenter methods. The low refractive index (mean of 1.53) is ascribed to the organic content of the substance and the density was found to differ in respect of the ivory from the elephant and mammoth (1.70 to 1.85) from that of the coarser textured material from the other animals (1.85 to 2.00). Micro-chemical tests for the presence of calcium and phosphate and other chemical and flame tests are indicated.

The substances used in the simulation of ivory are discussed with reference to their structure, physical and optical characters and in their reaction to chemical reagents in order to compare these with the corresponding properties of the genuine material. Among the substances discussed are bone, deer horn, vegetable ivory and those materials of artificial nature termed " plastics."

The summing up describes suggested methods whereby the different materials may be distinguished from each other using the data obtained from the investigation, and illustrated by a series of original photomicrographs showing the various types of structure, assisting a fuller understanding. The thesis concludes with a short list of references.

The
DIAMOND INDUSTRY
in 1945

(Extracted from the Jeweler's Circular-Keystone.)

IN its 2,500 or more years of existence, the diamond industry has never had such a prosperous year as 1945. Production reached an all-time peak, some 14,250,000 carats, the decided increase over recent years being due to marked up-turns in output of crushing bort in the Belgian Congo and of gem stones in the Union of South Africa. Notwithstanding this, stocks were further depleted by the fact that the Diamond Trading Company's sales of rough were £24,500,000, a figure never before attained. Demand, for the fourth successive year, greatly exceeded production, and hereafter diamond cutters and users of industrial diamonds must look largely to current production for their raw product, and wholly so far as some sub-types of it are concerned.

Sales of cut diamonds, in the United States at least, also were of record proportions, due to high wages during the war and to accumulated wartime savings and, during the past four years, to the American stock market boom.

Wholesale prices of industrials did not advance, although it is rumoured that the quality of shipments deteriorated somewhat due to depleted stocks ; prices of rough increased, and retail prices of cut diamonds have never been higher, although not out of line with other commodities.

Shares of diamond mining companies on the London Stock Exchange showed a gain of 17 per cent., an increment scarcely commensurate with the long-term outlook of the industry.

The diamond cutting industry continued its growth, largely through the remarkably rapid revival of the Belgian industry. There are now over 26,000 cutters widely scattered over the world. The industry is geared too high for the amount of gem rough which presumably will be available, and much unemployment is likely to result.

Prices of both cut stones and diamond shares temporarily dropped, with the German collapse, presumably because optimists inferred that there would immediately be a larger supply of consumer goods and an immediate restoration of international economic stability. When it was realized that neither of these inferences was correct, diamond prices snapped back. Inflation still looms ; hence the gem diamond continues to have its normal investment position, due to its proved value through the years, its ease of transport, and its international market.

The British Empire for over 75 years has had the dominant position in the diamond industry, and is likely to retain it for many years to come. She is not, however, too content to have it rumoured that she may lose administrative control of two of her minor producers, South-West Africa and Tanganyika Territory, both mandated areas. In the first, among the white are a certain number of irreconcilable Nazi sympathizers ; in the second, only loyal British colonists. The Union of South Africa does not propose to give up its mandate over South-West Africa, but the British Government has voluntarily offered to relinquish its 25-year-old mandate over Tanganyika Territory, a position which receives little support in South African diamond circles.

Early in 1945 the Anti-Trust Division of the Department of Justice of the United States brought an anti-trust suit against certain diamond producers and selling companies.

World War II established for the industrial diamond a place in the sun. In 1945, while improvement of diamond-set tools were made, no new uses were developed. With the end of the fighting, many war contracts were cancelled, but nevertheless imports of industrials are holding up satisfactorily. Year by year, the differentiation between the gem and the working diamond is strengthened. Henceforth different subsidiaries of the Diamond Corporation are to handle the sale of gem and industrial diamonds.

Now that the war is over, the industry may be congratulated on the fact that at no time during the war were the United Nations short of one of the most important of strategic minerals, the industrial diamond, without the use of which no important munition of war was made ; nor was the industry subsidized, nor did it sell its product under a premium price plan. Further, all industrials were sold throughout the war at pre-war prices.

The future of the industry is bright. Producers now have two products to sell, of first importance, gem stones, and of somewhat less importance, industrials. Stocks are depleted and demand exceeds current production. Unlike most mining industries, capacity was not greatly increased during the war and further plants now being installed can scarcely come into production for some three years. At worst, enough gems, particularly the smaller sizes, the bread and butter of the trade, should be sold to make the trade reasonably prosperous for some years. Further, with to-day's economy, if I see it rightly, many will have money to buy small diamonds who never did before, and at some future date China, Russia and many other countries may once again buy diamonds. Moreover, the producing companies are financially in a strong position and can, if necessary, ride out a normal depression.

ROUGH MARKET

The Diamond Corporation purchases in normal times 95 per cent. of the world's production in dollar value, indeed all production except part of that of Brazil, British Guiana, Venezuela and of some of the South African alluvial diggers. These stones its subsidiary, the Diamond Trading Company, sells to brokers and cutters. The Diamond Corporation has £5,000,000 in ordinary shares, 80 per cent., it is understood, being owned by De Beers and 20 per cent. by Consolidated Diamond Mine of South-West Africa. The Diamond Trading Company's capital (£3,000,000) is wholly invested in rough diamonds and as sales are made the proceeds are re-invested in rough. The Diamond Corporation's report is available only to its stockholders but the firm pays in good years, it is understood, handsome dividends. (1944 Diamond Corp., 10 per cent., and Diamond Trading Co., 12½ per cent.)

The main office of the Diamond Trading Co. is at Kimberley, but while sales are made there to the South African trade, its more important sales agency is in London. From mid-1942 until recently the company was under order of the Diamond Controller of Great Britain, but since the war's end this control, with others in the British diamond market, has doubtless been eliminated.

As late as 1934 total sales of the Diamond Trading Company were only £3,719,242, a year of depression in the industry and one in which few industrial diamonds were sold. More recent sales follow:—

Year	Total Sales	Gem Stones	% of Total	Industrials	% of Total
1939	£5,865,000	—	—	—	—
1940	6,144,314	—	—	—	—
1941	7,414,420	£5,500,000	74	£2,000,000	26
1942	10,694,671	6,250,000	59	4,240,000	41
1943	20,400,634	14,973,000	73	5,428,000	27
1944 (Est.)	17,000,000 +	13,000,000	76	4,000,000	24
1945 (About)	24,500,000	19,600,000	80	4,900,000	20 +

Sales in 1945 reached an all-time peak ; indeed, sales would have been larger had the company been in a position to offer more goods, as at most of the sights customers' needs could not be satisfied.

Stocks continue to decrease and that of the Corporation is low. Each year sales are more and more from current production. Sales in 1945 largely exceeded production (Sir Ernest Oppenheimer values gem production at £16,000,000 yearly) and it is doubtful whether 1946 sales will be as great as those of 1945, although higher prices, especially for industrials, may keep the value of sales from decreasing too markedly. For the next two years no increase in production can be expected.

During the year the Corporation extended all of its purchasing agreements with the producers, which expired at the end of the war.

The increases in prices of rough during the year, Sir Ernest Oppenheimer stated, are less than the increases of the index of commodity prices in the United States and South Africa and future price increases will not exceed such figures.

During the year the Diamond Trading Company was split into two companies, one under the original name to handle gem stones ; the second, Industrial Distributors (1946), Ltd. (capital £1,000,000), registered in Pretoria, to deal in industrials. The producers are the principal shareholders in the new company, although Anglo-American Investment Trust has an interest. Mr. Otto Oppenheimer is managing director. The price of industrials will be based on the value of each grade to industry and will be wholly uninfluenced by gem price fluctuations. Assortment will be according to uses in the industry. It will be remembered that to assist the United Nations prices of industrials were reduced just before the war and no price increases occurred during the war.

During 1945 the Diamond Trading Co. held a number of " sights," most of them gem grades. The quantity offered was disappointingly small, largely because the Corporation's stocks were becoming depleted, although partly because of a shortage of sorters. Due to stock shortages, quality, it is rumoured, fell somewhat. Many " askers " left with only a small part of their needs supplied. In the February, 1945, sight prices were some 8 per cent. over those of November, 1944. The lucky bidders were able, immediately after the sights, to re-sell their diamonds at a mark-up of as much as 19 per cent., it is said.

During the war, the old London office of the Corporation (8, Charterhouse Street) was destroyed by bombs ; it is now in St. Andrew's Building at the very centre of the diamond merchants' quarter.

In April industrials were sold. Retail prices of industrials were raised previously thereto, in expectation of appreciably higher prices for roughs.

Rough prices since before World War II, say November, 1939, to February, 1945, have increased, according to one merchant, appreciably on first quality goods, 1 to 13 carats about 120 per cent., while second quality stones have doubled in value. The advance for 1-carat to 5-carat stones has been from 135 to 160 per cent., that of 8-carat stones only about 100 per cent. The advance in rough under 1 carat has been appreciably less.

SYNTHETIC DIAMOND ATTEMPTS

Due to a shortage of industrial diamonds, German scientists during the war carried on extensive researches as to the production of synthetic diamonds (Guenther, P. L. ; Geselle, C., and Rebentisch ; Zeitschr Anorgan e. allgem Chemie, Vol. 99, 1943, pp. 357, 72. Excellent digest Industrial Diamond Review, Vol. 6, February, 1946, pp. 42-46). In summary, the possibility of diamond synthesis is discussed ; Moisson's experiments were repeated and improvements thereof tried, with disappointing results. Further, graphite and coal blocks were heated in about 6 seconds to a temperature of 3,000 deg. C. and then exposed to a pressure of 1,707,000 lbs. per sq. in. ; failure resulted.

WORLD PRODUCTION

For the sixth year, because of the war, even fairly accurate figures of world diamond production are not available. The 1945 figures are necessarily in part estimates, but the total, 14,257,157 carats (3,129 short tons), is probably a close approximation. The value at the mines was some $64,750,000. Caratage and value were respectively some 21 per cent. and 35 per cent. greater than the 1944 figures (revised value for 1944, $48,000,000). Of the total, gem rough made up about 18 per cent., a less percentage than last year because of the large produtcion of crushing bort by BCK, a Belgian Congo producer. By weight, some 5,125 pounds were industrials and 1,130 pounds gem stones.

The Belgian Congo was the leading producer, by weight (72.7 per cent.), but, because much of its production was crushing bort, it represented only 13 per cent. of the value of world production. On the other hand, the British Empire, which accounted for only 19.2 per cent. of the weight, represented 71 per cent. of the value.

The South American producers (Brazil, Venezuela and British Guiana) accounted for 2.09 per cent. of the world's production by weight and 9.6 per cent. by value.

Compared with 1944, the Belgian Congo increased its production, by weight, 38 per cent. The South African pipe mine production increased markedly, thanks to greater activity at the DeBeers mines. While Premier and New Jagersfontein are being reopened, they can scarcely get into production for two years longer. South African alluvial production increased appreciably. Tanganyika Territory continued its gain in production and, in consequence, DeBeers sent representatives to look over the field. The Venezuelan production continued to decrease, and that of Brazil probably was less than in 1944.

The following table shows, as accurately as available statistics permit, world production for the past four years.

Production, 1942-45, by Countries, in Metric Carats
(Including Industrial Diamonds)

	1942	1943	1944	1945
Africa:				
Angola	791,850	794,980	800,000	786,000
Belgian Congo	6,018,236	4,881,000	7,540,000	10,386,000
French Equ. Afr.	*20,000	*20,000	*5,000	*5,000
French W. Africa	1,500	35,000	*60,000	*60,000
Gold Coast	*1,000,000	*1,000,000	*1,000,000	*500,000
Sierra Leone	*850,000	*850,000	*700,000	*800,000
South-West Afr.	56,420	88,000	154,000	156,000
Tanganyika	41,000	52,998	90,667	115,666
Union of St. Africa:				
Mines	—	175,885	639,000	878,713
Alluvial	118,821	126,444	270,000	262,527
Total	118,821	302,329	909,000	1,141,240
Brazil	*300,000	*275,000	*370,000	*275,000
British Guiana	22,208	18,272	13,911	17,251
Other Countries**	40.836	29,650	34,000	15,000
Grand Total	9,260,781	8,347,239	11,676,578	14,257,157

* Estimated.
** Includes Venezuela (12,769 carats) ; Borneo, India, New South Wales, U.S.S.R.

(Reprinted from the Jewelers' Circular-Keystone.)

TEXTBOOKS ON GEMMOLOGY

Now available :

" Practical Gemmology," by R. Webster, F.G.A.
New and revised edition, 1946 (published by N.A.G. Press, Ltd.). Price 10s. 0d.

" Key to Precious Stones," by L. J. Spencer, C.B.E., F.R.S. (Blackie & Son.) Price 7s. 6d.

" Gems and Gem Materials," by E. H. Kraus, Ph.D., Sc.D., and C. B. Slawson, Ph.D.
Fourth edition (1941), (McGraw-Hill). Price 17s. 6d.

To be published shortly :

" Gemstones," by G. F. Herbert Smith, M.A., D.Sc.
New and revised edition, 1947. (Methuen & Co., Ltd.)

" Gem Testing," by B. W. Anderson, B.Sc., F.G.A.
New and revised edition. (Heywood & Co., Ltd.)

" Gemmologists' Compendium," by R. Webster, F.G.A.
New and revised edition. (N.A.G. Press, Ltd.)

Orders for the above books may be sent to The Gemmological Association.

R.I. Determination by the shadow method

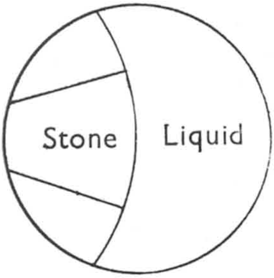
by
Lt.-Col. G. M. SPRAGUE
A.M.I.Mech.E., F.R.G.S.

THE purpose of this article is to describe a method of working which, though not met with in the standard textbooks on gemstones, nevertheless gives excellent results and is very easily applied. It is particularly useful when, as at present, refractometers are scarce. It is also available for stones which are cut en cabochon or for uncut stones which are too rough for examination with the refractometer. The method is described in textbooks on Mineralogoy for use with small grains of sand, but may be applied equally well to large stones. All that is required is a simple microscope without substage or condenser and a set of suitable liquids of known R.I.

Unlike the Becke test, which is described in most textbooks on gemstones, the shadow method works best with low power, say 2 ins. or 1 in. Ample working distance is therefore obtainable.

The procedure is as follows:—

The stone to be tested is made to rest on its table facet or any suitable surface, and is placed in a glass bottomed cell in a liquid of known R.I. The microscope is then focussed on the bottom edge of the stone, which is illuminated by means of the mirror to give as far as possible even illumination of stone and liquid (Fig. 1). A card is introduced above the mirror and below the stage and is moved in towards the edge of the stone as seen through the instrument (Fig. II). As the card moves, a shadow will appear on the side opposite to that from which it is put in and will move across the field. Now comes the test. If the stone has a higher R.I. than the liquid, darkness will develop all round the edge of the stone while the liquid around it is still lighted up (Fig. III). If, however, the stone has a lower R.I. than the liquid, the reverse will be the case, and the edge of the stone will remain light whilst the liquid all round is in shadow (Fig. IV).



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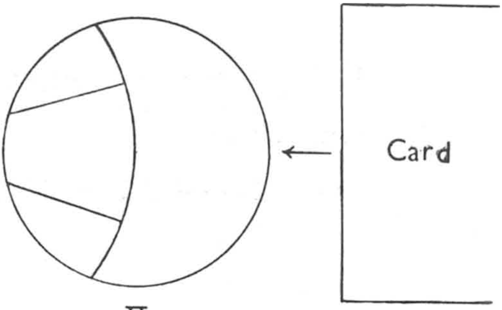

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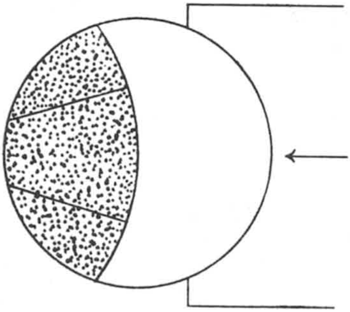

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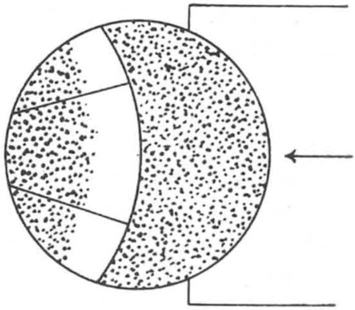

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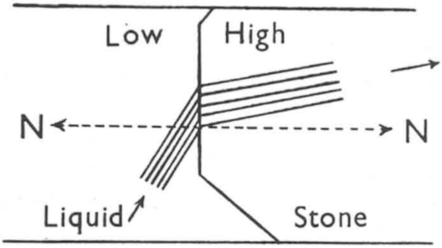
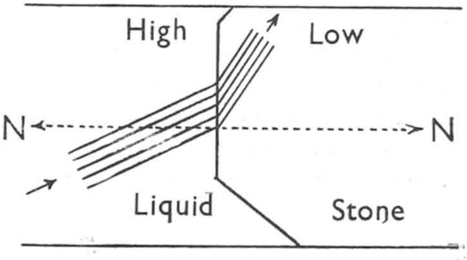


(a) Rays spread out by refraction on entering stone.

V



(b) Rays concentrated by refraction.

In both the above cases, if the card is put in from the opposite side the effect is reversed, i.e., if the stone showed a shadow in the first instance it will now show brightness.

The description may perhaps sound a trifle complicated, but the method is simple to use and after it has been tried once or twice will be performed without difficulty.

If the R.I. of the stone approaches that of the liquid to within, say, 2 or 3 units in the second decimal place, it will be found that a blue fringe will appear at the edge of the stone nearest the card. If the card be inserted from the opposite side, a red fringe will be seen at the edge of the stone, the shadow effect, of course, being reversed as before (i.e., if the stone showed in the first instance a shadow with a blue edge, it will now show brightness fringed with red).

Usually, as with testing in liquids for S.G., it will be sufficient to determine limits between which the R.I. must lie. A suitable set of liquids for this purpose might include Bromoform (R.I. 1.59), Monobromonaphthaline (1.66), Methylene Iodide (1.74) and Meth. Iodide saturated with sulphur (1.79). These will be found sufficient for all normal work in conjunction with other tests.

If complete accuracy is required, monochromatic light must be used. A method of obtaining this is given on page 21 of B. W. Anderson's excellent book, "Gem-Testing for Jewellers." Two liquids, one of R.I. above and one of R.I. below that of the stone are mixed until no shadow effect can be observed, the shadow passing across the field in the same way as if the stone were not there. Incidentally, the stone should now, of course, be invisible in the liquid except for such impurities as it may contain. The R.I. of the liquid will then have to be measured by refractometer or otherwise, so that there is little point in going to the trouble of mixing the liquids except in cases where the stone has no flat polished surface to allow of direct measurement by the refractometer.

For those who are interested in the why and the wherefore of such phenomena it may be explained that the effects described above are caused by the fact that a ray of light is bent towards the normal when travelling from a rarer into an optically denser medium. The effect of inserting the card is to cause the illumination to fall obliquely on the surface joining the stone and the liquid (Fig. V). If the stone has the higher R.I. the rays are spread out by refraction and so lose intensity on entering it. A shadow is therefore produced at the edge of the stone. If, however, the stone has a lower R.I. than the liquid, the rays will be concentrated by refraction and brightness will be produced, giving the opposite effect. The side on which the light falls is, of course, the side of the stone away from the card, but the microscope reverses the image so that the effect is seen on the side which appears nearest the card. It can be shown that the same effect is produced when the surface joining the stone and liquid is oblique instead of vertical, which explains why the method works well with any shape or size of stone.

The colour fringes are due to the relative dispersions of the stone and the liquid. Where these are seen, it is certain that the two R.I.s are close together. It is usually obvious which is the higher if one examines the edge with the card inserted first one side and then the other. The brightness may be more marked than the shadow effect, or vice versa, depending on whether the R.I. of the stone for red or for blue light is closer to the R.I. of the liquid.

Official Notices *(Continued.)*

MEMBERSHIP

Fellows and Members who may be aware of former members whose contact with the Association has lapsed during the war years, are requested to submit names to the Secretary of the Association.

GIFTS TO THE ASSOCIATION

The Council acknowledges, with deep appreciation, the following gifts and donations:—

£50 0s. 0d.—B. W. Anderson, Esq.
£26 5s. 0d.—M. Crombie, Esq.
125 gem mineral specimens—G. F. Andrews, Esq.
Gabochon Almandine Garnet (283 carats)—A. J. Fox, Esq.
Specimen of Tiger's Eye—Gems of the World, S. Africa.

MEMBERS' NOTICES

WANTED.—Good cut specimens of (a) light yellow fluorspar, (b) pink or red fluorspar, preferably table cut.—Ref. G/1.

OFFICIAL NOTICES

AWARD OF RESEARCH DIPLOMA

The Council of the Association, upon the recommendation of the Examiners, has awarded a Research Diploma in Gemmology to Mr. Robert Webster, F.G.A., for his thesis entitled " An investigation into the properties of ivory and of the materials used in its simulation, and into methods whereby they may be severally distinguished."

In his thesis Mr. Webster has studied a subject which has hitherto received little systematic attention. His work contains the record of much original research, and for the first time the physical properties of the natural substances which rank or pass as ivory and of their plastic imitations have been systematically determined and compared with one another.

MEMBERS' MEETING

Notice is given that a Meeting of Fellows and Members of the Association will be held on Thursday, 27th February, 1947, at 6.30 p.m., in the Hall of the **GEOLOGICAL SOCIETY OF LONDON, BURLINGTON HOUSE, W.1.**

The Meeting will be followed at 7 p.m. by short lectures and discussion on selected gemmological subjects.

LECTURE

It is hoped to arrange a lecture, illustrated by lantern slides, entitled " Gemstone Inclusions," to be given by Dr. E. Gubelin, Ph.D., F.G.A., C.G., of Lucerne, Switzerland, some time in March. Further details will be announced later.

1947 EXAMINATIONS IN GEMMOLOGY

The 1947 Examinations in Gemmology will be held in June.

PROVISIONAL DATES :

Preliminary Examination—Wednesday, 25th June.
Diploma Examination (Theoretical)—Thursday, 26th June.
Diploma Examination (Practical)—Friday, 27th June.

Examination entrance forms may be obtained from the Association's offices.

ENTRY DATES :

Overseas candidates—no later than 15th March.
Provincial candidates—no later than 10th May.
London candidates—no later than 24th May.

Candidates overseas should make early application, in order that arrangements can be made. Where proper facilities are available the Diploma practical examination may be taken oversea.

All candidates are required to qualify in the Preliminary Examination before sitting for the Diploma Examination.

ENTRY FEES :

Preliminary—£1 1s. 0d.
Associate—£3 3s. 0d.
Diploma (Fellowship)—£3 3s.0d.

All enquiries in respect of the Examinations should be addressed to the Director of Examinations, Gemmological Association of Great Britain, Audrey House, Ely Place, London, E.C.1.

THE EXAMINATIONS

The Association's Examinations in Gemmology are held normally in June of each year. Candidates are admitted for examinations at the discretion of the Council.

PRELIMINARY EXAMINATION

Theoretical papers only. A certificate is awarded to qualifying candidates. Entrance fee: £1 1s. 0d. The Examination may be taken provincially or abroad by arrangement.

A prize of books, to the value of £3 3s. 0d., is awarded annually to the candidate submitting the best papers in the examination which, in the opinion of the Council and Examiners, are of sufficiently high standard to merit the award.

DIPLOMA EXAMINATION (Fellowship)

Theoretical and Practical papers. A diploma is awarded to qualifying candidates (subject to their having qualified in the preliminary examination). The Diploma Examination is held normally in London, but may be taken provincially or abroad, provided that proper facilities are available. Entrance fee: £3 3s. 0d.

The " Tully Memorial Medal " is awarded to the candidate submitting the best papers in the Diploma examination which, in the opinion of the Council and Examiners, are of sufficiently high standard to merit the award. In addition to the award of the medal, the " Rayner Prize," a refractometer presented by Messrs. Rayner & Keeler, Ltd., is awarded to the winner of the Tully Medal.

The " Anderson Prize," a spectroscope presented by B. W. Anderson, Esq., is awarded to the candidate submitting the best papers in the practical examination, subject to the papers being of sufficiently high standard to merit the award.

Successful candidates in the Diploma Examination may be admitted as Fellowship Members of the Association.

ASSOCIATESHIP EXAMINATION

Open only to candidates who, having passed the Preliminary Examination, are unable to sit for the Fellowship Examination for reasons acceptable to the Council and Examiners. The examination, which may be taken in London, provincially or abroad, consists of theoretical papers of Diploma grade only. Entrance fee: £3 3s. 0d. Associates may qualify for Fellowship by passing practical examinations of Diploma grade subsequently. Entrance fee: £1 1s. 0d.

The practical examinations for Associates must be taken at the normal date of the examinations.

Syllabus of Examinations

I.—PRELIMINARY

1. Crystallography.

Nature of crystals. Crystal systems.

2. Physical Mineralogy.

Hardness, cleavage. Specific gravity ; its determination by hydrostatic weighing and approximate determination by heavy liquids. Reflection, refraction, total-reflection, double refraction. Refractive index ; its determination by refractometer. Colour, lustre, sheen, opalescence, iridescence, asterism, chatoyancy, dispersion, dichroism.

3. Elementary Use of Apparatus.

Refractometer, dichroscope, lens, " Chelsea " colour filter, balance.

4. Description of Gem Materials.

(*a*) NATURAL GEMSTONES. Chemical and physical properties of—beryl (including emerald and aquamarine), chrysoberyl (including alexandrite), corundum (including ruby and sapphire), diamond, garnet family, jade, quartz (including chalcedony), spinel, topaz, tourmaline, turquoise, zircon.

(*b*) SYNTHETIC AND IMITATION STONES. Synthetic corundum and spinel ; composite and paste stones.

(*c*) ORGANIC PRODUCTS. Native, cultured and imitation pearl ; their formation and structure ; base system of calculating the value of pearls. Amber.

5. Fashioning of Gemstones.

Styles of cutting.

II.—DIPLOMA

1. Crystallography.

Crystal morphology and habit. Crystal structure. Isomorphism and isomorphous replacement.

2. Physical Mineralogy.

Specific gravity ; its determination by hydrostatic weighing and by heavy liquids (advanced technique). Estimation of weight. Optical properties of crystals. Refractive index ; its measurement by refractometer and by other methods. Polarized light. Colour and its artificial alteration. Interference and diffraction of light. Spectroscopy and absorption spectra. Luminescent and electrical properties. Application of X-rays to gem testing. Inclusions and other internal features.

3. Advanced Use of Apparatus.

Construction and use of—refractometer, dichroscope, spectroscope, spectrometer, microscope (including polarizing type), endoscope, balance.

4. Description of Gem Materials.

(*a*) NATURAL GEMSTONES.

(i) Chemical and physical properties, mode of occurrence and localities of—beryl, chrysoberyl, corundum, diamond, feldspar family, fluor, garnet family, jadeite, lazurite (lapis Lazuli), nephrite, olivine, opal, quartz (including chalcedony), sphene, spinel, spodumene, topaz, tourmaline, turquoise, zircon.

(ii) Chief chemical and physical properties of—andalusite, apatite, axinite, azurite, benitoite, calcite, cassiterite, cordierite, danburite, diopside, enstatite, epidote, haematite, idocrase, kornerupine, kyanite, malachite, phenakite, prehnite, pyrites, scapolite, smithsonite, sodalite, variscite.

(*b*) SYNTHETIC AND IMITATION STONES. Synthetic corundum, spinel, and emerald. Composite and paste stones ; plastics.

(*c*) ORGANIC PRODUCTS.

(i) Native and cultured pearl ; their formation, structure and occurrence, and methods of distinguishing them. Imitation pearl.

(ii) Amber, coral, jet ; ivory, tortoise-shell.

5. Fashioning of Gemstones.

Cleaving, slitting, cutting and polishing. Machinery used. Styles of cutting.

INSTRUCTION CENTRES

LONDON

Chelsea Polytechnic, Manresa Road, S.W.3.

Evening lectures and practical work. Preliminary, Diploma and post-Diploma Courses. Senior Lecturer: Mr. B. W. Anderson, B.Sc., F.G.A. Junior Lecturer: Mr. T. G. Jones, F.G.A. Assistant Lecturer and Demonstrator: Mr. R. Webster, F.G.A.

Courses commence in September each year. Prospectus and enrolment forms may be obtained from the Secretary of the Association.

BIRMINGHAM

Jewellers' and Silversmiths' School, Vittoria Street.

Evening Lectures. Preliminary Course. Lecturer: Mr. N. Harper, F.G.A., F.R.G.S. Details may be obtained from Principal of the School.

EDINBURGH

Heriot-Watt College.

Evening courses of Preliminary grade. Lecturer: Mr. D. Ewing, F.G.A. Details may be obtained from the Principal of the College.

CORRESPONDENCE COURSES

The courses cover Preliminary and Diploma work. Enrolments must be made in August and September of each year. The courses are conducted by the Association's official Instructors, Mr. B. W. Anderson, B.Sc., F.G.A., and Mr. C. J. Payne, B.Sc., F.G.A. Full particulars may be obtained from the Secretary of the Association.

RESEARCH DIPLOMA

Regulations for the Research Diploma:—

1. Candidates for the Research Diploma of the Gemmological Association shall either have gained the Fellowship Diploma with distinction, or satisfy the Board of Examiners that they possess the qualfications necessary for undertaking such work.

2. Candidates shall either select their own subject or follow a line suggested by the Instructor. The intended scope of the investigation shall be submitted to the Board of Examiners for approval at an early stage.

3. The candidate's own account of the investigation shall be submitted (in triplicate) to the Board of Examiners in the form of a typewritten or printed paper. In addition, the Board of Examiners may require the attendance of the candidate for an interview.

4. In order to qualify for the Research Diploma the paper must form a distinct contribution to Gemmology, and afford evidence of originality, shown either by the discovery of new facts or by the exercise of independent critical power.

5. The investigation may be carried out either at a suitable Institute or in approved cases at home. Candidates will be expected to show that they are familiar with the work of previous investigators on the subject selected.

6. Each successful candidate will be awarded a Research Diploma, and be entitled " Research Gemmologist."

7. The copyright of the papers of successful candidates shall be the property of the Gemmological Association, at whose discretion they may be published.