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and

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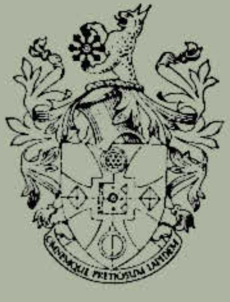

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NOTES FROM THE LABORATORY

By A. E. FARN, F.G.A.
The Gem Testing Laboratory of the London Chamber of Commerce and Industry

Just before starting a talk to one of the Branch meetings of the Gemmological Association we had an informal chat among ourselves. It seemed that an argument or discussion had taken place earlier on the rights and/or wrongs of a decision on a gemstone. One member in particular wanted to know *which* instrument I would first use on testing a sapphire.

Not wishing to be drawn in this instance (since I was fully informed on background details) I answered truthfully that the first test or testing was done automatically by eye upon opening a stone paper and noting the colour of the gemstone. 'The first impact of a gemstone is its colour'.* This, of course, presumes a working knowledge of, or experience in handling, stones and/or pearls. There are many non-F.G.A. merchants and dealers who know when a stone *looks* wrong or the colour is wrong. Frankly not many synthetic sapphires look quite right—certainly by colour alone they

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*See A. E. Farn, The First Impact of a Gemstone, *Z.Dt.Gemmol.Ges.*, 1979, 28(4), 188-90.—Ed.

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look wrong, *too* good, or empty centres—something indefinable but enough to arouse one's suspicions. Not many pearl dealers will look too long at a cultured pearl necklace before deciding that it *looks* wrong. An even colour, matching throughout, nuances of sheen influenced by the nuances of mother of pearl serve to arouse suspicions. Perhaps the most dangerous aspect of a gemstone is that betrayer of acumen—the prospect or possibility of a very handsome or quick profit?

Not long ago we had in to test a largish, cushion-cut, native-cut, red stone looking like a possible fine garnet or red spinel. It didn't look like a ruby of Siam or Burma origin or Siam or Burma colour for that matter—but it *did* look like a natural red stone. It did *not* look a synthetic ruby—but it was! First examination with a lens and bench lamp over white mat paper showed distinct curved lines sideways through the rather heavy belly of the stone. It was carrying quite a lot of weight below the girdle. Through the table one could glimpse an effect of twin planes not just in one direction but crossing each other. Using a microscope, the effect was very strongly seen. Had the stone been mounted as a ring with perhaps a border surround of small diamonds, it would have been very easy indeed to be fooled by the crossing twin planes. The ring setting would have limited the view and what could have been seen would

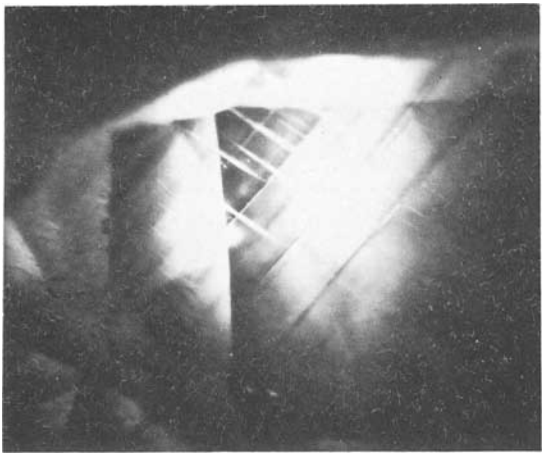

FIG. 1. Twin planes in a synthetic ruby.

be sufficient to indicate a natural stone. However the colour did not look quite like ruby and so we decided a photograph would be of interest (see Figure 1—photograph by K. V. Scarratt).

* * *

Very recently we received a Byzantine style necklace to test. It consisted of a flexible flat gold collar adorned with enamelling, supporting a slightly tapering graduated series of baroque (but regularly so) drop-shape, opaque, brown/terra-cotta beads, a few with a pearly lustre—the beads being elegantly mounted with a festoon effect. One of my colleagues undertook the test and after some time took a small dental x-ray film of a section (Figure 2). The result was most rewarding and satisfying. The structures showed (as a radiograph) concentric lines following the shape of the beads with the text-book regularity and repetition of the cross section of an onion only better! I was quite surprised at such a sharp result i.e. such clear definition—particularly since a dental x-film was used. Normally we use a fine grain film, but there was a shortage of this particular film, of which we were awaiting supplies. We decided to use up our dental film to conserve our small stock of fine grain material. The results were those of a fresh-water pearl, because such non-nacreous pearls are usually course in growth and externally are more often than not of a muddy hue,

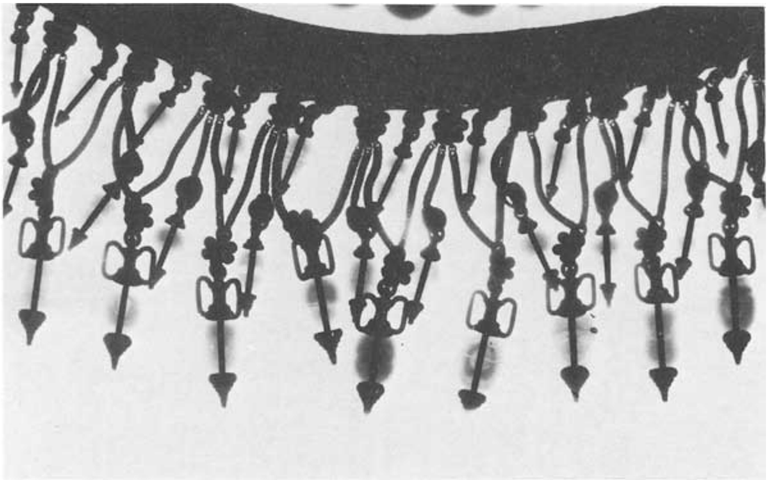

FIG. 2. Byzantine necklace—'cave pearls'. (Positive print)

ranging from dull off-white through to brown. These 'pearls', though, were a terra-cotta colour mostly; one or two had a pearly lustre, albeit non-nacreous, but most were opaque and granular and their shapes were peculiarly drop- or pendant-like, some with a grooved or belted exterior. They were all small 'pearls'; it was the apparent regularity of shape and colour which worried me. Could someone have possibly collected so many poor-quality fresh-water 'pearls' with somewhat similar shapes *and colour?* I doubted it—we did a very very discreet microchemical test to prove a carbonate reaction, which was positive. This didn't help really, because pearls are carbonates. Then we studied the surface structure more carefully, and the penny dropped! Of course they were carbonates! Of course they would show perimeter structure lines. Their shapes added up to stalactitic 'cave pearls'.*

The sharp line structures are, I believe, due to trace iron in the water which passed through the limestone to form stalactites in caverns below.

* * *

I used to have quite a bit of trouble in the 'black-out' during the War. It took me quite a time to become dark-adjusted. Somewhat similar conditions occurred in a 'white-out' recently in the Laboratory. As you will have gathered from previous 'Notes from the Laboratory', on occasions we have members of our section who, upon receiving consignments of (to them) new stones or new sources, invariably ask us to check them. We often receive a specimen for the Laboratory collection in this manner. One of our frequent donors and Laboratory-orientated gemmological members is the firm of E. A. Thomson. Andradite, herderite and diaspore† are among recent welcome gifts. Sometimes it is not necessarily a new stone but a new colour in a range which prompts the gift and the interest.

Ideally certain gemstones are colourless; it is only the imperfections of nature putting in a trace of chromium, iron, manganese, etc., which causes odd colours of ruby in corundum

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*Walton, Sir James. (1952) *Physical Gemmology,* p.123 (Inorganic Limestones). Pitman, London. Webster, R. (1975) *Gems,* 3rd edn, p.260. Newnes-Butterworths, London.

†See Kenneth Scarratt, Faceted Diaspore, *J. Gemm.,* 1980, XVII(3), 145-8.—Ed.

and shades of emerald green in beryl etc. Iron is said to be the impurity causing amethyst colour in quartz. However, when one thinks of opal, it is usually a ‘play of colour’ which springs to mind, whether basically white or black background or even Gidgee Opal (what an attractive stone!). In this case it is not an impurity causing colour so much as interference effects of light.

When recently we were shewn some specimens of *colourless opal* we were intrigued. These stones (we were shown four specimens) to me *looked* soft. Doubtless they were—we did not apply a hardness test. They were (in gemmological or jewellery terms) colourless, save for the faintest of milky blooms when placed on a black cloth background.

The four stones weighed 7.96 ct, 4.17 ct, 3.32 ct and 2.19 ct respectively. Their densities were taken by hydrostatic method in distilled water (with 0.5% detergent as a ‘wetter’). We obtained densities ranging from 2.012-2.047.

Normally we use ethylene dibromide for our hydrostatic weighings, but since we were dealing with opal they would have floated in that liquid, which has a density of about 2.17 depending on temperature. Just for the fun of it I put the colourless opals into a tube of ethylene dibromide in which they floated, then diluted it with monobromonaphthalene so that they slowly sank. This didn’t prove or disprove anything, except to demonstrate how closely they were together in their specific gravity. (There *were* fractional differences.) Using a filter-paper in a funnel, I poured off some of the liquid and the opals poured out as well. I didn’t *see* them: I *heard* them ‘clink’ over the lip of the tube. Against the white filter-paper in a liquid nearly matching in refractive index, they disappeared in the ‘white-out’’ I mentioned earlier. The refractive indices were in fact 1.442, 1.443, 1.443 and 1.445.

I literally had to feel for the stones to find them. With natural opal—the normal type with a play of colour—there is a marked whitish fluorescence and phosphorescence under long-wave ultraviolet light. When these colourless opals were viewed under long-wave UV, they varied in their reactions. Under long-wave UV one was a bright green, two were a much more subdued hue, and one was practically white.

Under short-wave UV three were a very bright green and one was inert. There was no phosphorescence under long- or short-wave ultraviolet light. These were, of course, gemmologically interesting and will add to collectors' colour ranges of opal. Work (or play) in the laboratory does not have to be all the heavy equipment, electronic calculators, etc.: it can be good gemmological fun, using simple instruments backed by gemmological knowledge. With these colourless opals being such a low density material, one seemed to get a large stone for a few carats.

[*Manuscripts received 23rd February, 1980.*]

JAPANESE SYNTHETIC EMERALDS?

By R. KEITH MITCHELL, F.G.A.

A small parcel of synthetic emeralds, said to be of Japanese origin, offered under the name 'Crescent Vert', recently came to my notice. The small stones in this sample (and there are indications that production is on a fairly large scale) are of very intense colour with the usual tendency to a rather bluish-green. Some stones were apparently clean, while others had a few of the wisp-like veils of healed cracks associated with Gilson and Chatham stones.

The two tiny stones I acquired both gave good chromium absorption spectra, and an RI of 1.568-1.564 was obtained with some difficulty from one of them. This stone was clean but had a dull khaki fluorescence under both long and short ultraviolet light. The second stone had a rounded table and no RI was obtainable on the refractometer. It had a single veil-like healed crack which, at 50×, showed a yellow-green, apparently crystalline, incrustation, possibly of flux material, between the long two-phase tubules over part of its area. Rather unexpectedly the writer could see no apparent fluorescence under UV, although a younger man claimed he could just see a very dull red. Through the Chelsea filter both stones gave a moderately strong, but slightly orange, red. Neither

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was nearly as bright or as orange as was a Chatham synthetic placed alongside them.

In the same week a stone-dealer friend asked my opinion of an exceptionally fine emerald of 1.50 carats which was quite clean under a 10× lens. The residual colour under the Chelsea filter was rather like that seen in the synthetics, and, although the immediate question was rather whether the dealer could afford to buy the stone at a substantial but not excessive price for a genuine emerald of that quality, my reaction was to advise that it should be bought only if it could be proved beyond doubt to be genuine.

The stone was eventually tested and had an RI of 1.574-1.570, so the birefringence was 0.004, the same as for the Japanese synthetics, even though the RI is higher. Birefringence as low as this is a probable indication that an emerald is synthetic, but in the case of a possibly important stone it was necessary to have confirmation. This was obtained by the Gübelin Laboratory, who tested for absorption in the deep infrared which is always present in hydrothermal and natural emeralds. It was absent, and the stone was beyond doubt a flux-fusion synthetic. SG, at 2.66, was also that expected of a synthetic.

Under high-power magnification this stone did show growth lines which were unlike those normally seen in a natural stone, but they were difficult to find and not easy to interpret. It was inert under long-wave ultraviolet light and had a normal strong chromium absorption spectrum.

At a time when new synthetic emeralds seem to be cropping up from a number of sources I feel that these two reports should be noted and fine colour emeralds of exceptional cleanness viewed with suspicion. In neither case did the stone give the bright residual colour normally expected of a synthetic emerald when viewed through the emerald filter.

[*Manuscript received 1st July, 1980.*]

'GEUDA SAPPHIRES'—THEIR COLOURING ELEMENTS AND THEIR REACTION TO HEAT

By HERBERT S. GUNARATNE, F.G.A.
Gemmologist-Chief Valuer, State Gem Corporation, Sri Lanka

The heat-treatment of gemstones has been practised for quite some time to improve the quality of the original colour or to bring out another colour which in such varieties is known or unknown to occur. This treatment is also sometimes meted out to remove turbidity which could be the result of certain inclusions. The detection of such heat-treated gemstones has only been by observation and since this process did not really concern the more expensive gemstones, being confined mainly to less valuable varieties, not much interest was taken to make such detection scientifically. Deducing by observation was good enough and was acceptable. Nevertheless the burning of 'rubies' (purplish red members of the corundum family) was also practised. Such stones were heated (burned) for considerable periods of time to remove the purplish tints present. By this process of heating, very good and favourable results are obtained and the result is deemed permanent and therefore acceptable in the trade. This factor of acceptance has kept the gemmologist and mineral-scientist from making the effort to find out if heat-treated stones could be scientifically detected. Today, it not only becomes more and more necessary to make such distinctions, but it also remains an open challenge to science to determine non-destructive means and ways of detection.

In Sri Lanka the process of burning rubies remains essentially a local adaptation. The stones are burnt embedded in an open charcoal fire, where the blowing is done either entirely by human effort or by mechanical devices. This process is continued for a specified period of time; sometimes it may be as long as forty or fifty hours. Before burning, care is taken to eliminate trapped liquid or gas in crevices or tiny fissures, if any, that may result in cracking up the stone on heating due to expansion. The stones are also given a thick coating of a local paste prior to burning. In this process, two factors are evident—some rubies react readily to the heating and become visibly clear and of a better shade of red, while

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others seem to be more stubborn and do not react to such treatment, or, if at all, the effect is very mild. The purplish tint in rubies is caused by titanium and/or iron in combination with chromic oxide, unlike the blue colour in the sapphire, which is caused by titanium and/or iron only. In instances where the titanium and the chromic oxide are responsible for the colour mixture, the temperature of the local charcoal system is inadequate to bring about any change in colour. On the other hand, where the colour mixture is attributed to chromic oxide and iron, this system readily works, removing the bluish tints and making the red colour caused by the chromic oxide more conspicuous. The theory behind this is the removal from or the concealing of the iron ion (which when present generally causes a dulling or dampening effect on rubies) behind the crystal lattice in the process of heating. The commonly accepted theory that a ruby once heated cannot be re-heated for better results is true on the basis of the above, as much higher temperatures will be required to cause a change in the colour mixture resulting from titanium and chromic oxide. Such high temperatures could produce the adverse effect of causing a purplish colour, as the titanium under such circumstances is most likely to produce a more intense blue, which in combination with the red of the chromic oxide could produce this effect. A further possibility is that such intense heat may cause it to lose its bluish tints altogether and produce the effect of 'geuda' in the ruby, while the reddish tints caused by the chromic oxide will persist. Webster in his book on *Gems** suggests the possibility of titanium producing the colour red on being subject to re-heating. Accordingly, it also remains possible under extremely rare circumstances for 'geuda' rubies to produce a better red on being subject to intense heat, provided the titanium present reacts favourably to produce the colour red rather than blue.

The cooking or baking of particoloured blue sapphires or deep blue sapphires which are very nearly black is also practised in Sri Lanka. These stones are baked for comparatively shorter periods of time, possibly for a few minutes only. The resultant gemstone is either one in which the existing colour patches get dispersed and distributed into regions that had no colour or the stone is made lighter in colour, thereby making it more transparent and pleasing.

**Gems*, by R. Webster, 3rd edn, p.354. London: Newnes-Butterworths, 1975.

Here again the results are permanent. Similarly the cooking of Australian blue sapphires has been practised both in Australia and Thailand, and today this is acceptable in the trade and is commonplace.

Of late an improvement of this process has been extended to the 'geuda' corundum in order to convert the 'geuda' into colour. During the last two or three years this system of burning 'geuda' has been widely carried out in Thailand using Sri Lanka's geuda corundum. Strangely enough, for some reason or other it is still maintained that Sri Lanka 'geuda' corundums are by far the more suited and superior raw material for this purpose. This process is now catching on fast in Sri Lanka and some Sri Lankan merchants are now engaged in this endeavour.

What is a 'geuda'? Not too long ago, buying and selling of 'geuda' stones was only in limited circles. 'Geuda' stones were a 'poor' merchant's merchandise, and these were selling very cheap. Today, however, the situation has taken a complete turn (for the better) and the 'geuda' stone is good business. 'Geuda' in gemstones was a quality that was detested and disliked and was a factor that brought down the value of a gem considerably in relation to accepted standards of evaluation, till such time as the heat-treatment process caught on and changed the standards. 'Geuda' in a gemstone is a milky white opaline character seen within and even outside the stone and is the result of a network of inclusions. In relevance to the text, it is a corundum with an excessive amount of titanium, very often in the form of the mineral rutile, arranged in relation to and conforming to certain crystallographic laws in the crystal structure of the host mineral. This could occur in any variety of the corundum family. The titanium in corundum is the essential ingredient that brings about the colour to such stones on heating. Examination under the microscope, or with other optical aids, or any other relevant analysis will undoubtedly reveal its presence. More sophisticated equipment could even provide a qualitative and quantitative analysis of the guest mineral and this would no doubt help the researcher, who would very much like to delve deeper into the more academic aspects of this problem of geuda heating. The milky white appearance in the texture is only an indication of the presence of the above inclusions, and this is presently the basis for the selection of the suitable rough. Detailed examinations are not carried out for assessments of this nature.

Among geuda stones are different grades and qualities, and these are in different levels of demand according to how suited these would be for heat treatment. The ideal stones are considered to be the ones which have a very faint powder-blue tint, display a milky white sheen appearance, and which, when held against a light source, give the colour appearance of clean thin honey. Since this colour is similar to a thin flow of diesel oil the local term 'diesel geuda' is now widespread. Freedom from flaws and fissures is a prerequisite. Inclusions, other than geuda, if present should preferably be at a minimum. Liquid and gaseous phases, when present in stones that are to be heated, are detrimental, while completely healed cracks prove to be of little or no risk. Different qualities of rough react differently, and as such these have to be treated differently. Accordingly, in the selection of the rough stones for heat treatment human expertise is vital, as the extent of colour and the degree of success depends largely on the quality of the rough and how it is handled. The judicious examination of some successfully treated stones prompts us to infer that the process in itself is quite a success. Pale, fancy to rich deep blue colours have been obtained by this process. Right now, of course, information on the measure of success in relation to failure is scanty, and it remains impractical to work out the ratio of success in relation to failure.

From the description of the ideal geuda stone (the most suitable for heat treatment) it is evident that it is chemically an oxide of aluminium with a higher than normal (though still negligible) percentage of impurities occurring as titanium, very often in the form of the mineral rutile. Rutile is the guest mineral in corundum crystallized from the chance impurity titanium, which does not in any way alter or affect the chemical formula of corundum nor its crystal lattice, and which during the genesis of corundum has been an associated constituent. The geuda corundum, too, is essentially an allochromatic mineral.

Dr Gübelin records that rutile in corundum could occur syngenetically and epigenetically.* Under the circumstances there is enough reason to think that it is more the syngenetic rutile (that has undergone rapid cooling and consequent crystallization) which is

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**Internal World of Gemstones*, ABC Edition, Zurich, 1974, pp.52, 86-8, 112-13.—Ed.

primarily responsible for producing Geuda corundums that are most susceptible to heat and the ones that would invariably react with favourable results. For rutile to be syngenetic in corundum, it has to have its genesis almost simultaneously with that of corundum. To create such a development the growing crystal of corundum during formation engulfs a fair quantity of mother liquid rich in titanium. This quantity of liquid is soon trapped within the solidifying host and is also subject to a rapid drop in temperature. This drop in temperature consequently hastens the process of crystallization, producing microscopic acicular rutile from the titanium-rich mixture. This rapid crystallization process does not promote adequately favourable conditions for the full manifestation of titanium as a colouring agent, but instead these crystals soon fit into place within the host in relation to crystallographic laws. The result is an apparent milky-white geuda corundum. The titanium ions in such stones, if subsequently subject to prolonged intense heat at temperatures close to the melting point of rutile, would invariably re-adjust and re-align themselves within the host. In the process, the titanium ions being true to their function as a colouring element, would even bring out their hidden colouring properties and also impart this colour to the host mineral. This transformation could take place in a metamorphic phase in nature or in the laboratory provided the conditions are right.

In the case of corundum whose rutile inclusions are epigenetic in origin, it is most likely that the guest element has had the greatest possible opportunity to manifest itself in producing the maximum possible colour, once again conditioned by the favourability of the crystallization process. The inference is that if the rutile in corundum, whether of syngenetic or epigenetic origin, is subject to very favourable cooling and crystallization processes in nature, then the colouring process is complete. Such stones could not be re-heated to advantage in the laboratory.

The producing of geuda corundum in nature could be a direct result of a hastened process of crystallization of the guest mineral. Accordingly the revelation of the genetic history of rutile in corundum is of paramount scientific importance for the greater success of treating geuda in the laboratory.

Titanium and iron are both colouring elements to which is attributed responsibility for imparting colour to blue sapphires.

These elements have been found in varying proportions as insignificant impurities which are jointly or by themselves responsible for the colour. In the geuda of the ideal stone the rutile present has remained, so to say, in a state of inactivity, in the sense that its true function as a colouring element has not fully revealed itself. On the other hand, the faint powder-blue tint in such a stone could be attributed to iron present in some form, which, if subject to heat, totally disappears at certain temperatures, making the stone visibly whitish. On being subject to still higher temperatures (temperature closer to the melting point of titanium), the titanium begins to melt within the host while the host is still in a solid state. In this state the atoms of the rapidly melting titanium not only begin to readjust themselves once again in relation to crystallographic laws, but also to bring out its colouring properties which gradually diffuse into the host. This really is the critical temperature—the temperature at which the maximum colour is produced and diffused into the host corundum. At this point, expert handling should control the temperature. Overheating is harmful, as it would tend to destroy the crystal pattern of the host, producing globular and glassy stones of an amorphous form.

In Sri Lanka three methods of heating are adopted with the same object in view, i.e. the imparting of colour to milky-white geuda corundum. The difference in these three methods lies only in the nature of firing. The first is the use of gas, the second the use of dieselene, while the third is heating by electricity. What is common to all three methods is that the stones to be heated are given a thick coating of a local paste. The duration of heating is variable according to the temperatures achieved and the nature of the rough selected for the purpose. The oil and gas furnaces are turned out of metal, locally, and their inner walls are lined with fire-bricks and fire-clay, while the electric furnaces are of foreign design, manufactured to withstand high temperatures. All three methods have invariably achieved the same end result—i.e. the transformation of geuda into colour. Theoretically the results should remain permanent unless and until re-subjected to intense heat.

It now remains a matter for the mineral scientists and gemmologists alike to determine ways and means which are non-destructive to distinguish between a heat-treated geuda corundum and its untreated counterpart. So far only observations have been made backed with no scientific exactitude. However, with these observations it now seems possible to a very great extent to determine the differences between the heat-treated geuda corundum and its untreated counterpart. A substantial amount of reasoning and shrewd observation are right now the only criteria to make this distinction; some, if not all, have scientific attributes, which should and could be proved positive, it is hoped in the very near future.

In the earlier part of this article I have already theorized on the nature and genesis of rutile in geuda corundum and an attempt was made to tie up certain types to their possible favourable susceptibility to heat. Experimentation in this direction could reveal more about the genetic history of rutile in milky-white geuda corundum. This, though it may sound a little too academic, seems to me the most rational approach towards understanding the problem before offering a solution.

In addition to the burning of milky-white sapphires, the mention of the treatment of two other varieties of corundum seems relevant at this juncture. These are particoloured blue sapphires with even the faintest touch of blue within the stone or outside and the very pale yellow geuda sapphires with scattered streaks of blue. These react very favourably to heat, and the resultant colours are extremely good, being blue and showing uniformity in its distribution. The degree of success in this group of stones in comparison to the milky-white geuda sapphires is very high, and as such these are in greater demand.

The following are the observations made in a representative range of successfully heated geuda corundum for the conversion of geuda into colour.

1. All successfully treated stones have unfailingly indicated the presence of diffused or 'blotchy' colour bands or zones giving the general impression of colour migration within the stone. This colour diffusion has given rise to a tendency to reduce the sharpness of the growth lines seen in these corundums. This is most apparent in deep blue stones, fading out gradually to be less apparent in stones of lighter shades. This could be due to the lack of colour contrast.
2. Certain stones give the appearance of the presence of 'woolly' white isolated patches or small white flaky spots

giving credence to the possible thought that these could be residual titanium that has as yet failed to bring out its blue colour for some reason or the other. It is probably still in a state in the process of conversion.

3. The stones so far examined failed to reveal the presence of zircon crystals which are considered typical in Sri Lanka blue sapphires. It seems very likely that the raw materials so far used have been free from such inclusions.
4. There is a complete absence of any traces of percolation deposits in minute fissures or cracks causing stains in the stone.
5. Completely healed cracks have been observed in several stones. Evidently these could not cause any damage to the stone as a result of different degrees of expansion as the infillings are wholly of corundum material.
6. Exposure to short wave ultraviolet radiation revealed that a large majority of stones were totally inert while a fair amount of still others on exposure to long wave ultraviolet radiation showed a dirty brown to brownish red glow. Of a selected one hundred stones examined (both rough and polished) only four deep blue polished stones displayed a powder-blue glow on exposure to short wave ultraviolet radiation.
7. Tests carried out to determine their optical and physical constants showed nothing different to their untreated counterparts.
8. The colour absorption pattern as determined by the hand spectroscope was found to be identical with the untreated. This however, was expected as no new colouring elements were introduced.

While the above observations could draw a distinction, it should not be expected that a case study of this nature is by any means complete. Many more stones will have to be observed, more so in their rough pre-heated state. If efforts to establish scientific reasoning are concentrated on observations 1 to 5 above, then I feel some conclusive finality could be reached.

An article of this nature undoubtedly leaves behind a series of unanswered questions some of which are:

i. What are the physical changes that are brought about to geuda sapphires on being subject to intense heat and how could such changes be recognized and distinguished scientifically.

ii. How could one predetermine the critical temperature in relation to the nature and quality of the raw material at which the transformation takes place.

The foregoing conclusions have been arrived at by me under certain limiting circumstances. Most of the examinations were carried out on already treated stones, given to me by courtesy of private organizations that have adopted this heat treating process for strictly commercial purposes and not for scientific research. Further, my observations were confined to a representative collection of successfully treated stones and an adequate amount of rough pre-heated geuda has not yet been subject to such a scrutiny.

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DIRECT RADIOGRAPHY OF DIAMOND JEWELLERY

By A. J. MOULE, Ph.D., F.G.A., F.G.A.A., and
G. BROWN, Dip.D.T., F.G.A., F.G.A.A.

Diamond's transparency to a beam of x-radiation has been known since the late nineteenth century (Doetler, 1915). Since that time, it has been demonstrated that diamond is the only gem mineral that is completely transparent to x-radiation (Anderson, 1971; Webster, 1975; Brown, Moule and O'Neil, 1975) and as such will not leave any image on high speed radiographic film exposed to x-radiation. While most gemmological textbooks claim that diamond can be readily discriminated from its imitations by this property, and while several x-ray units have been specifically designed for direct radiography of diamonds and of pearls*, the potential use of x-rays for the detection of mounted and unmounted diamonds has not

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*GAAJ Diamond Penetrating X-ray Apparatus (Gemmological Association of All Japan).

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been adequately emphasized. This lack of emphasis has probably occurred because x-radiation sources are usually considered specialized instruments for the exclusive use of research laboratories and the medical and dental fraternity.

Fundamentally, x-radiation obeys the laws of visible light and will affect a photographic film in the same way as visible light. Additionally, x-rays possess some properties not possessed by visible light — short wavelengths (0.01 — 0.05 nm) enabling penetration of materials which would reflect or absorb visible light, and high energy capable of producing biological injury.

Provided proper precautions are taken (Brown, 1979), we would suggest that the use of small x-ray machines, such as routinely used in dentistry, coupled with the utilization of high speed dental x-ray film*, can be simply and effectively used for the positive discrimination between diamond and its imitations and simulants. This technique is equally applicable for both mounted and unmounted stones.

Modern dental x-ray units are manufactured to operate within the 50-90 kV/5-20 mA range and to produce x-radiation with wavelengths which range from 0.01 to 0.05 nm. The x-ray unit used for these studies† operated at a fixed 50 kV/7 mA which could be delivered in single exposures from 0.1 to 5 s. A diaphragm contained within the head of the x-ray unit limited the radiation beam to a diameter of 58 mm at a source-to-film distance of 25 cm. This machine proved to be an effective and reliable source of x-rays for the purpose of demonstrating the radiolucency of diamond. High speed dental x-ray film was chosen as it produced radiographs of good diagnostic quality with extremely short (0.1 to 0.5 s) exposure times. Development and fixation times used for the exposed radiographs were those recommended by the manufacturer.

UNMOUNTED STONES

Unmounted stones could be rapidly examined by placing them face down on a suitably sized x-ray film packet‡ and radiographing them at a source-to-film distance of 25 cm and an exposure time of 0.1 to 0.5 s.

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*Kodak DF-58 or DF-54 Ultra-speed Dental Periapical X-ray film: Agfa-Gavaert M2 Ultra-speed Dental Periapical X-ray Film.

†Siemens Heliodent 50 dental x-ray machine.

‡Kodak DF-45.

Even at very low exposure times, e.g. 0.1 s, the radiographic images of diamond always appeared completely radiolucent (dark) whereas its imitations and synthetics were comparatively radio-opaque (light) (Figure 1). While it was not possible to discriminate accurately between the different imitations and simulants, diamonds could always be positively identified. Most diamond imitations and synthetics were completely radio-opaque. Synthetic spinel and synthetic sapphire were two exceptions. While these stones always left an image on the radiographic film, the image they produced was not as distinct as that produced by other diamond imitations and simulants. (Figure 1)

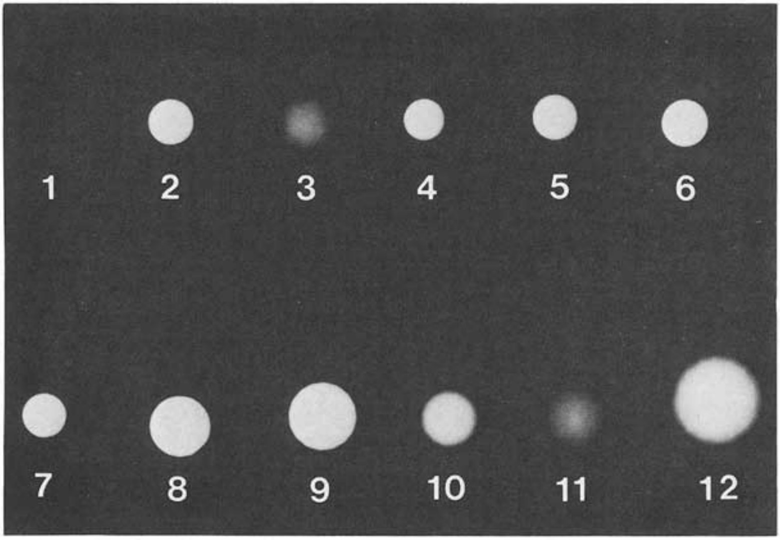

FIG. 1. Radiograph of a diamond and some of its imitations and synthetics demonstrating the comparative radiopacity of (1) Diamond (2) Gadolinium gallium garnet (GGG) (3) Synthetic spinel (4) Yttrium aluminium garnet (YAG) (5) High zircon (6) Cubic zirconia (Yttrium stabilized) (7) Cubic zirconia (Calcium stabilized) (8) Strontium titanate (9) Synthetic rutile (10) Quartz (11) Synthetic sapphire (12) Crown Glass. (Exposure time – 0.2 s)

MOUNTED STONES

A literature search has failed to elucidate a detailed description of any technique suitable for the use of x-rays in the detection of diamonds mounted in jewellery. Most diamonds mounted in jewellery have some portion of their pavilion facets not covered by the metal of the mount. If the film could be so positioned that x-rays could pass uninhibited in a straight line through the stone to

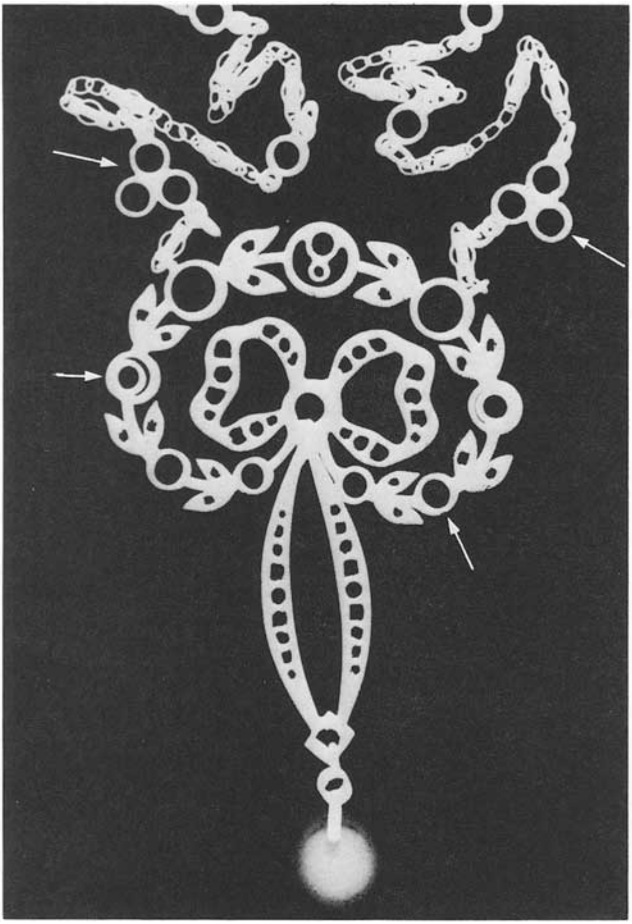

FIG. 2. Radiograph of a pearl and diamond necklace showing the transparency of diamond (arrowed) to x-rays.
NOTE: The radiograph also illustrates the classical radiographic appearance of a nucleated cultured pearl (Brown, 1979).
(Exposure time — 0.5 s)

the film, then a positive identification of the mounted diamond was possible.

(A) *Flat pieces of jewellery,* e.g. pendants and brooches, could be placed directly onto a film of appropriate size and radiographed. On the resulting developed x-ray film diamond appeared completely radiolucent (dark), whereas the mounting metal and the diamond simulants and imitations appeared comparatively radio-opaque (white) (Figure 2).

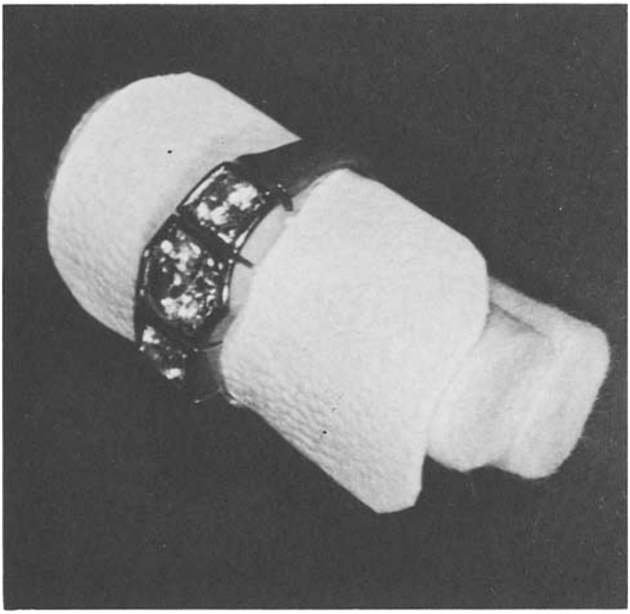

FIG. 3. Photograph of a diamond and cubic zirconia ring in which a small dental periapical film has been positioned inside the ring shank.

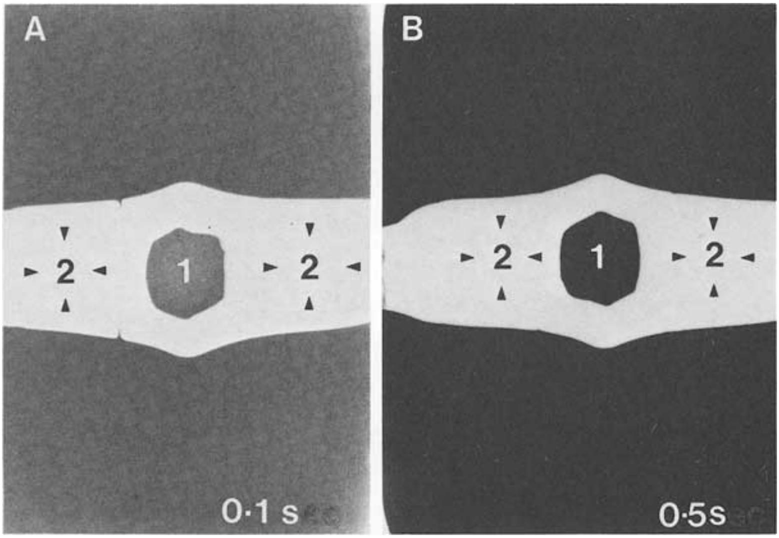

FIG. 4. Radiographs of the ring in Figure 3 illustrating the radiolucent image of diamond (1) and the radio-opaque image of cubic zirconia (2) (arrowed) at different exposure times. (A–0.1 s; B–0.5 s) The metal mounting was completely radio-opaque.

(B) *Diamonds mounted in rings* posed a further problem which could easily be overcome by the use of the smaller periapical type dental x-ray film*. These films are small enough to be curved and placed into a ring and adapted to the undersurface of the mount (Figure 3). Provided the x-rays passed uninhibited through the stone, (i.e. provided the undersurface of the stone was not completely covered by the metal of the mount), a radiographic image was formed which allowed positive identification of the diamond (Figure 4).

SUMMARY AND CONCLUSION

1. A simple technique for the identification of diamond using standard commercially available dental x-ray facilities has been described.
2. While it is not possible to discriminate accurately between the different diamond imitations and simulants by direct radiography, diamonds could always be positively identified.
3. In view of the speed and positive nature of this technique in establishing the identity of diamond, and in view of the advent onto the market of newer and better diamond imitations, it is suggested that direct radiography should be playing an increasingly important role in the positive discrimination of diamond from its imitations and simulants.

ACKNOWLEDGEMENTS

We wish to acknowledge the photographic assistance of Mr Des Lund and the radiographic assistance of Mr Len Street.

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*Kodak DF-54.

RAMAN SPECTROSCOPY AS A GEMSTONE TEST

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INTRODUCTION

A variety of spectroscopic techniques can be used as non-destructive tests for gemstone identification. Visible and infrared spectroscopy are widely used in technology and can be most helpful, at times, in gemmology. Visible spectroscopy in the form of the hand spectroscope is widely used,(1) and infrared spectroscopy can, as one example, identify the presence, as well as the nature, of the water in emerald.(2) The various magnetic resonance techniques have been recently described in this *Journal*(3) and the full range of all such techniques has been covered in a recent text by Crooks.(4)

With the ready availability of lasers, Raman scattering has now joined the growing list of non-destructive tests which can be applied to gemstones. It has the convenient characteristic that only one surface of a material needs to be accessible to identify the nature of the material. The results depend on the chemical constitution and crystal structure. Even doublets can be identified merely from an examination of the table facet. An outline of the principles behind the technique, the practice, and some typical results are presented.

I wish to thank Dr J. E. Griffiths for permission to use the spectra which we have published elsewhere in an investigation aimed at light-coupling prisms for thin-film studies.[5] For this use a high refractive index and optical transparency are essential; since these are also characteristics of gemstones, in particular diamond imitations, such materials were tested accordingly.

I. THE NATURE OF OPTICAL ABSORPTION AND SCATTERING

The absorption spectrum of an emerald is shown in Figure 1. In the visible (0.4 to 0.7 micrometres)* and adjacent regions of the electromagnetic spectrum are found absorptions due to the chromophores, such as iron and chromium, which cause colour in

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*i.e., 400 to 700 nm, or 4000 to 7000Å.—Ed.

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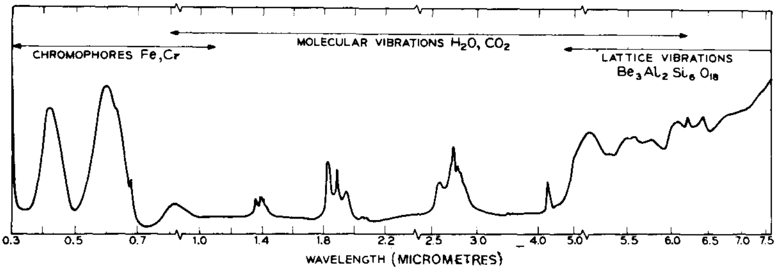

FIG. 1. The visible and infrared spectrum of an emerald.

beryl(2) (the causes of colour in gems and minerals have been described elsewhere(6)).

In the near infrared region there are seen absorptions originating from molecules such as carbon dioxide and water present in channels in the beryl structure. Figure 2 illustrates how these features arise. Consider a light atom attached to a massive structure, with the bond represented by a spring, as in Figure 2(a). Depending on how this bond is stimulated, it can oscillate in a stretching mode *s* or a bending mode *b* as in Figure 2(a). Each of these two modes will have its own oscillating frequency, the exact frequencies depending on the stiffness of the spring, i.e. the strength of the bonding, the masses of the atoms involved, and any constraints arising from adjacent atoms.

In a linear molecule, such as carbon dioxide, CO_2, there are three possible modes: the symmetrical stretching of Figure 2(b), the symmetrical bending of Figure 2(c), and the antisymmetrical stretching of Figure 2(d). Because of subtleties involving the 'polarity' produced by charges on the atoms as well as the 'polarizability', the symmetrical stretch does not absorb in the infrared, but the other two vibrations do absorb, i.e. they are *infrared active.*

In a bent molecule, such as water, H_2O, there are again three modes, but this time all three are infrared active. When infrared radiation falls on a beryl containing such water and carbon dioxide molecules, those frequencies corresponding to the infrared active bond bending and stretching modes will be absorbed, leading to the spectral features seen in the central region of Figure 1.

The features seen at the extreme right of Figure 1 and way beyond, arise in a similar fashion from vibrations in the bonds between the atoms involved in the beryl framework itself, i.e., in

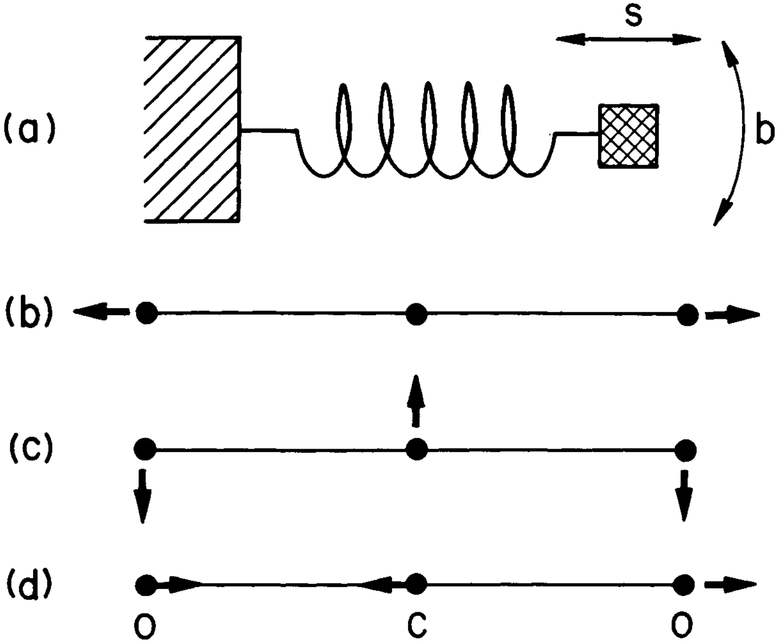

FIG. 2. The stretching mode *s* and the bending mode *b* of a bond represented as a spring at (a) and the three vibration modes of the linear CO_2 molecule: the symmetrical stretch (b), the symmetrical bend (c), and the antisymmetrical stretch (d).

the $Be_3Al_2Si_6O_{18}$. Since this is a large framework with heavier atoms, the vibrations occur at lower frequencies, i.e. longer wavelengths, than do those of the water molecule. Again, it is only the infrared active modes that will absorb light.

The infrared spectrum can be used for identification, but the substance to be tested must be available either as a fine powder or in a thin slab with approximately parallel faces, neither form being convenient for gemstone testing. In addition, measurements in the far infrared region are difficult to make. Collections of spectra have been published for inorganic and mineral substances.(7)

When light of a frequency different from that absorbed falls on a material, a small amount, perhaps one hundred-thousandth of it, is scattered in *Rayleigh scattering.* This is independent of the nature of the scattering material, the intensity depending on the size of the atoms and molecules involved. It is strongly wavelength-dependent and results, e.g., in the scattered blue of the sky.(6)

There is a second type of scattering which is even weaker, perhaps only one ten-millionth of the incoming light, and accordingly is best observed by using the very intense light beam from a laser. This is the ***Raman effect,*** or ***Raman scattering,*** first reported(8) in 1928 by Sir Chandrasekhara Venkata Raman (1880-1970) shown in Figure 3. The Raman-scattered light is shifted a little from the frequency of the light beam to a lower frequency, the so-called 'Stokes peaks' ('anti-Stokes peaks', shifted to a higher frequency, are even weaker and are rarely used).

FIG. 3. Sir C. V. Raman, who was awarded the Nobel Prize in 1930. *(Copyright 1980 by the American Chemical Society: used by permission.)*

The process involved in the Raman effect involves the excitation of a vibration, as in the absorption spectrum. In this case, however, the energy is extracted from light having a much higher energy than that corresponding to the excited vibration, and the scattered light has therefore a lower energy; it is the Raman shift, i.e. the difference between exciting and scattered light energies, that depends on the nature of the atoms and the bonding involved in the structure.

In the case of carbon dioxide, the mode which is not infrared active is *Raman active,* but in the case of water, all three modes are both infrared and Raman active. There are many advanced texts dealing with Raman spectroscopy; a typical one is that by Long.(9)

The laser beam used for producing Raman scattering can be almost any frequency, just as long as it is energetic enough and does not result in fluorescence. Usually, lasers in the visible region are used and a choice of frequencies is desirable. There are polarizing effects in Raman spectroscopy, just as there are with visible light and infrared radiation absorptions (dichroism, etc.); these are controlled by the symmetries of the vibrations involved.

Consider a laser operating in the blue-green at 5145 Å (0.5145μm). This light has a wavenumber of 19 436 cm^{-1}. If we subtract from this up to 2000 cm^{-1}, a typical useful region of interest (corresponding to the infrared region from 5μm on out) we obtain Raman scattered light from the laser light out to 17 436 cm^{-1}, corresponding to 5735 Å (0.5735 μm) in the green. Accordingly, the Raman active vibrations in the infrared are seen in the blue-green to green Raman-scattered region and a good resolution spectrometer is necessary. In this way investigation can be shifted from the relatively difficult infrared to the easier visible region. This only became possible with the ready availability of powerful lasers; typically a laser output power level of 1 watt may be used.

II. EXPERIMENTAL

The various samples tested are summarized in Table 1 and included natural and synthetic diamonds, diamond imitations, a number of beryls, a topaz, and two doublets.

Raman spectra were obtained at room temperature as shown in Figure 4, using a back-scattering geometry in which the beam from a Spectra-physics Model 164 argon ion laser at 5145 Å entered the front face of the various gemstones at near Brewster's angle. The scattered light was focused as shown into the collection optics of an Instruments S. A. Ramanor HG2S spectrometer and detected by a Hammamatsu R928P photomultiplier detector. In general, the crystallographic axes of the samples were not known and therefore the scattered light was not polarization analysed. The spectra are

TABLE 1

Gemstones Examined (Synthetic unless otherwise specified)

Compound	Formula	Source	Comment
Diamond	C	South Africa	Natural, colourless, Type I
		General Electric Co.	Yellow (nitrogen containing)
		General Electric Co.	Blue (boron containing)
		General Electric Co.	Colourless (pure)
Cubic zirconia*	$ZrO_2(Y_2O_3)_x$	Ceres Corp.	Skull melting
	$ZrO_2(CaO)_x$	Djevahirdjian S.A., Switzerland	Skull melting
	$ZrO_2(Y_2O_3)_x$	Lebedev Inst., USSR	Skull melting
Garnet	$Y_3Al_5O_{12}$	Airtron Corp.	'YAG', Czochralski pulling
	$Gd_3Ga_5O_{12}$	Airtron Corp.	'GGG', Czochralski pulling
Strontium titanate	$SrTiO_3$	NL Industries	Verneuil flame fusion
Rutile	TiO_2	NL Industries	Verneuil flame fusion
Sapphire	Al_2O_3	Djevahirdjian S.A., Switzerland	Verneuil flame fusion
Spinel*	$MgO.xAl_2O_3$ $x \sim 2.5$	Djevahirdjian S.A., Switzerland	Verneuil flame fusion
Quartz	SiO_2	Hot Springs, Ark., U.S.A.	Natural
Silicon carbide	SiC	Carborundum Corp.	High temp. furnace, transparent tan colour
Beryls*	$Be_3Al_2Si_6O_{18}.xH_2O$ $0<x<1$	—	—
Aquamarine	$x>0$	Brazil	Natural, contains Fe
Emerald	$x=0$	Chatham Co.	Contains Cr, flux
Emerald	$x>0$	Linde Co.	Contains Cr, hydrothermal
Yttralox*	$Y_2O_3(10\% \ ThO_2)$	General Electric Co.	Stabilized, hot pressed
Topaz*	$Al_2SiO_4(F,OH)_2$	Unknown	Natural, pale blue
Doublet #1	$C+ZrO_2(Y_2O_3)_x$	Fabricated	Natural diamond crown over cubic ZrO_2 pavilion
Doublet #2	$Al_2O_3+SrTiO_3$	'Nifty Gem'	Sapphire crown over $SrTiO_3$ pavilion

*Composition variable

thus generally 'I_{HU}' where H refers to the horizontal polarization of the incident exciting light and the U refers to the unanalysed scattered light of intensity I.

The one exception to this involves cubic zirconia, where it was important to show that changes in the relative amplitudes of some of the Raman bands as a function of the orientation of the various samples were caused by the effects of polarization and orientation, and not due to compositional changes.

Representative spectra are shown in Figures 5 to 8. Experimental parameters used for Figures 5 to 8 included: laser power at 5145 Å ranged from 50 to 1000 mW, spectral slit widths of

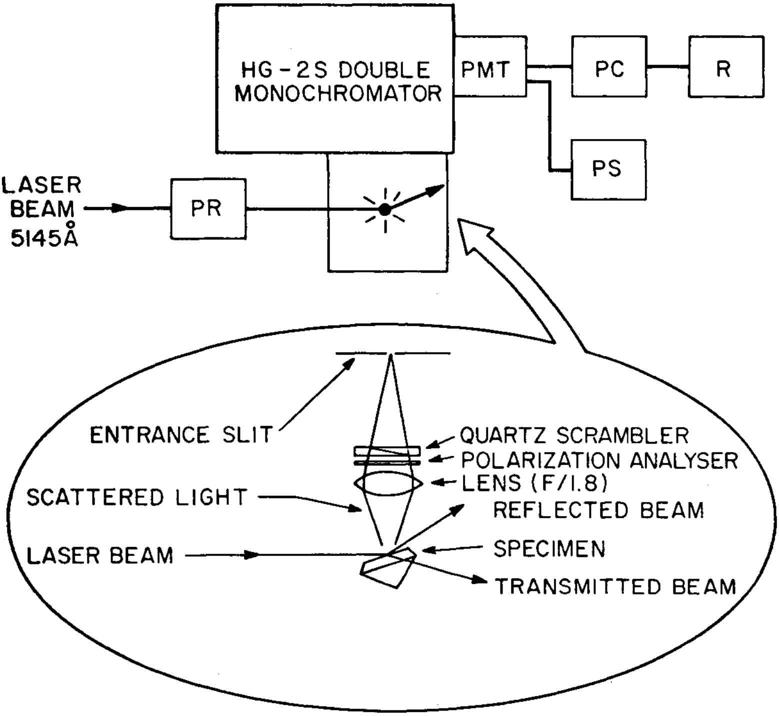

FIG. 4. Raman scattering apparatus. PR = polarization rotator, PMT = photomultiplier tube, PC = photon counter, PS = power supply, R = recorder.

0.9 to 2.6 cm^{-1}, full-scale count rate 10 000 to 100 000 c/s, time constant 0.01 to 0.1 s, and scan rate 50 cm^{-1}/min. Exact details are given elsewhere.(5) The cm^{-1} (wavenumber) scale gives the *Raman Shift* which is the change in frequency between incident and scattered light (conversion factors to other energy or to wavelength units have been given elsewhere(10)).

III. RESULTS AND DISCUSSION

Diamond—The Raman spectrum of natural diamond was first observed by Raman(11) and it is indistinguishable from that of the synthetic variety. Both show only a single intense narrow Raman band centred at 1332 cm^{-1}. The spectrum of diamond, shown in Figure 5, is typical for a natural white stone, a synthetic yellow, a synthetic blue and a synthetic white diamond.

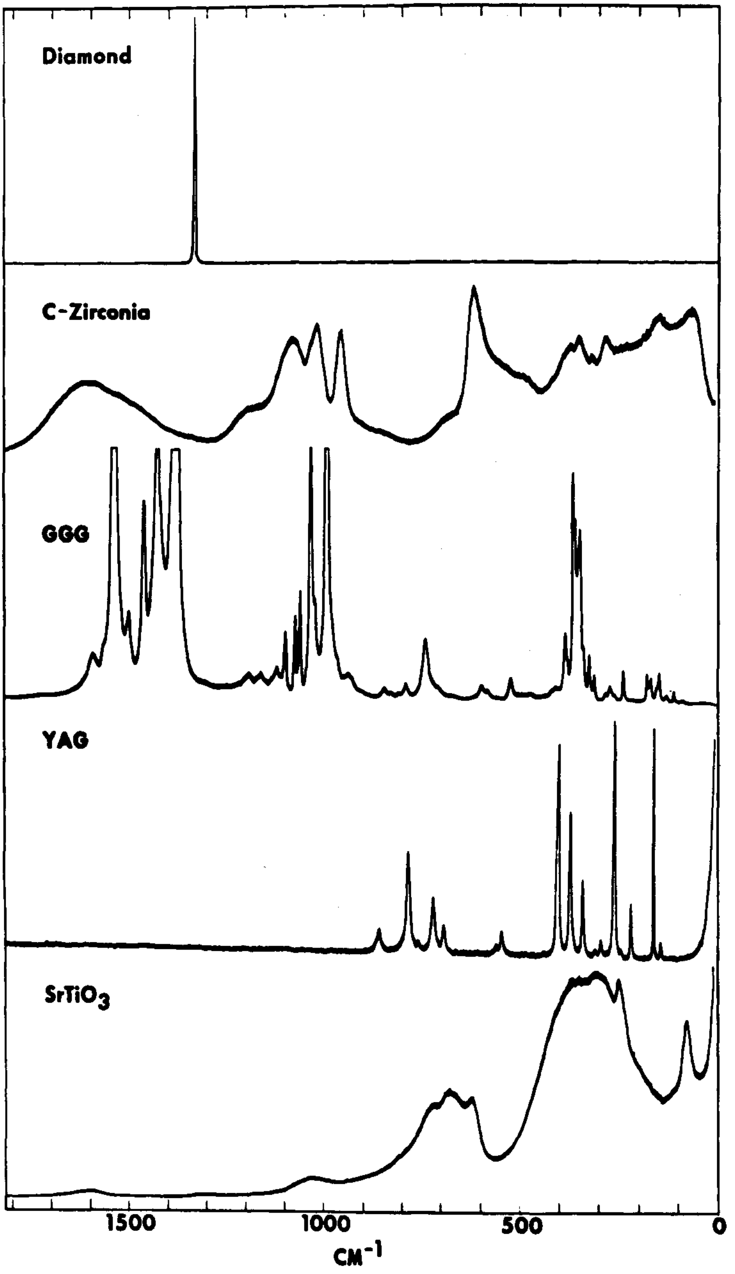

FIG. 5. Raman spectra of diamond and some diamond imitations.

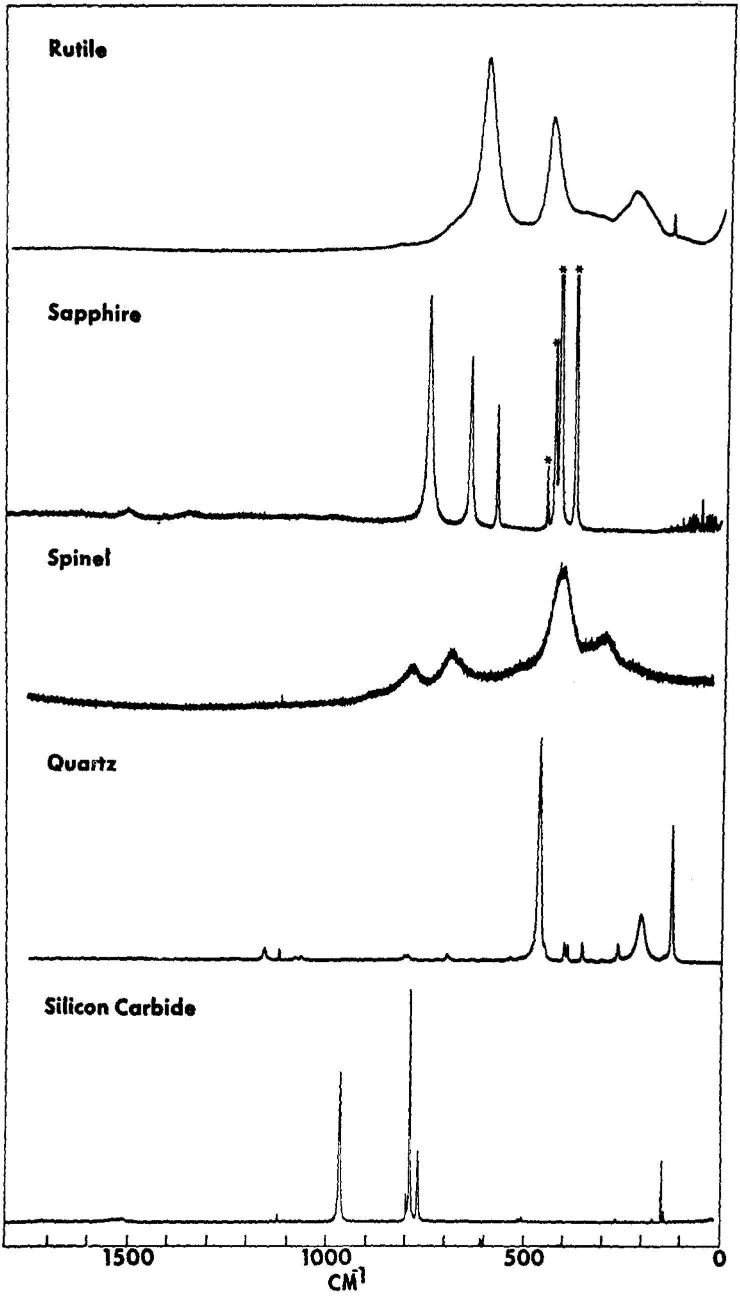

FIG. 6. Raman spectra of some diamond imitations. Lines marked with asterisks originate from light leakage from fluorescent room lighting.

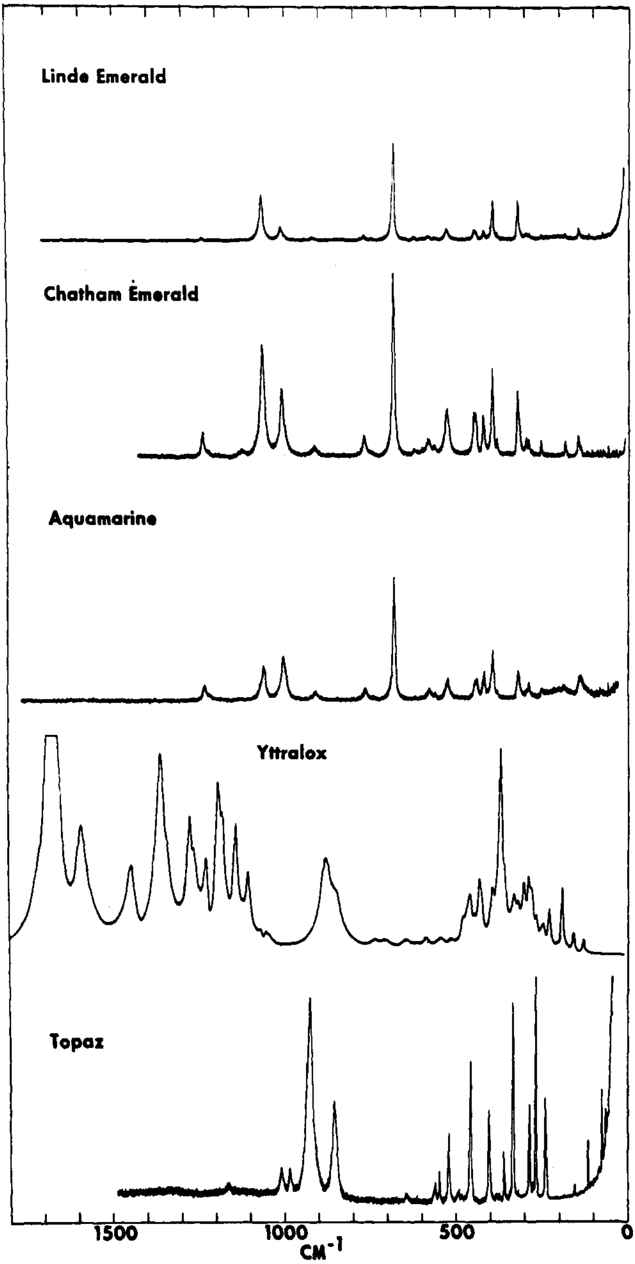

FIG. 7. Raman spectra of three beryls, yttralox, and topaz.

Cubic Zirconia—Zirconia (ZrO_2) commonly exists at room temperature as the monoclinic crystal baddeleyite(12) and its Raman spectrum has been known for some time.[13,14] Stabilization of the high temperature cubic form by addition of various additives has resulted in a room temperature *cubic* form that can be produced readily using a skull melting technique.(15,16) The appearance of cubic zirconia to the untrained eye is so much like that of diamond that it is displacing essentially all other diamond imitations.

The very strong Raman signals that originate in cubic zirconia cover a wide cm^{-1} wavenumber range (Figure 5). Perry *et al.*(17) recently reported spectra of cubic zirconia in which care was taken to study the effect upon the observed spectra of sample and polarization orientation. Accordingly, a crystal was oriented and polarized spectra are shown in Figure 8. Comparison of the cubic zirconia spectrum in Figure 5 with that of a 'Djevalite' spectrum of Figure 8 shows the effect of crystal axis orientation on the relative intensities of the bands. In Figure 5 the bands in the 700-1800 cm^{-1} region are prominent, as they are in the 'Ceres' spectra of Figure 8. The 'Djevalite' spectrum, on the other hand, shows these bands to be significantly reduced. Such variations are dependent on the orientation of the crystal axes with respect to the direction of propagation and polarization of the incident laser beam and to the polarization analysis of the scattered beam. Differences in stabilizer amount or type do not seem to be involved.

'Garnets': GGG and YAG—Gadolinium gallium and yttrium aluminium 'garnets' have been used as reasonably convincing diamond substitutes.(6) Their Raman spectra (Figure 5) are complicated and are significantly different from each other so that identification of these materials by Raman scattering is easy and convincing.

Strontium Titanate. A Raman spectrum of $SrTiO_3$ has been published previously.(18) As a substitute material for diamond in jewellery, $SrTiO_3$ has exceptional optical properties to recommend it but with an unfavourable softness. It is readily distinguishable from diamond without recourse to sophisticated techniques. Its Raman spectrum (Figure 5) is also distinctive and suitable for positive identification.

Other Diamond Imitations—The Raman spectra of rutile (TiO_2), sapphire (Al_2O_3), spinel ($MgO.xAl_2O_3$ with $1<x<5$, usually about 2.5), quartz (SiO_2), and silicon carbide (SiC) are shown in

Figure 6 and it is apparent that identification by Raman spectrum of each is straightforward. Both glass and plastics show variable Raman spectra, and may also show strong fluorescence. None of these materials is a serious contender with cubic zirconia as a substitute for diamond in jewellery at present, nor are these materials likely to emerge as such in the future.

Emerald, Aquamarine, Yttralox, and Topaz*—The Raman spectra, shown in Figure 7, allow easy identification of Yttralox, Topaz, and Beryl, but distinguishing between the various beryls (emerald, aquamarine, etc.) is probably not possible. Their spectra are qualitatively similar, differing only in the relative intensities of a few bands. The intensity ratios of the bands near 1065 and 1002 cm^{-1} are such that I_{1065}/I_{1002} are in the order Linde emerald > Chatham emerald > Aquamarine. For the pair of bands near 395 and 320 cm^{-1}, the intensity ratios I_{395}/I_{320} are in the reverse order, Aquamarine < Chatham emerald < Linde emerald. It is not known whether these trends would remain if a large number of samples were to be studied; it is also possible that these are orientation-polarization effects.

Doublet Structures—When the optical properties of a material mimic those of diamond and the value of this material is very low, the possibility exists for doublets to be made using the lesser valued material as the major component and a thin diamond platelet on the surface. If the fabricator is skilled, such a doublet structure might pass many of the tests for diamond, including the new Ceres 'Diamond probe' thermal conductivity instrument.(19) A doublet of cubic zirconia capped with a diamond platelet for example, would assume an apparent value far in excess of its real worth, and therefore positive identification of these structures is of importance. A gemmologist aware of such a possibility would, of course, recognize a doublet during the usual gem testing routine.(1)

A doublet, made from natural diamond and a 'Ceres' cubic zirconia crystal, was fabricated using a cyanoacrylate adhesive and was subjected to a Raman scattering experiment. The incident light beam entered at the diamond surface, passed through the outer platelet and also through the underlying cubic zirconia. The collection lens of the spectrometer was focused at the point of entry of the laser beam on the first surface. The acceptance cone of this

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*According to R. Webster, *Gems*, 3rd edn (1975), p.380, yttralox is an especially sintered polycrystalline product containing about 90% yttrium oxide and 10% thorium oxide.—Ed.

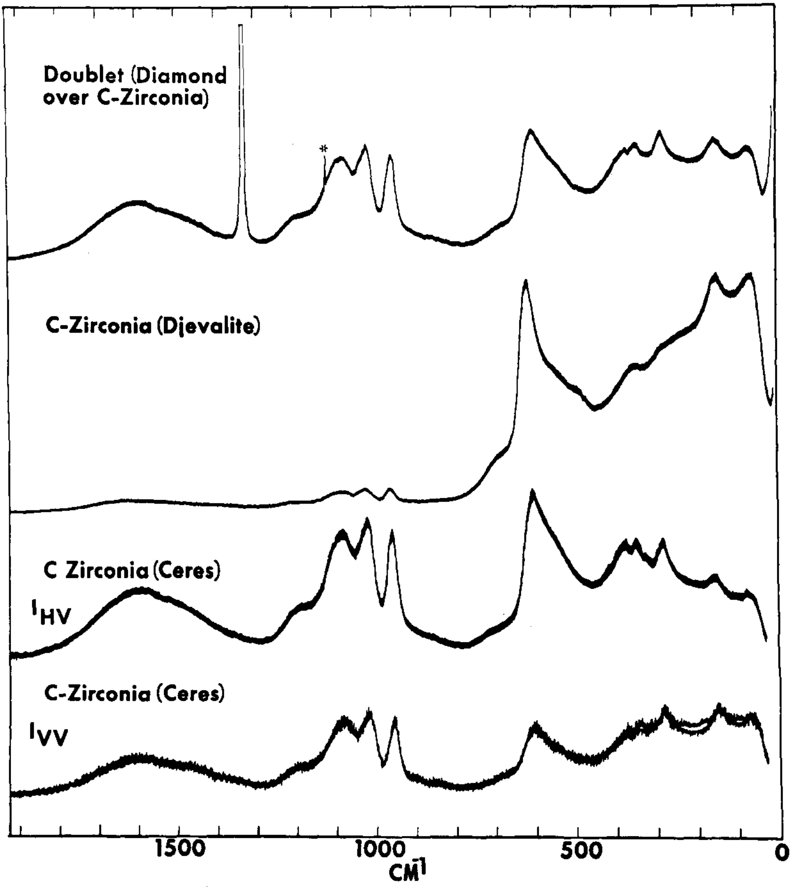

FIG. 8. Raman spectra of three cubic zirconias and of a diamond/cubic zirconia doublet.

lens was sufficient, however, to collect a large fraction of the Raman scattered light originating from both components of the sample. The result is shown in Figure 8 (top) where the observed spectrum, as expected, is a superposition of the spectra of diamond (Figure 5, top) and cubic zirconia (cf. Figures 5 and 8). The very narrow spike-like line at 1122 cm^{-1} that is marked with an asterisk is the 5460Å line of mercury originating from a laboratory fluorescent light. Conventional techniques can certainly be used to detect doublet structures. The Raman method, however, not only can detect doublet structures and identify the constituent parts, but can do so even when only the table facet is exposed without removing the stone from its setting.(Nevertheless, it still could not identify a 'diamond-air doublet', consisting of a diamond crown over a hollow mounting!)

A 'Nifty Gem' doublet with a sapphire crown (for its hardness) and a strontium titanate pavilion (for its high refractive index and dispersion) was also examined. In this case, the adhesive used in the fabrication fluoresced so strongly under laser excitation that the Raman bands of the crystalline components were completely masked. Thus it was immediately obvious that the specimen was not diamond. If the adhesive were carefully chosen to minimize fluorescence, then the spectra of the crystalline components would be obvious and identification of the components would follow. In either case, the technique is useful in identifying the existence of a multiplet structure.

Summary

A number of natural, synthetic, and imitation gemstone materials were characterized by their Raman spectra. Each was found to be readily identifiable as to its chemical composition and crystal structure, but not usually as to differences of colour or origin. In doublets, both materials can be readily identified even if only the table surface is accessible; if the adhesive fluoresces, then this prevents the identification but, nevertheless, reveals the stone as a doublet. Since Raman testing equipment is comparable in price to a visible-infrared spectrometer, say $(US)20,000 and up, it can hardly be recommended as a routine gemmological test instrument. Nevertheless, it could prove useful for solving some particularly difficult problems.

ACKNOWLEDGEMENTS

I wish to thank Dr J. E. Griffiths for permission to use our results, Doreen DiStefano for some of the Raman measurements and L. Kaplan & Sons, of New York City, for the loan of the diamonds used in this study. Figures 4 to 8 are reproduced with the permission of the *Journal of Applied Spectroscopy* (Reference 5); Figure 3 with permission of the American Chemical Society.

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TEST REPORT ON THE RIPLUS ER602 REFRACTOMETER

By PETER READ, C.Eng., F.G.A.

Until recently, the Rayner diamond-table refractometer(1,2) was the only commercially available instrument of this type which could measure refractive indices above 1.81. Even with this version, the top end of the measuring range is limited to 2.03 by the RI of the associated contact fluid.*

Last year, however, an alternative extended-range refractometer was developed by the Swiss mineral and gemstone company, Siber and Siber. This instrument, the Riplus ER602 (Figure 1), is currently being manufactured and marketed by the German optical company Krüss, of Hamburg. The following report is the result of tests made by the writer on two prototype ER602 refractometers.

The new refractometer is fitted with a strontium titanate measuring prism having an RI of 2.41. In order to improve on the limitations of earlier contact liquids, Siber and Siber have also developed a new contact 'fluid' having an RI of 2.22, and this enables the range of the instrument to be extended to 2.21.

The new 'Riplus Kleber' contact fluid is a viscous non-toxic brown paste, which only becomes free-flowing when heated to around 40 °C. To achieve this condition, the paste is contained in a small bottle which is placed in a heated socket in the refractometer's operating plinth.

The paste is maintained in its liquid state, when deposited on the instrument's table, by means of an electrical element (energized from a transformer in the plinth) which heats the strontium titanate prism to 40 °C.

Because of the high dispersion of the prism material (0.19) it is essential to use a monochromatic light source to avoid colour fringing and loss of sharpness in the instrument's shadow line, and for this reason the operating plinth is also fitted with a sodium

*West's solution (a saturated solution of white phosphorus and sulphur in methylene iodide): or Cargille's Series EH1 Index of Refraction liquids (maximum value 2.11). [Cargille liquids, obtainable from McCrone Research Associates Ltd, London, are formulated (in the 1.81 - 2.11 RI range) from arsenic tribromide, arsenic disulphide, sulphur and selenium. They are highly toxic and corrosive: quite unsuitable for general use in a jeweller's shop, they should be used only in strictly controlled laboratory conditions.—Ed.]

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FIG. 1. The Krüss Riplus ER602 refractometer uses a heated strontium titanate prism and a special contact paste. Its measuring range is 1.79 - 2.21

lamp. (For purchasers who already have a sodium light source, the refractometer can be obtained without the plinth unit, but with a separate transformer to supply the prism heater).

When the unit is switched on from cold, it takes approximately fifteen minutes for the paste and the prism to reach their operating temperature. A small quantity of the contact paste can then be applied to the table surface of the prism and spread out to form a 2 - 3mm diameter disc.

The gemstone under test is positioned on the paste and pressed down firmly to squeeze out any surplus material and thus obtain the thinnest possible contact layer. When moving the gemstone on the instrument's table, this must be done with care to avoid scratching the relatively soft surface of the strontium titanate prism.

The writer chose four brilliant-cut gemstones in the 1-carat size range to test the two prototype refractometers. Readings obtained on the instruments were as follows:

1. YAG, 1.825
2. Colourless zircon, 1.930, 1.990
3. GGG, 1.960
4. Cubic zirconium oxide, 2.175

All four stones gave repeatable readings on both refractometers, although the value measured for GGG's refractive index was lower than expected.(3) However, a reference(4) was later found which suggested that GGG had been manufactured by Bell Telephones with an RI as low as 1.92. A subsequent check on a Rayner diamond-table refractometer gave a reading of 1.965 for this specimen (a reflectivity meter reading and the specimen's orange fluorescence under SWUV confirmed that the stone was in fact a GGG).*

For a stone of a given size, the shadow line appeared to be fainter than that produced by a standard refractometer. However, for very small stones, the writer found that the shadow image could be enhanced by switching off the current supply to the refractometer's heater and allowing the film of contact paste to harden.

After each stone was tested it was necessary to clean the paste remnants from both the stone and the table of the prism by using a swab of cotton wool soaked in a solvent such as methylene chloride or methylene iodide.

Like the Rayner Diamond-table refractometer, the lower end of the ER602's range is somewhat restricted and starts at 1.79 (the Rayner version, with a sliding eyepiece, has a scale calibrated from 1.59), and it is assumed that a standard instrument is available for checking gemstones below this figure.

Although the testing of gemstones is necessarily a slower procedure using the ER602 and its associated contact paste, this was more than compensated for by the advantages of being able to determine the refraction of high RI gemstones to an accuracy of

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*See K. Nassau, *The optical constants of GGG,* J.Gemm., 1980, XVII(3), 148.—Ed.

three decimal places: and, as it is a critical-angle refractometer, birefringence can be measured in the usual way with the normal degree of accuracy.

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ANALYSIS OF A SIMPLE GEM-TESTING PHENOMENON

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ABSTRACT

A simple gem-testing method is described. An explanation and the critical condition for the occurrence of the phenomenon are presented. The method may be used to distinguish diamond from stones with RI below 2.37. Limitation of the method is discussed.

With the arrival of stabilized cubic zirconia as a diamond simulant, many attempts have been made to distinguish the two.(1,2) Detailed description of its properties has been given by Bossart,(3) and identification of it presents no problem to the gemmologist in the laboratory. Such identification tests, however, involve properties such as specific gravity, refractive index, dispersion, etc., or require instruments making use of thermal or electrical conductivities. Positive identification using conventional refractometers is not possible, since the material has RI above the refractometer value of 1.81. A simple and effective method without the use of special instruments is described by Hodgkinson.(4) This involves looking at

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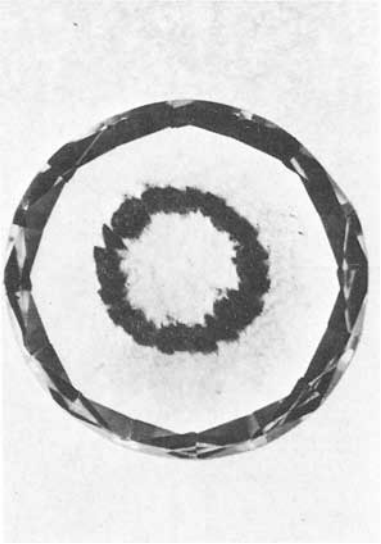

FIG. 1. Dot-ring observed in cubic zirconia.

FIG. 2. Dot-ring absent in diamond.

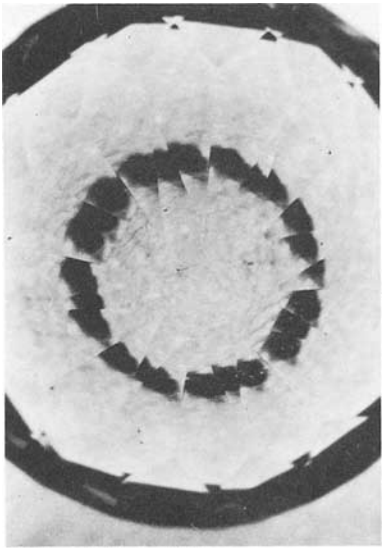

FIG. 3. Dot-ring observed in YAG.

FIG. 4. Dot-ring absent in strontium titanate.

the image of a distant light source through the stone and noting how large the angle is at which one sees the image. In this paper another convenient method is described, which is so simple that probably some jewellers have made use of it one time or another, perhaps in a slightly modified form. The explanation and the understanding of its limitation seem, however, lacking.

If a small dot is made (a pencil would do) on a piece of white paper, and a round brilliant-cut stone, such as synthetic white corundum or YAG, is placed symmetrically with table facet down on top of it, a dark ring can be seen if one looks down vertically on the stone (Figure 3). Actually the ring is made up of images of the dot through the pavilion facets. Depending on the width of the facets, the images may be close enough to appear as a continuous ring to the observer. The ring is very marked and no overhead lamp is required, if the room is properly illuminated. With stones such as diamond and strontium titanate no ring is seen (Figures 2 and 4). This is true only for round brilliant-cut stones which do not deviate appreciably from the ideal cut for diamond (i.e. pavilion angle about 41°). With cubic zirconia, again the ring is unmistakable (Figure 1). It seems, therefore, this simple observation may help to distinguish stones with RI above and below some critical value. The question to answer is: what is the critical refractive index of the stone, cut at a given pavilion angle, which is just about to display the ring? Conversely, with a given transparent gem material what is the critical angle (pavilion) with which it must be cut so that the ring will just appear? The answer lies in the understanding of the optical path taken by the light that reaches the eye of the observer.

For the full ring to be seen, light from the dot (since it is the contrast we see, whether light from the dot or its surroundings is immaterial) must reach the eye in the vertical direction from around the pavilion facets of the stone (Figure 5). This requires the light ray to travel in the stone in a definite direction, i.e. ray V making angle v with the vertical. Light rays in any other direction inside the stone will not emerge vertically. The relationship between v and p, the pavilion angle, is simply:

$$\sin p = n \sin (p-v)\,, \tag{1}$$

where n is the refractive index of the stone and is related to the critical angle for total internal reflection, θ_c, by

$$\sin \theta_c = 1/n\,. \tag{2}$$

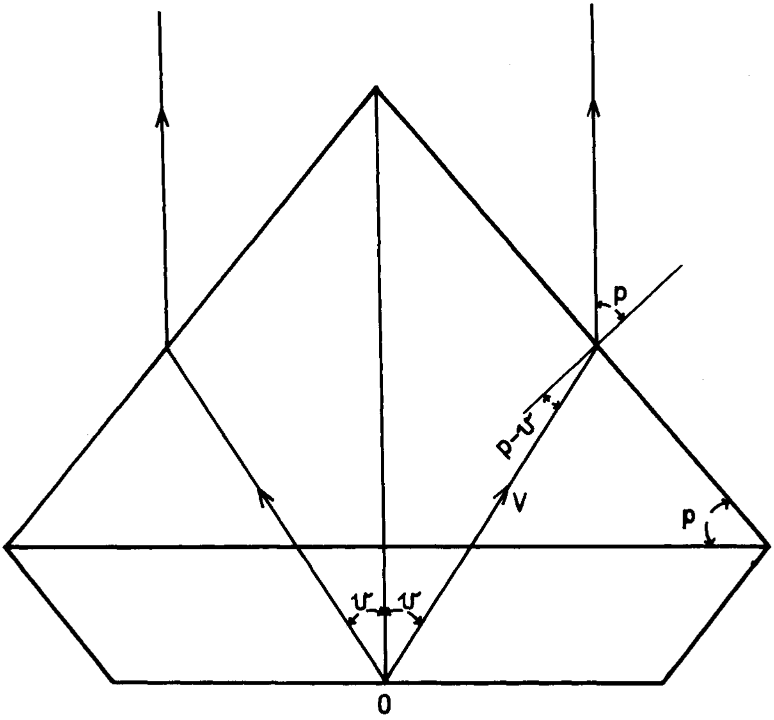

FIG. 5. The light path for observation of the dot-ring.

Since light from the paper is diffused it comes in all directions. For light entering the right hand portion of the stone, Figure 6 shows four such rays. Ray A which enters the stone horizontally is refracted at the critical angle θ_c and emerges from the pavilion facets. Rays B and C will enter the stone and be refracted at angles smaller than the angle θ_c. Ray D enters the stone normally. It does not require much convincing to see that all light upon entering the stone will be confined in directions between the vertical and the critical ray A′. All other directions (except those undergoing reflection within the stone) are not possible.

Now for some stones with low RI and suitable pavilion angle, ray A may emerge from the pavilion facets on that side of the vertical *away* from the culet of the stone. This would be the case if angle θ_c is greater than angle v defined in (1). Such a stone is then ring-positive, i.e., the ring can be seen, because among all the

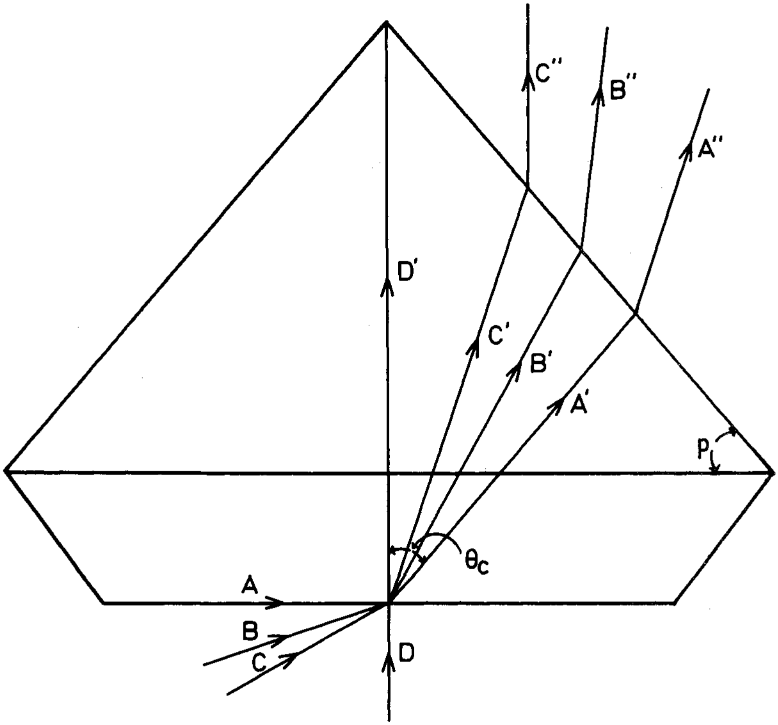

FIG. 6. A dot-ring positive stone. Light rays are confined within angle θ_c inside the stone. $\theta_c > v$.

possible rays there must be one that satisfies condition (1). On the other hand, for stones with higher RI and suitable pavilion angles the critical angle θ_c can be smaller than angle v and the light emerging from the pavilion facets will be directed on that side of the vertical *towards* the culet of the stone (Figure 7), and no light can be seen in the vertical direction.* Such stones must be ring-negative, because no light can emerge vertically. It is appropriate here to point out that it is irrelevant at which point light enters the table facet; it is the directions of the light rays that matter. For convenience the centre of the table facet is taken as the point where light enters the stone in the illustrations.

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*For stones of sufficiently high RI it is possible that ray A′ is totally internally-reflected at the pavilion facet and no refracted ray emerges at all. The condition for this to happen is $p - \theta_c > \theta_c$, and for $p = 41°$, the corresponding refractive index must be greater than 2.86.

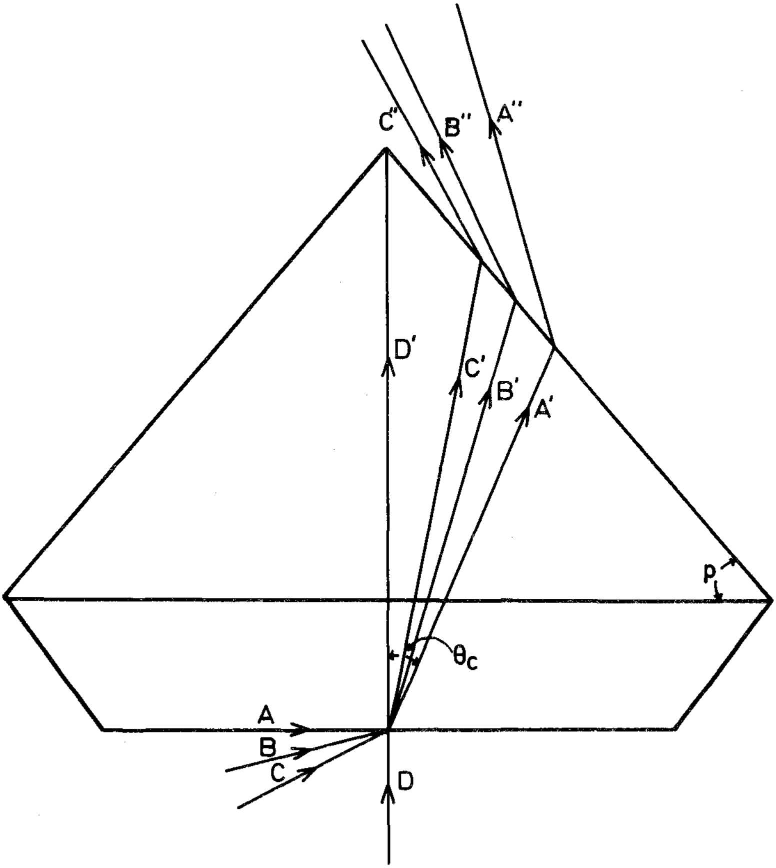

FIG. 7. A dot-ring negative stone. $\theta_c < v$.

To summarize:

$\theta_c > v$ ring-positive
$\theta_c < v$ ring-negative

It is interesting to compare angles θ_c and v for different gems cut at different pavilion angles. Equation (1) has an admissible solution for v:

$$\sin v = \frac{\{n^2\sin^2(2p) + 4n^2(n^2-1)\sin^2 p\}^{1/2} - n\sin(2p)}{2n^2} \tag{3}$$

Table 1 lists v for different gems cut at pavilion angles p = 39, 40, 41, 43. The critical angles are calculated from (2) with RI values

θ_c p	39°	40°	41°	43°
Spinel 35.31°	17.67°	18.19°	18.71°	19.78°
YAG 33.12°	18.89°	19.44°	19.99°	21.12°
Cubic Zirconia 27.44°	22.17°	22.77°	23.40°	24.68°
Strontium Titanate 24.52°	23.86°	24.53°	25.20°	26.56°
Diamond 24.41°	23.93°	24.60°	25.27°	26.63°

Table 1. Angle v (equation 3) for various pavilion angles p and different materials.

1.73, 1.83, 2.17, 2.41, 2.42 for synthetic spinel, YAG, cubic zirconia, strontium titanate and diamond respectively. It can be seen from the table that among the 5 stones only strontium titanate and diamond with $p > 40°$ satisfy $\theta_c > v$, i.e. ring-negative. All others are ring-positive. It is interesting to note that at $p = 39°$, $\theta_c > v$ even for diamond, i.e., the ring appears even for diamond. Hence the dot-ring method (a name proposed for easy reference and to avoid confusion with the red-ring test for garnet-topped doublets) depends on both the RI of the stone and the pavilion angle at which it is cut. Since the majority of the diamond is cut with the pavilion angle close to 41° so as not to lose its brilliance, the method can be useful for those who wish to make a quick judgement.

Following the argument given above, the condition for the dot-ring to be just about to appear is obviously $\theta_c = v$. Combining this with equations (1) and (2) one obtains for the critical condition

$$\sin \theta_c \sin p = \sin (p - \theta_c) \qquad (4)$$

Given p, the critical angle θ_c and hence the critical refractive index n_c can be obtained.

The solution is:

$$n_c = \left\{ \sin \left[\tan^{-1}\left(\frac{\tan p}{1+\tan p}\right) \right] \right\}^{-1} \tag{5}$$

Table 2 lists the critical refractive indices n_c for various angles p. At $p = 41°$, n_c is 2.37. This value lies between the refractive indices of cubic zirconia and diamond and provides therefore a handy and simple test to distinguish the two.

p	39°	40°	41°	42°	43°
n_c	2.45	2.41	2.37	2.34	2.30

Table 2. Critical refractive indices (for the dot-ring to be observed) for different pavilion angles p.

On the other hand, if a transparent gem material is given, the critical pavilion angle p_c which will permit the dot-ring to be seen can be obtained from equation (4). The solution is

$$p_c = \tan^{-1}\left(\frac{\tan \theta_c}{1-\tan \theta_c}\right) \tag{6}$$

For diamond the critical pavilion angle p_c is 39.72° i.e. with p less than 39.72° diamond is dot-ring positive. This is in accord with Table 1 and previous discussions. This implies the dot-ring test fails for such cases. For cubic zirconia the critical angle p_c is 47.20°. Hence if cubic zirconia is cut with a pavilion angle greater than 47.20°, it will be dot-ring negative. Again the test fails in this case. The author, however, has not yet encountered a dot-ring positive diamond or a dot-ring negative cubic zirconia.

In conclusion, for round brilliant-cut stones the dot-ring test is a quick and simple method to distinguish stones with RI above and below a critical value depending on the pavilion angle, and typically about 2.37. If the stone has RI above this critical value, no ring is seen, while for stones with RI below this value, the dot-ring appears. One must be aware, however, of the pavilion angle of the specimen. If the angle can be measured independently, the analysis given in this paper helps one to decide whether the test is valid or not. It should be noted that, strictly speaking, the analysis given in this paper applies to isotropic materials only, i.e. singly refracting stones. Double refraction obviously presents complicating problems that lie beyond the present discussion, although doubly refracting stones, such as corundum, with RI below the critical value, also display the dot-ring clearly.

Appendix on Equations (3), (5) and (6)

Derivation of equations (3), (5) and (6) requires only a knowledge of elementary trigonometry and simple algebra. The following trigonometric identities for any angles A and B will be used:

$$\sin(A-B) = \sin A \cos B - \sin B \cos A \qquad \text{(i)}$$

$$\sin^2 A + \cos^2 A = 1 \qquad \text{(ii)}$$

$$2 \sin A \cos A = \sin 2A \qquad \text{(iii)}$$

$$\tan A = \frac{\sin A}{\cos A} \qquad \text{(iv)}$$

Equation (1) can be rewritten as, using (i) above,

$$\sin p = n (\sin p \cos v - \sin v \cos p).$$

Rearranging and squaring, one gets

$$(\sin p + n \sin v \cos p)^2 = n^2 \sin^2 p \cos^2 v$$
$$= n^2 \sin^2 p (1 - \sin^2 v).$$

This reduces easily to

$$n^2 \sin^2 v (\cos^2 p + \sin^2 p) + 2n \sin p \cos p \sin v - (n^2 - 1) \sin^2 p = 0$$

or,

$$n^2 \sin^2 v + n \sin 2p \sin v - (n^2 - 1) \sin^2 p = 0.$$

This is a quadratic equation in sin v, identical to

$$ax^2 + bx + c = 0,$$

with $a = n^2$, $b = n \sin 2p$, $c = -(n^2 - 1) \sin^2 p$, and $x = \sin v$.

The solution to this equation is

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}.$$

Substituting a, b, c from above, one obtains equation (3) for sin v, where the solution with negative sign before the square root has been discarded because it leads to a negative value for sin v, an inadmissible situation.

Equation (4) can be rewritten as

$$\sin \theta_c \sin p = \sin p \cos \theta_c - \sin \theta_c \cos p \quad \text{from (i)},$$

or $\tan \theta_c (\sin p + \cos p) = \sin p$

giving

$$\theta_c = \tan^{-1}\left(\frac{\tan p}{1 + \tan p}\right)$$

$$\therefore n_c = \frac{1}{\sin \theta_c} = \frac{1}{\sin \left[\tan^{-1}\left(\frac{\tan p}{1 + \tan p}\right) \right]}$$

which is equation (5).

Similarly from (4),

$$\sin\theta_c \sin p = \sin p \cos\theta_c - \sin\theta_c \cos p$$

or $$\frac{\sin p}{\cos p}(\sin\theta_c - \cos\theta_c) = -\sin\theta_c$$

or $$\tan p = \frac{\sin\theta_c}{\cos\theta_c - \sin\theta_c} = \frac{\tan\theta_c}{1 - \tan\theta_c}$$

or $$p = \tan^{-1}\left(\frac{\tan\theta_c}{1 - \tan\theta_c}\right)$$

which is equation (6), where we have written p_c for p to emphasize that this solution is the *critical* pavilion angle.

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NOTE ON THE AIR-BOUNDARY REFRACTOMETER

By R. M. YU, Ph.D., F.G.A., and D. HEALEY, Ph.D., F.G.A.
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Since the publication of our article concerning a new refractometer *(J.Gemm.,* 1979, XVI (8), 521-36) we have received several comments worthy of attention. Much confusion resulted from the fact that the phrase at the bottom of p.523 should have read 'at an angle JDK *larger* than θ_1.' Also the first and second paragraphs of p.525 refer to the situation of Figure 1a of the paper rather than Figure 1 as implied in the text. To clarify the issues here we give a simplified summary of the principles involved in the instrument and discuss the effect of different methods of illuminating the gem.

The basic idea of the instrument is that, with reference to Figure 1 below, a transition from partial reflection (ray R) to total internal reflection (ray R′) occurs for rays striking the table facet from within the gem at incident angle θ_C, the critical angle for total internal reflection. As indicated in the diagram, such a ray incident

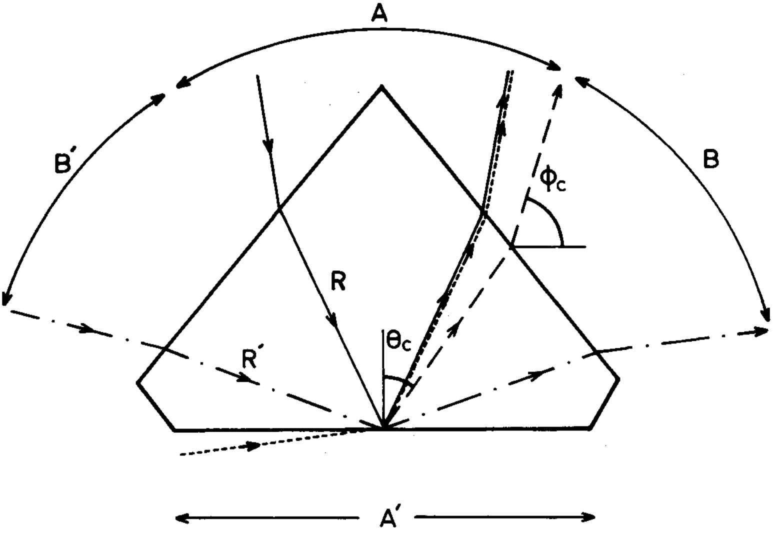

FIG. 1

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at θ_C on the table would leave the pavilion facet at angle ϕ_C to the horizontal. ϕ_C is thus determined by the refractive index of the gem and the pavilion angle (also measured by our instrument). Thus for given (or measured) pavilion angle a measurement of ϕ_C determines the refractive index.

The comments received are of two types. Firstly, as the eye of the observer moves from the region A ($\phi > \phi_C$) to the region B ($\phi < \phi_C$), what change does one observe? Secondly, is this change sharp enough so that ϕ_C and hence the refractive index may be determined with sufficient accuracy?

The first of these comments may easily be dealt with. When observations are made with the eye in region A ($\phi > \phi_C$), one is observing light transmitted from the region A′ below the table (together with any light partially reflected at the table), while for the eye observing from region B ($\phi < \phi_C$) any light observed comes from B′ outside the opposite pavilion facet. In our instrument region A′ is illuminated and region B′ is not, hence as the angle of observation moves from region A to region B a transition occurs from light to dark. It should be noted, however, that if the gem were to be placed table face down on a mat black surface and the pavilion area illuminated the light/dark transition would occur in reverse order. Thus we see that exactly what is observed as the observation angle ϕ passes through ϕ_C is determined by the method of illuminating the gem.

Comments regarding the sharpness of the light/dark transition are difficult to answer in quantitative terms, since ultimately one is involved with the ability of the human eye to distinguish different levels of illuminations, unless, of course, photo-detection of the transition is contemplated. Firstly we would agree with readers who point out that both the absolute reflectivity and the change in reflectivity is small for small variations in angle about the critical angle. However, in our instrument with the gem illuminated from below and the side facets in darkness the reflectivity variation contributes nothing since no light is reflected via the table from B′ to B. By contrast as soon as the eye observes from region A it may receive light, however weak, from the illuminated area A′ underneath the table. We can only emphasize that the transition is sufficiently sharp to enable ϕ_C and hence the refractive index to be determined to the accuracy given in our article, an accuracy somewhat less than that given by (say) the Rayner refractometer, which incidentally also determines the RI by observing a light/dark transition occurring at total internal reflection.

For readers who still remain sceptical about the sharpness of the transition we can only suggest, failing the construction of the refractometer, the following experiment. Place a brilliant-cut gem (e.g. YAG) table face down on a black cloth, the light/dark transition will now occur in reverse order to that in the instrument. The gem should now be observed from vertically over the pavilion when the black cloth will be observed through the gem. As the angle of observation is lowered, viewing the black cloth through a pavilion facet, a point will come when total internal reflection occurs at the table facet and the black cloth will no longer be 'visible' but rather one will see a bright facet—actually one is observing light coming into the gem through the opposite pavilion facet. This simple experiment should help convince readers both of the nature and the sharpness of the transition. Since in this experimental set-up the illuminated region is viewed by internal reflection at the table facet, the low level of reflectivity near the critical angle reduces the sharpness of the transition, though we would claim that even under these adverse conditions it is still fairly sharp. It should also be noted that with observations made in region A, in principle light can reach the gem from both B′ and A′ whereas for observation made from region B only light from B′ (if any) could be reflected into the eye at the table/air boundary. In our instrument, with the gem illuminated from below the table, the light/dark transition appears to be sharper than in the experimental set up described above and hence enables a reasonably accurate determination of the refractive index.

[*Manuscript received 15th September, 1980.*]

GEMMOLOGICAL ABSTRACTS

ARGUNOV (K. P.), KIRIKILITSA (S. I.), MALOGOLOVETS (V. G.), POLKANOV (Y. A.). (X-ray luminescence of fine natural and synthetic diamonds.) (In Russian.) Mineralogicheskii Zhurnal, 2, 97-101, 1980.

Fine stones of different origin show weak x-ray luminescence. A brighter luminescence is shown by stones from the Yakut ASSR than that shown by stones from the East European platform and from Kazakhstan. M.O'D.

BALL (R. A.) *Letter to the Editor.* Aust. Gemmol., **14**, 1, 23, 2 figs, 1980.

Points out that while sedimentary opals (most colour-play opals) are essentially amorphous, volcanic opals (Mexican fire opal, etc) display disordered cristobalite-tridymite structures and are partially crystalline. [Figs need some explanation and appear to have been cropped, which has partly destroyed the evidence they are supposed to convey.] Reference to a paper in J. Geol. Soc. Aust. (1971) mentions Opal-A, Opal-CT or Opal-C [for which see abstract in J. Gemm., 1972, XIII (3), 107]. A further reference is to a paper by J. V. Sanders in Am. Mineral. (1975) [abstracted in J. Gemm., 1976, XV (3), 145]. R.K.M.

BARNES (V. E.), EDWARDS (G.), MCLAUGHLIN (W. A.), FRIEDMAN (I.), JOENSUU (O.). *Macusanite occurrence, age and composition, Macusani, Peru.* Bull. Geol. Soc. America, **81**, 1539-46, 3 figs, 1970.

The natural glass called macusanite after its location, Macusani, Peru, is to be related to sillar of the same region by K-Ar measurements. These give identical Pliocene ages for sillar and macusanite (4.2 million years) and relate the deposits to ash flows of the southern Andes. Macusani is located 70° 27′ W, 14° 4′ S, on the north-eastern slope of the Andes at about 4300m elevation. M.O'D.

BEDOGNÉ (F.). *Val Malenco.* Lapis, **5**, 6, 9-13, 9 figs (3 in colour), 1980.

The Val Malenco in northern Italy is celebrated for its andradite, which is described here. A map of the area is included. M.O'D.

BOSCH FIGUEROA (J. M.), MONES ROBERDEAU (L.). *Nuevas tecnicas de observación de la luminiscencia en diamantes y en algunos de sus substitutos.* (New techniques for the observation of luminescence in diamond and some of its substitutes.) Gemologia, **11**, 43/44, 7-12, 16 figs (12 in colour), 1980.

Luminescence in diamond and some of its substitutes was examined by the authors with a specially designed luminoscope with accompanying camera. Various temperatures were used for the study and the results illustrated in colour. In addition to diamond, synthetic corundum and spinel, YAG and GGG were examined. M.O'D.

BROWN (G.). *Corallium precious corals. Part two.* Aust. Gemmol., **14**, 1, 14-19, 9 figs, 1980.

This continuation of Part 2 of this paper* (begun in the previous issue) contains the references for the whole paper, and establishes by thin section microscopy that *Corallium rubrum* is composed chiefly of internally secreted calcite spicules rather than the externally secreted aragonite skeletons found in other corals. The spicules move down with age to fuse into the consolidated axis of red coral. Red corals have a diffuse absorption band centred at 495nm and no fluorescence under LWUV. Paler shades fluoresce with increasing strength as the absorption becomes weaker. Conclusions: *Corallium* corals are structurally different from reef-building corals and are modified gorgonian corals. They may be identified by characteristic thin longitudinal striations, RI and SG where necessary. [Thin section microscopy, while interesting, has little practical application in gemmology.] R.K.M.

CASSEDANNE (J.), CASSEDANNE (J.). *Note sur l'andalousite gemme de la Chapada Diamantina.* (Gem andalusite from the Chapada Diamantina.) Revue de Gemmologie, **63**, 15-17, 3 figs (2 in colour), 1980.

The Chapada Diamantina lies in the centre of the state of Bahia, Brazil. Andalusite is found alluvially; the colour is yellow-green to peridot green, hardness 7.5 and SG 3.15. RI is 1.638, 1.642, 1.649, DR 0.011. Pleochroic colours are yellowish-red to orange. Small hematite inclusions were noted. Strong absorption is found between just short of 700nm to 510nm, with other bands at 550-560nm and 520nm. The material is inert under ultra-violet light. M.O'D.

DEINES (P.). *The carbon isotopic composition of diamonds: relationship to diamond shape, color, occurrence and vapor composition.* Geochimica et Cosmochimica Acta, **44**, 7, 943-61, 1980.

330 new ^{13}C analyses of diamonds are presented. Among other conclusions presented is a note that stones from the Premier and Dan Carl mines, South Africa, show that differences in ^{13}C content that can be related to diamond colour and shape are smaller than 1‰ and that the mean ^{13}C content of kimberlite carbonates is 1-2‰ lower than that of associated diamonds. It was also found that there were significant differences in ^{13}C content between the two pipes. M.O'D.

DELE-DUBOIS (M.-L.), DHAMELINCOURT (P.), SCHUBNEL (H.-J.). *Etude par spectroscopie raman d'inclusions dans les diamants, saphirs et émeraudes-1.* (Raman spectroscopic study of inclusions in diamonds, sapphires and emeralds.) Revue de Gemmologie, 63, 11-14, 11 figs (1 in colour), 1980.

Raman spectroscopic techniques are used to examine inclusions in diamond, sapphire and emerald, though only the first two stones are examined in this part of the paper. M.O'D.

GRAZIANI (G.), GUIDI (G.). *Euclase from Santa do Encoberto, Minas Gerais, Brazil.* Am. Miner., **65**, 183-7, 4 figs, 1980.

Euclase from Santa do Encoberto, county of São Sebastião do Maranhão, Minas Gerais, Brazil, contains previously undescribed inclusions of hexagonal

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*Abstracted in J.Gemm., 1980, XVII (3), 182.—Ed.

apatite crystals, hematite plates, minute needles of rutile and rounded grains of zircon. The crystals are doubly terminated, milky or transparent, ranging up to several centimetres in length. M.O'D.

HÄFLIGER (I.), SIBER (H.), WEIDERT (W.). *Stein ist nicht gleich Stein. Mineraleigenschaften für den Hobbyschleifer.* (No two stones are alike. Mineral characteristics for the ameteur cutter.) Mineralien Magazin, **4**, 4, 161-4, 7 figs in colour, 1980.

Illustrates and describes Mohs's scale of hardness. M.O'D.

HARDER (H.). *Edelsteine durch Brennen von Korunden.* (A gemstone from heating corundum). Fortschritte der Mineralogie, **58**, 1, 45-6, 1980.

Describes the use of heating as a treatment for alteration of colour in corundum. M.O'D.

HOPPE (R.). *Diamonds from the Kalahari.* Engineering and Mining Journal, **181**, 5, 64-74, 5 figs (4 in colour), 1980.

Describes the operation of the Orapa mine from which 15 000 ct of diamond are recovered daily. About 2300 ct are of gem quality. Recovery methods are based on x-rays. M.O'D.

KVASNITSA (V. N.), MALOGOLOVETS (V. G.), VISHNEVSKY (A. A.), KHARKIV (A. D.). *IR absorption spectra of fine natural diamonds.* Mineralogicheskii Zhurnal, 2, 95-7, 1980.

IR absorption spectra of fine stones from eclogitic xenolith, Yakutian kimberlites and Ukrainian placers show systems of the $A_1B_1B_2$ bands from nitrogen which are common to naturally occurring diamonds. M.O'D.

LIEBER (W.). *Sri Lanka—die strahlende Insel.* (Sri Lanka, the shining island.) Lapis, **5**, 6, 14-19, 10 figs (6 in colour), 1980.

A general review of gemstone recovery in Sri Lanka with a map of the island showing the main gemstone-producing areas. M.O'D.

MOREL (B.). *Les joyaux de la couronne de France à la veille de la revolution.* (The French crown jewels on the eve of the revolution.) Revue de Gemmologie, **63**, 2-8, 6 figs, 1980.

The major items in the French regalia are described with particular reference to the stones contained in them. M.O'D.

NASSAU (K.). *The history and present status of the synthetic quartz family—1.* Lapidary Journal, **34**, 3, 718-26, 10 figs, 1980.

Describes the beginnings of the work on quartz grown by the hydrothermal method with illustrations of the aparatus used. M.O'D.

PLYUSNINA (I. I.). *Infrared spectra of opals.* Sov. Phys. Dokl., **24**, 332-3, 1 fig, 1979 (publ. 1980). Transl. from Dokl. Akad Nauk SSSR, **246**, 606-9, 1979.

Specimens selected to form a transitional series from chalcedony to opal yield IR spectra which vary systematically. The extremes are correlated with chalcedonies which are cryptocrystalline quartz and with x-ray amorphous opal, intermediate members of the series involving disordered quartz, disordered cristobalite, and, over a short range, some tridymite. In the IR spectra the absorption bands near 510, 560, and 950 are eliminated in this transition, whereas the more prominent bands near 475, 815, and 1120cm^{-1} persist. A.P.

POUGH (F. H.). *Chrysoberyl.* Lapidary Journal, **34**, 3, 792-5, 1980.

Cursory review of the chrysoberyl family with reference to African deposits. M.O'D.

READ (P. G.). *Computer-aided identification of gem diamond simulants.* Industr. Diamond Rev., 167-9, 6 figs, 1980.

The use of data storage and associated diagnostic techniques made possible by present-day low-cost computers is discussed. R.A.H.

SCHMETZER (K.), BANK (H.). *Explanations of the absorption spectra of natural and synthetic Fe- and Ti-containing corundums.* Neues Jahrbuch für Mineralogie Abhandlungen, **139**, 2, 216-25, 3 figs, 1980.

Natural sapphires were heated and their absorption spectra examined before and after treatment. A weakening of the absorption bands at 17 880cm^{-1} and 14 300cm^{-1} was noted after heating and this applied to stones from all the localities studied. From some only of the occurrences fresh bands at 11 500 and/or 20 000cm^{-1} were produced or enhanced. The bands at 20 000cm^{-1} are attributed to Ti^{3+} d-d transitions; bands at 17 880/14 300cm^{-1} and 11 500cm^{-1} are independent from each other and their intensities are ascribed to the respective concentration of Fe^{2+} and Ti^{4+}. M.O'D.

SCHMETZER (K.), BANK (H.), GÜBELIN (E.). *The alexandrite effect in minerals: crysoberyl, garnet, corundum, fluorite.* Neues Jahrbuch für Mineralogie Abhandlungen, **138**, 2, 147-64, 1980.

The article discusses the absorption spectra of alexandrite-like minerals with notes on the cause of the colour change. Alexandrites show strong bands of Fe^{3+} and Cr^{3+} on octahedrally co-ordinated lattice sites. Alexandrite-type garnets fall into two classes: the chromium-rich pyropes and the vanadium- or chromium-bearing spessartine-rich pyropes. Absorption maxima of Cr^{3+} ($^4T_2 \leftarrow {}^4A_2$) and V^{3+} ($^3T_2 \leftarrow {}^3T_1$) in both groups are in the same spectral region, about 17 500cm^{-1}. Alexandrite-like natural corundum shows spectra attributed to superposition of d-d transitions of Cr^{3+}, Fe^{3+} and V^{3+} in addition to charge transfer bands of Fe^{2+}/Ti^{4+} and Fe^{2+}/Fe^{3+}. Alexandrite-like fluorite shows absorption bands of Y^{3+}, Ce^{3+} and Sm^{2+}. All colour changing minerals show absorption minima between 15 000 and 16 000cm^{-1} and between 19 700 and 21 000cm^{-1}, in addition to a strong maximum between 17 300 and 17 800cm^{-1}. M.O'D.

SCHMETZER (K.), GÜBELIN (E.). *Alexandrite-like natural spinel from Sri Lanka.* Neues Jahrbuch für Mineralogie Monatshefte, 9, 428-32, 2 figs, 1980.

A spinel with a colour change from violet in daylight to reddish-violet in artificial light had 2.27% FeO, 0.06% Cr_2O_3 and 0.03% V_2O_3. In the absorption spectrum bands caused by Fe^{2+}, Cr^{3+} and V^{3+} are superimposed. M.O'D.

Schöttler (G.). *Synthese, Dublette, Imitation.* (Synthetics, doublets, imitations.) Lapis, **5**, 6, 25-7, 5 figs (in colour), 1980.

A general survey of the man-made gemstone field with notes on alteration of colour and simple identification techniques. M.O'D.

Shaub (B. M.). *Genesis of agates, geodes, septaria and other concretions of sedimentary origin-1.* Lapidary Journal, **34**, 3, 650-62, 7 figs (5 in colour), 1980.

The geological origin of sedimentary bodies is explained with special reference to North American occurrences. M.O'D.

Taylor (J. B.). *Pleochroscopes.* Aust. Gemmol., **14**, 1, 3-12, 7 figs, 1980.

A rather elaborate account of monochroscope (single polar?), dichroscope, and a postulated, but as yet uninvented, trichroscope. (Contains some small misconceptions.) R.K.M.

Yefimova (E. S.), Sobolev (N. V.). *Abundance of crystalline inclusions in Yakutian diamonds.* Doklady Akad. Nauk SSSR, **237**, 1/6, 231-3, 1980.

Olivine and chromite predominate among the inclusions in diamonds from Yakutia; in the pipes of Aykhal and Udachnaya olivine is more common than chromite, while in the Sytykan and Mir pipes the two minerals are found in roughly equal quantities. In these four pipes crimson garnets are found more commonly than orange ones, while in the pipes of the northern part of the Siberian platform the reverse is the case. M.O'D.

Zeitner (J. C.). *Notes about blue stones.* Lapidary Journal, **34**, 3, 780-8, 11 figs, 1980.

A brief reviews of blue gem and ornamental stones with particular reference to those found in the United States. M.O'D.

BOOK REVIEWS

Becker (V.). *Antique and twentieth century jewellery.* NAG Press, London, 1980. pp.301. Illus. in black-and-white and in colour. £15.00.

This is an exceptionally well-produced book, and for the price it is a real bargain—probably the last opportunity this reviewer will have to make this comment, such are the costs in the printing trade today. It can be read through in a (long) sitting, is not too heavy to be carried about with comfort, and the paper is of reasonable quality. For so reasonably-priced a work the colour reproduction is very good, and, since the book depends a good deal on this, it can be counted a great success.

So large a range of possible objects, materials and styles could have been introduced that almost any scheme of arrangement would have been in order. The author has elected to cover a range of subjects and within those confines to treat the matter chronologically. In this way chapters on diamond brooches, coral jewellery, goldwork of the nineteenth century, pique, stick pins, animals in jewellery, find their place. Celebrated figures such as A. L. Liberty and his contemporaries have a chapter to themselves.

There is a bibliography and an index. Students of jewellery should make every effort to buy this book. M.O'D.

EMBREY (P. G.), FULLER (J. P.), ed. *A manual of new mineral names, 1892-1978.* British Museum (Natural History) and Oxford University Press, London and Oxford, 1980. pp.ix, 467. £24.00.

From time to time lists of new mineral names have appeared in Mineralogical Magazine and there have been 30 such lists since 1897. The lists do not include names which are already established but do show a variety of discredited, alternative and trade names, some of the latter being descriptive of gem materials. About 50 new names are accredited each year. Entry is alphabetical with references to the original list and to significant papers being provided. This is in every sense a major reference work and one to be obtained by all serious students of mineralogy; standard of production is high and the price not unreasonable for a reference work today. M.O'D.

HOCHLEITNER (R.). *Fotoatlas der Mineralien und Gesteine.* (Photoatlas of minerals and stones.) Gräfe und Unzer, Munich, 1980. pp.237. Illus. in black-and-white and in colour. DM 68.

This well-produced book includes 400 photographs in colour in addition to 600 diagrams in the text. It is aimed at the 'educated beginner', since a fair knowledge of, or at least interest in, minerals is assumed. The concise specimen descriptions seem to confirm this supposition. Each of the 400 minerals described and illustrated has been well chosen; the quality of the selections is quite high without being too outstanding. The photographs, of the high quality necessary today, are accompanied by brief notes on the hardness, specific gravity, streak, body colour, crystal system and common forms with a note on locations, many of which are German. The order of the photographs is determined by the colour of the streak, an unusual arrangement to say the least. A second set of colour pictures illustrates the commoner rock types. The remainder of the text is workmanlike, though not differing materially from other, similar books. M.O'D.

LÜSCHEN (H.). *Die Namen der Steine.* (The names of stones.) 2nd edn. Ott Verlag, Thun, 1979. pp.380. 25 plates, 7 in colour. Fr 49.50.

This second edition of a most useful book is enlarged and contains an attractive set of colour plates with an especially fine dust-cover, whose magnificent subject is not stated. [It is, however, a proustite from Chanarcillo, Chile.] As in the previous edition, the main part of the book is an alphabetical list of names with their derivations. Not all minerals are included, but there is a wealth of historical information. It forms a useful complement to Mitchell's *Mineral names—what do they mean?* M.O'D.

NASSAU (K.). *Gems made by man.* Chilton Book Company, Radnor, Pennsylvania, 1980. pp.xvii, 364. Illus in black-and-white and in colour. $28.50.

A book by Kurt Nassau on man-made gemstones is the kind of event one encounters during benignant dreams; the reality has just that definition and imagination that characterizes the world of crystal growth. Dr Nassau has arranged his material under the most important gemstone classes; diamond ant its simulants, corundum, emerald, opal, alexandrite, the oxides YAG, GGG and CZ; there are sections on glass and plastic imitations, on the alteration of stones, the techniques of crystal growing and a long section on the cause of colour in gemstones. Most sections are followed by a few references, but there is no general bibliography. It is fair to say that if a bibliography were included to match the rest of the text, it would have to contain many works to which few gemmologists would have easy access. The standard of both the colour illustrations and the black-and-white photographs is good; I have one or two reservations about the paper.

For the gemmologist the main joy of the book is the detailed description of the manufacture of gem-quality crystals. A great deal of information that has not appeared in the standard tests is given (see the section on spinel) and for many processes the historical background is recounted. Trade names are given for many substances, and in passing much useful detail on natural materials creeps in. This is an essential tool for the gemmologist at any level; the gemmological instructor will also accord it a particular welcome. M.O'D.

SMITH (B.), SCHROMM (A.). *Gemcutting, a lapidary handbook.* Prentice-Hall, Englewood Cliffs, N.J., 1980. pp.viii, 184. $6.95.

Illustrated only by diagrams in the text, this book tells the reader nothing that cannot be easily found elsewhere. The book is not recommended; there is no bibliography and the glossary is inadequate, some of the explanations being incorrect and others too general. M.O'D.

WATERMEYER (B.). *Diamond cutting.* Purnell, Cape Town, 1980. pp.387. Illus. in black-and-white and in colour. R15.00.

This is the first book that I have seen which has been entirely devoted to a step-by-step account of diamond polishing. There are 55 chapters, so each one is fairly short; every step is very well illustrated by both diagrams and photographs—the only poor feature in the book is the indifferent reproduction of the colour work, but this is of little importance. A good deal of information on modern fancy cuts is given, and there is sufficient (but not too much) information on famous diamonds, the details of which are easily found elsewhere. The student and the embryo polisher will find this book invaluable. M.O'D.

ASSOCIATION NOTICES

GIFTS TO THE ASSOCIATION

The Council of the Association is indebted to the following for their gifts:

Mr R. Holt, F.G.A., London, for a parcel of crystals and rough material for students' use.

Mr Walter E. Johansen, Morgan Hill, California, U.S.A., for two slices of synthetic corundum produced in Israel, suitable for cutting as star sapphire and star ruby.

Mr Eric Morris, F.G.A.A., Dip.D.T., McLaren Vale, S. Australia, for a copy of the book 'Semiprecious and ornamental stones of South Australia' and six copies of 'Opal in South Australia', both issued by the South Australian Department of Mines and Energy, 1980: also for two excellently formed spessartite garnet crystals from the New Consolidated Mine, Broken Hill, N.S.W., Australia.

Mr Per Paulin, B.Sc., F.G.A., Uppsala, Sweden, for 90 cut pieces of aquamarine weighing 24.9 ct.

Mr Herbert Tillander, F.G.A., C.G., Helsinki, Finland, for a copy of the Scandinavian Diamond Nomenclature and Grading Standards, second edition.

OBITUARY

Major R. F. Cassidy, F.G.A. (D.1950), of Evesham, died on 5th September, 1980.

Mrs Marie-Louise Chisholm, F.G.A. (D.1952), wife of Mr J.R.H. Chisholm, F.G.A., died on 3rd December, 1980.

Miss N. M. N. Coop, F.G.A. (D.1963), died on 11th August, 1980. Former students at Sir John Cass College and many Fellows who have attended the London meetings of the Gemmological Association over the past 17 years will recall the diminutive figure of Miss Nora Coop. With no gem trade connexion, she had spent her business life in printing and publishing. Educated at St Paul's School for Girls, she was trained in music by Gustav Holst, with whom she remained friends until his death. A keen amateur musician, she had a fine voice in her younger days, and had many friends among famous musicians. Gemmology became an interest some years after her retirement, and, with her lively mind, she was an enthusiastic and good gemmologist, lecturing to various organizations up to about a year ago. Although born in York she had actually lived almost all of her very long life in a flat in Barnes, within a stones-throw of the Thames, and died there, very peacefully, at the age of 88. A charming little lady who will be greatly missed by her many friends in the Association. R.K.M.

Mr Henry J. Whitehead, F.G.A., (D.1959), Edinburgh, whose death on 24th March, 1980, was reported briefly on page 201 above, was an instructor on the Gemmological Association Courses for a number of years. A top ranking man in Post Office Telephone engineering, he came originally from Hounslow, transferring to Edinburgh in 1933, where he married in 1938. Both Henry and Helen Whitehead were good students of mine in 1957 to 59. Sadly, Helen died in 1960 without finally qualifying for Fellowship. Up to 1965 Henry was concerned directly with conversion locally to the STD system. Then he took charge of the P.O. Engineers Training Centre at Muirhead. His experience in teaching there helped considerably in his work for the Gemmological Association. Retiring in 1972 he concentrated on this, interrupting it only for two extended visits to Sri Lanka, where he made many friends. At one time he spoke of writing a book on the Gems of Sri Lanka, but his son, Dr Colin Whitehead, tells me that no notes for this have been found. He was active in the affairs of the local branch of the G.A. and gave many lectures on gems and on his experiences in the Far East. He had plans for further extensive travel, but these were thwarted by deteriorating health, which culminated in the stroke from which he eventually died. The Whiteheads were good and kindly people; Henry, a very intelligent and immensely likeable man, had been my good friend for more than twenty years. His passing is greatly mourned. R.K.M.

NEWS OF FELLOWS

On 9th September, 1980, Mr Peter Read, C.Eng., F.G.A., gave a talk on 'Some new gem-testing instruments' to the Bristol and West of England Jewellers Association, in the Royal Hotel, College, Bristol. On 27th September, 1980, he demonstrated his computer gem identification system (see pp.239-249 above) at the D.Gem.G. 2nd Technical Weekend, Idar-Oberstein, West Germany, and on the following day gave an illustrated talk on the two computer programs in the Börse.

On 6th October, 1980, Mr Ivan Tarratt, F.G.A., was installed as President of the Leicester Literary and Philosophical Society.

MEMBERS' MEETINGS

Midlands Branch

On 26th September, 1980, Mr Alan Hodgkinson, F.G.A., gave an illustrated talk on 'Precious Commercial Gemmology' at the Society of Friends, Dr Johnson's House, Colmore Circus, Birmingham. Mr Hodgkinson was unable to show the whole of his collection of slides, and a further meeting was held on the 31st October when the remainder were shown. A panel drawn from the Branch members discussed each slide.

On 27th November, 1980, Mr T. M. Osborne, of Birmingham City Council, gave a talk at the Society of Friends, Dr Johnson's House, Colmore Circus, Birmingham, on plans for the Jewellery Quarter.

North-West Branch

On 18th September, 1980, a visit was organized to Liverpool Museum.

On 6th November, 1980, the Annual General Meeting of the Branch was held at Church House, Hanover Street, Liverpool. Mrs M. P. Gayton, F.G.A., was re-elected Chairman and Mrs E. Cartmel elected Secretary.

South Yorkshire and District Branch

On 21st October, 1980, Dr D. A. Carswell, a specialist in high pressure minerals at the University of Sheffield, gave an illustrated talk on garnets and olivines at Sheffield City Polytechnic.

On 4th December, 1980, the Annual General Meeting of the Branch was held at Sheffield City Polytechnic Mr I. R. Lewis, F.G.A., was elected Chairman and Miss J. I. Platts, F.G.A., was re-elected Secretary.

COUNCIL MEETING

At the meeting of the Council held on Wednesday, 24th September, 1980, at Saint Dunstan's House the following were elected to membership:

FELLOWSHIP

Anderson, Maximillian J., London. 1980
Andersson, Arild, Oslo, Norway. 1979
Bennett, Elaine, Stockport. 1980
Bertrand, Sarah, Worthing. 1980
Coombes, Martin L., Crewe. 1980
Deascenti, James H., Accrington. 1980
Falkus, Geoffrey C., Hainault. 1980
Farrow, Karen A., Great Yarmouth. 1980
Faux, Teresa M. F. A., London. 1980
Glen, Jillian, London. 1980
Gray, John Stephen, Pontefract. 1980
Harrison, Kathryn, Doncaster. 1980
Hetherington, George, Ashton-under-Lyne. 1980
Kemp, Roy E. H., Farnham. 1980
Knight, Antony J., Chippenham. 1980
Lee, Anthony H., London. 1980
Mindry, Ernest R., Manningtree. 1980
Nisbet, Alistair S., Johannesburg, S.Africa. 1979
Payne, Nicholas G., Bournemouth. 1980
Pine, Ann M., Hemel Hempstead. 1980
Rogers, John, Portrush, N.Ireland. 1980
Rowe, Regina, Torquay. 1979
Rutzler, Nigel P., Twickenham. 1980
Smith, Ian J., Aberdeen. 1980
Teraura, Shin, Nara Pref., Japan. 1979
Thomas, Judy, Skipton. 1980
Uren, Derek C., London. 1980
Vashishtha, Shekhar, Delhi, India. 1979
Villars, Irja A. K., Stockholm, Sweden. 1980
Wilson, Andrew R., St Ives. 1980
Wright, Elaine C., Purley. 1980
Wright, Michael W., Redhill. 1980

TRANSFERS FROM ORDINARY MEMBERSHIP TO FELLOWSHIP

Aiiso, Miki, Tokyo, Japan. 1980
Amasaki, Tetsuya, Osaka, Japan. 1980
Asakawa, Mamoru, Fukuoka, Japan. 1980
Aylward, Peter S., Westonaria, Transvaal, S.Africa. 1980
Bacon, John E., Cape Town, S. Africa. 1980
Bannon, Lewis A., Baton Rouge, La, U.S.A. 1980
Blake, Jeannette A., London. 1980
Bogues, Patrick M., Omagh, N. Ireland. 1980

Bolin, Jacoba M., Stockholm, Sweden. 1980
Bonisoli, Giovanne, London. 1980
Butler, Russell T., Wirral. 1980
Bylander, Liliane D., Sigtuna, Sweden. 1980
Chiu, Carol C., Hong Kong. 1980
Coelho, Susan O., Richmond. 1980
Cowling, Denise E., Northampton. 1979
Cudworth, Patricia J., Mansfield. 1980
Dharmadasa, Sunil P., Colombo, Sri Lanka. 1980
Eckermalm, Hjordis, Tumba, Sweden. 1980
Eldridge, W. R., Kerrville, Tex., U.S.A. 1980
Elzinga, Vivienne, Cape Town, S.Africa. 1980
Emms, Eric C., Brentwood. 1980
Etoh, Tomooki, Fukuoka, Japan. 1980
Farooqi, F. M. A., Peshawar, Pakistan. 1980
Fujiwara, Osamu, Hyogo, Japan. 1980
Gabella, Laurent P., St Laurent du Var, France. 1980
Gaudy, Monica E., Stockholm, Sweden. 1980
Goatly, Andrew M., Surbiton. 1980
Goby, Jacqueline A., Castletown. 1980
Gordon, Clement R., Brisbane, Qld, Australia. 1980
Green, Richard D., Sedgley. 1980
Greeson, Gordon, Carmel, Ca, U.S.A. 1980
Hall, Michael G., Builth Wells. 1980
Heeney, Barbara A., Repulse Bay, Hong Kong. 1980
Hiraoka, Satoshi, Tokushima, Japan. 1980
Horvath, Elsa, Ste Julie, Que., Canada. 1980
Hurst, Adam K., Solihull. 1980
Ishii, Hajime, Kyoto, Japan. 1980
Jones, Gwilym M., Abergavenny. 1980
Kajita, Yukio, Tokyo, Japan. 1980
Kerr, D. J., Northcote, Auckland, N.Z. 1980
Kuehn, Robert L., Dallas, Tex., U.S.A. 1980
Larcombe, David B., Wincanton. 1980
Lau, Theodora A., Hong Kong. 1980
Levine, Carolyn E., Hong Kong 1980
Leybourn-Needham, Gerald, Knutsford. 1980
Lundholm, Carolyn, Stockholm, Sweden. 1980
McCallum, Marcus A., London. 1980
Maeda, Kosaku, Fukuoka, Japan. 1980
Mai, Lionel, Brussels, Belgium. 1980
Matsunobu, Hiroshi, Fukuoka, Japan. 1980
Miyaki, Yasuhiro, Kyoto, Japan. 1980
Moury, Armand J., Brussels, Belgium. 1980
Murphy, Mary M., Forest Hills, N.Y., U.S.A. 1980
Nelson, James B., London. 1980
Ng, Shirley S. Y., Hong Kong. 1980
Noach, Louis, London. 1980
Noble, George E., London. 1980
O'Grady, Gabriel F., Dublin, Ireland. 1980
Okuzumi, Hiromi, Tokyo, Japan. 1980
Onnink, Jannie A., Abbotsford, B.C., Canada. 1980
Owen, Neil T., Romford. 1980
Parr, Dorothy M., Toronto, Ont., Canada. 1980
Perrella Estelles, Loto, Barcelona, Spain. 1980
Poff, Stephen G., Invercargill, N.Z. 1980
Potter, Matthew S., Tokyo, Japan. 1980

Rosen, Elly, Brooklyn, N.Y., U.S.A. 1980
Rufli, Lisbet, Sollentuna, Sweden. 1979
Sever, Katherine M., Altrincham. 1980
Shibataka, Yasuhiro, Osaka, Japan. 1980
Sibtsen, Johannes C., Heerjansdam, Netherlands. 1980
Sjöström, Bjarne J., Taby, Sweden. 1980
Smith, Alan J., Birmingham. 1980
Spence, Lynette M., Hong Kong. 1980
Sweeny, Patrick J., London. 1980
Tajika, Kazutaka, Tokyo, Japan. 1980
Takahashi, Toshio, Tokyo, Japan. 1980
Takai, Toshisuke, Shizuoka, Japan. 1980
Takayama, Tetsuo, Ooita, Japan. 1980
Tamai, Hideo, Osaka, Japan. 1980
Taylor, Richard P., Mold. 1980
Timms-Hackworthy, David, Majorca, Balearic Is. 1980
Tormino, Frederick J., North Brunswick, N.J., U.S.A. 1980
Toshima, Tetsuo, Fukuoka, Japan. 1980
Uematsu, Yasuo, Hyogo, Japan. 1980
Wakefield, Raymond S., Durban, S.Africa. 1980
Wickramaratna, H. P. D., East Croydon. 1980
Wieman, Jacob, Amsterdam, Netherlands. 1980
Woodward, Christine M., London. 1980
Zimmermann, Ursula T., Kowloon, Hong Kong. 1980
Zoysa, G. Edirimuni G., Delft, Netherlands. 1980

ORDINARY MEMBERSHIP

Abdulrashid, Harun-Ibrahim, Las Vagas, Nev., U.S.A.
Abi-Habib, Cynthia S., Riyadh, Saudi Arabia.
Aspinall, Anthony, Wigan.
Atlan, Gabriel, Rio de Janeiro, Brazil.
Azeuedo, John F., San Francisco, Ca, U.S.A.
Beduze, William L., Watertown, Wis., U.S.A.
Bell, Robert D., Durban, S.Africa.
Benatar, Samuel, Wembley.
Bengali, Khodi B., London.
Betts, Margaret Y., Bushey.
Bhangu, Gurpal S., Manama, Bahrain.
Bishnu, Sudha, Temple City, Ca, U.S.A.
Blackburn, Mary-Rose, Roodeport, Transvaal, S.Africa.
Boulle, Jean-Raymond, London.
Boulle, Bertrand M. P., London.
Braga, Henrique C., Lisbon, Portugal.
Bridgwood, Corynna W., Seria, Borneo.
Brittain, Mark, Birmingham.
Brown, Linda M., Epsom, Auckland, N.Z.
Buckley, Melville, Paignton.
Bullock Peter H., Fairfield, N.S.W., Australia.
Callahan, Thomas P., Bloomfield, N. J., U.S.A.
Camelinat, Valma M., Jersey, C.I.
Canas, Jose M., Eglin, Fla, U.S.A.
Caouette, Paul A., Washington D.C., U.S.A.
Cestaro, Thomas L, Cheshire, Conn., U.S.A.
Chernichan, Catherine R., Winnipeg, Man., Canada.
Chiang, Yu-Chu A., Taipei, Taiwan.

Chien, Victoria S. L., Scarsdale, N.Y., U.S.A.
Chow, Man H., Kowloon, Hong Kong.
Clark, Richard M., Gibraltar.
Cleanthous, Angela, Nicosia, Cyprus.
Conaway, Jerrold O., Bloomington, Minnesota, U.S.A.
Cottafavi, Aliette, Geneva, Switzerland.
Croydon, Charles E., Ipswich.
Cuellar, Rebecca A., Honolulu, Hawaii, U.S.A.
da Cosse Brissal, Helene, Paris, France.
D'Adamo, Marina, Milan, Italy.
Desai, Suresh M., Chisekesi, Zambia.
Dormer, Joseph L., Barking.
Duke, Paul E., Vancouver, B.C., Canada.
Dykman, Christine S., Hong Kong.
Eisenburger, Sabine F., Thalheim, Austria.
Entremont, Pascal J., Alby sur Cheran, France.
Fickenscher, Rudolf A., Erlangen, W.Germany
Fletcher, Paul M., Dunfermline.
Freeman, Agnes G., London.
Freeman, William D., Fernandina Beach, Fla, U.S.A.
Gabriel, Kevin V., London.
Gertig, Gary K., Froid, Mont., U.S.A.
Gilbert, Charles, New York, N.Y., U.S.A.
Gill, Jogindar S., Kuala Lumpur, Malaya.
Gimpel, Beatrice, London.
Gimpel, Remy F., London.
Glidden, Wilfred, Offenbach, W.Germany.
Glossman, Norton, Walnut Creek, Ca, U.S.A.
Godkin, Paula S., Preston.
Goldsmith, John, Hayle.
Goodman, Diana, Mountsorrel.
Goossens, Pierre J., Trivandrum, Kerala, India.
Gordon, Scott, Oklahoma City, Okla, U.S.A.
Ha, Shek-to, Kowloon, Hong Kong.
Hale, Colin W., Wrexham.
Hammam, Nada S., Riyadh, Saudi Arabia.
Hansson, Henrik L., Bramhult, Sweden.
Harrison, John W., Ballincurra, Ireland.
Hedges, Stephen, Solvang, Ca, U.S.A.
Helm, Charles D., Los Angeles, Ca, U.S.A.
Hill, Allan, Swansea.
Horak, Joseph, Nhulunbuy, N.T., Australia.
Horovitz, Theodore, Geneva, Switzerland.
Hung, Chi-Chuan, Manila, Philippines.
Hurlbut, Cornelius S., Cambridge, Mass, U.S.A.
Hutton, Andrew J., Croydon.
Jacobs, Ronald J., Maldon.
Johnson, Gerald R., San Francisco, Ca, U.S.A.
Joris, William J., Mosman, N.S.W., Australia.
Kalbakjian, Jean, Aleppo, Syria.
Kavanagh, Seamus P., Dublin, Ireland.
Kennedy, James H., Belfast, N.Ireland.
Kimura, Mariko, London.
Klauda, Frank P., Rochester, Minn., U.S.A.
Kong, Suk C., Kowloon, Hong Kong.
Kornis, Elizabeth R., Rio de Janeiro, Brazil.
Kosik, Thomas A., Arlington, Va, U.S.A.
Kotahwala, Vinod, New York, N.Y., U.S.A.

Koy, Bohdan K., Warsaw, Poland.
Kwan, Edward S. M., Kowloon, Hong Kong.
Lau, Kee, Kowloon, Hong Kong.
Laurent, Paul J., Hastings, N.Z.
Lee, Hong G., The Hague, Netherlands.
Lee, Martin Y., London.
Lees, Gordon E., Belize.
Lees, Lilian, Belize.
Leung, Andy W. K., Kowloon, Hong Kong.
Maguire, Brian R., Belfast, N.Ireland.
Matsumoto, Shigeru, Fukuoka, Japan.
Mau, Enoch C., Kowloon, Hong Kong.
Mayer, Stephan P., Schillerstrasse, W.Germany.
Metudi, Mark T., Sherman Oaks, Ca, U.S.A.
Miguel, Hector, Argentina.
Miller, Ian J., Salisbury, Zimbabwe.
Morley, Sandra, Budleigh Salterton.
Murray, Geoffrey P., Maidstone.
McCune, Patrick M., Santa Maria, Ca, U.S.A.
McIntosh, Marsha S., Arlington, Va, U.S.A.
McKenzie-Davidson, Fraser J., Lymington.
Nagata, Misuzu, Yokohama, Japan.
Ng, Allan Y., Singapore.
Nivera, Maridi, Hong Kong.
Parker, David F., Harrogate.
Pattni, Shushil S., Loughborough.
Perillo, Anthony D., Mt Vernon, N.Y., U.S.A.
Phillips, Kathleen-Anne, Carmarthen.
Porto, Marcia E., Belo Horizonte, Brazil.
Prickett, Peter J., Brisbane, Qld, Australia.
Raphay, Jalaldin, Kuala Lumpur, Malaya.
Rees, Gwynfor E., Dundee.
Rolim de Camargo, William G., São Paulo, Brazil.
Ryan, Patrick, Kilkenny, Ireland.
Saeed, Agha M., Ilford.
Saeed, Ahmad, Petaling Jaya, Malaya.
Shauketaly, Asger F., London.
Sharma, Charanjiv L., Cheadle.
Shu, Yau L., Kowloon, Hong Kong.
Siegl, Jörg, St Gallen, Switzerland.
Simon, Christian, St Gallen, Switzerland.
Siow, Chee L., Ipoh, Perak, Malaya.
Singh, Janaki J., Paris, France.
Sivarajasingham, T.S., Ipoh, Perak, Malaya.
Smith, Adrian S., Southsea.
Smith, William B., Ruislip.
Stimler, Harvey J., Wembley Park.
Subramaniam, V.S. Gurusamy, Selangor, Malaya.
Swan, Richard J., Maidstone.
Teo, Tiong W., Singapore.
Tether, John G., Lusaka, Zambia.
Thenuwara, Ananda S., Mt Lavinia, Sri Lanka.
Theodosis, Rallis S., Forest Hills, N.Y., U.S.A.
Tishlias, Jimmy, Houston, Tex., U.S.A.
Tong, Kwong K., Hong Kong.
Trickett, Joyce E., Blandford Forum.
Trickey, Sheila A., Henley-on-Thames.
Tsui, Sunny K., Kowloon, Hong Kong.
Turk, Noriko, Hong Kong.
van Diepen, John W., Germiston, Transvaal, S. Africa.
Wake, Barry A., Snodland.
Waterworth, Michael, Swansea.
Weerasekera, Lampson, New Malden.
Weiss, Amy E., Briarclift Manor, N.Y., U.S.A.
Weller, Mark, Loughton.

Wondergem, Vivienne P., Remuera, Auckland, N.Z.
Wong, Dorothea S., Hong Kong.
Wong, Kin-Wah, Kowloon, Hong Kong.
Wood, James G., Mt Isa, Qld, Australia.
Yenson Chu, Mabel, Kowloon, Hong Kong.
Yuen, Jenny, Bristol.
Zonca, Guido, Rome, Italy.

GEM DIAMOND EXAMINATION 1980

In the Post-Diploma Gem Diamond Examination, 46 candidates sat and all passed, six with Distinction. The following is a list of their names arranged alphabetically.

QUALIFIED WITH DISTINCTION

Brohier, Kenneth Gordon, West Kirby.
Cukier, Gerard, London.
Esteve Fernandez, Jaime, Barcelona, Spain.
Franks, William, Bowdon.
Hysted, Anne Elizabeth, London.
Wright, Stephen Richard, Borehamwood.

QUALIFIED

Alvarez Fernandez, Laurentino, Barcelona, Spain.
Alvarez Fernandez, Manuel, Barcelona, Spain.
Bennett, Frederic, Hazel Grove.
Borreda Perez, Federico, Barcelona, Spain.
Breden, Robert John, Maghull.
Burslem, William Arthur, Liverpool.
Callaghan, Gerard, Liverpool.
Carpenter, Janet Elizabeth, Yelden.
Castello Torres, Ma Dolores, Barcelona, Spain.
Charlesworth, Anthony Robert, Southport.
Clark, Alan Joseph, Croydon.
Connolly, John Patrick, Over Peover.
Costell Ibanez, Manuel, Barcelona, Spain.
Crossland, Julie Hall, London.
Davies, Robert Ian, Coventry.
Derry, Catherine Eleanor, Nottingham.
Dolz Adell, Carmen, Barcelona, Spain.
Fagg, Primrose Mary, Wallington.
Franks, John Wilson, Altrincham.
Green, Edward Maurice, London.
Hernandez Ordonez, Arturo, Barcelona, Spain.
Hinton, Vera Georgina, Farnham.
Howarth, Janet, Bolton.
Jealouse, Roy George, Crewe.
Julia Miralles, Nuria, Barcelona, Spain.
Lewis, Robert George, Dartford.
Moore, Roderich Rüdiger, Solihill.
Nott, Shelley Naomi, West Harrow.
Pomar Llado, Ma Antonia, Barcelona, Spain.
Priestman, Arthur, Wythenshawe.
Puiggali Fabregas, Josep Ma, Barcelona, Spain.
Sanchez-Lafuente Mariol, José, Barcelona, Spain.
Smart, Denis Owen, Kettering.

Sorolla Maupoey, Marinela, Barcelona, Spain.
Stanley, Edward, Denton.
Suren, Jane Lucienne Linzee, London.
Theobald, Robert, Leighton Buzzard.
Vazquez Pavon, Rafael, Barcelona, Spain.
Whatton, Edwin Albert, Sutton Coldfield.
Winter, Julie, Fetcham.

EXAMINATIONS IN GEMMOLOGY 1980

In the 1980 Examinations in Gemmology, 425 candidates completed the Diploma Examination and of these 206 succeeded in passing, twenty of them with Distinction.

The best set of answers was returned by Christine Marie Woodward, of London, who deserves the congratulations of the Examiners for her excellent work.

In the opinion of the Examiners, however, no candidate achieved the high standard needed to warrant the award of a Tully Medal.

In the Preliminary Examination 746 candidates sat and 416 passed. The Rayner prize for the best set of answers in the Preliminary Examination was awarded to Graeme Roy Hogarth.

The following are lists of the successful candidates arranged alphabetically.

DIPLOMA EXAMINATION

QUALIFIED WITH DISTINCTION

Beach, Wendy L., Twickenham.
Bonanno, Kathryn L., Washington, D.C., U.S.A.
Carlsson, Björn O., Täby, Sweden.
Chiu, Carol C., Hong Kong.
Eldridge, W. R., Kerrville, Tex., U.S.A.
Emms, Eric C., Brentwood.
Gray, J. Stephen, Pontefract.
Hunger, Giselle H., Lugano, Switzerland.
Jones, Gwilym M., Abergavenny.
Lakdawalla, Darayus N., Bombay, India.
Leybourn-Needham, Gerald, Knutsford.
Okuzumi, Hiromi, Tokyo, Japan.
Onnink, Jannie A. P., Abbotsford, B.C., Canada.
Reynolds, Roderick H., Montreal, Que., Canada.
Smith, Ian J., Aberdeen.
Takada, Fujio, Osaka, Japan.
van Muyden, Paul P. M. A., Rotterdam, Netherlands.
Villars, Irja A. K., Stockholm, Sweden.
Woodward, Christine M., London.
Wright, Elaine C., Purley.

QUALIFIED

Aiiso, Miki, Tokyo, Japan.
Amasaki, Tetsuya, Osaka, Japan.
Anderson, Maximilian J., Edinburgh.
Asakawa, Mamoru, Fukuoka, Japan.
Aylward, Peter S., Johannesburg, S. Africa.

Bacon, John E. T. S., Wellington, C.P., S.Africa.
Banford, William D., Liverpool.
Bannon, Lewis A., Baton Rouge, La, U.S.A.
Bennett, David W., London.
Bennett, Elaine, Hazel Grove.
Berkowitz, Joseph, Toronto, Ont., Canada.
Bertrand, Sarah, Worthing.
Bill, David N., Hednesford.
Blake, Jeannette A., Ely.
Bogues, Patrick M., Omagh, N.Ireland.
Bolin, J. J. M., Stockholm, Sweden.
Bonisoli, Giovanne, Torino, Italy.
Bramwell, William J., Durham.
Butler, Russell T., Moreton.
Bylander, Liliane D., Sigtuna, Sweden.
Carson, Constance, London.
Cartier, Richard H., Toronto, Ont., Canada.
Castellote Mas, Guillermo F., Barcelona, Spain.
Charlton, Maurine, Scarborough, Ont., Canada.
Chu, Miu Hing, Hong Kong.
Coelho, Susan O., Kew.
Cook, Graham A., Dundee.
Coombes, Martin L., Crewe.
Cooper, Judith M., Colchester.
Cudworth, Patricia J., Mansfield.
Culpin, David I., Weston-super-Mare.
Day, Ghislaine H., Arlington, Va, U.S.A.
Day, William H. L., Arlington, Va, U.S.A.
Deascenti, James H., Accrington.
Dickson, Amanda J., London.
de Grefte, Glaudina J. M., Tilburg, Netherlands.
Dharmadasa, Sunil P. S. H. M., Colombo, Sri Lanka.
Eckermalm, Hjördis M. E., Tumba, Sweden.
Eger, Christine R., Lynchburg, Va, U.S.A.
Eide, Gry V., Bergen, Norway.
Elzinga, Vivienne, Cape Town, S.Africa.
Etoh, Tomooki, Fukuoka, Japan.
Fairlie, Alison H., Cheltenham.
Falkus, Geoffrey C., London.
Farooqi, Farooqi M. A. A., Peshawar, Pakistan.
Farrow, Karen A., Belton.
Faux, Teresa M. F. A., Winslow.
Ford, Karen J., Annapolis, Md, U.S.A.
Fraquet, Helen R., Frinton-on-Sea.
Fujihara, Shigeru, Tokyo, Japan.
Fujiwara, Osamu, Hyogo, Japan.
Gabella, Laurent P., London.
Gallardo Bravo, Matilde, Barcelona, Spain.
Gaudy, Monica E., Solna, Sweden.
Glen, Jill, London.
Goatly, Andrew M., Surbiton.
Goby, Jacqueline A., Nairobi, Kenya.
Gonzalez-Quiros Corujo, Ma Angeles, Barcelona, Spain.
Gordon, Clement R. I., Brisbane, Qld, Australia.
Gowling, Leslie G., Toronto, Ont., Canada.
Graus, Jeremy Z., London.
Green, Richard D., Sedgley.
Greeson, Gordon, San Diego, Ca., U.S.A.
Guinot Sierra, Agustin I., Barcelona, Spain.
Guinot Sierra, Carlos Ma., Barcelona, Spain.
Hall, Michael G., Builth Wells.
Harris, Barbara, Toronto, Ont., Canada.
Harrison, Kathryn M., Doncaster.
Hata, Kenichi, Kyoto, Japan.
Heeney, Barbara A., Hong Kong.
Heiskanen, Erkki T., Helsinki, Finland.
Hellmark, Thorsten A., Örebro, Sweden.

Hetherington, George, Ashton-under-Lyne.
Hiraoka, Satoshi, Tokushima, Japan.
Horvath, Elsa, Ste Julie, Que., Canada.
Huizinga, Jeroen, Amsterdam, Netherlands.
Hurst, Adam K., Solihull.
Ishii, Hajime, Kyoto, Japan.
Jackson, John G., Sunderland.
Johnson, Colin M., Birmingham.
Jones, L. Bruce, Seattle, Wash., U.S.A.
Jones, Mark L., Cromer.
Junquera Sanchez Del Rio, Mercedes, Barcelona, Spain.
Kämäri, Arvi N., Helsinki, Finland.
Kajita, Yukio, Tokyo, Japan.
Kawakami, Sumiyo, Osaka, Japan.
Kemp, Roy E. H., Farnham.
Kerr, D. J., Auckland, N.Zealand.
Knight, Antony J., Chippenham.
Krapenc, Terry S., Painesville, Ohio, U.S.A.
Kuehn, Robert L., Dallas, Tex, U.S.A.
Laine, Paul D., Guernsey
Lakdawalla, Zubin N., Bombay, India.
Lamb, Revital T., Salisbury, Zimbabwe
Larcombe, David B., Wincanton.
Lau, Theodora, Hong Kong.
Lee, Anthony H., London.
Leria Bernaus, Magda, Barcelona, Spain.
Levine, Carolyn E., Hong Kong.
Linko, Ilpo I. K., Espoo, Finland.
Lundholm, Carolyn L., Stockholm, Sweden.
McCallum, Marcus A., Newbury.
Maeda, Kosaku, Fukuoka, Japan.
Maguire, Martin P., Liverpool.
Mai, Lionel, Brussels, Belgium.
Matsunobu, Hiroshi, Fukuoka, Japan.
Mindry, Ernest R., Manningtree.
Miyake, Yasuhiro, Kyoto, Japan.
Moury, Armand J. A., Brussels, Belgium.
Murphy, Mary M., New York, N.Y., U.S.A.
Naebers, Joseph L. M. G., Hulsberg, Netherlands.
Nakajima, Minako, Birmingham.
Nelson, James B., London.
Ng, Shirley S. Y., Hong Kong.
Nichols, Robert T., Albuquerque, N.M., U.S.A.
Noach, Louis, London.
Noble, George E., London.
O'Grady, Gabriel F., Dublin, Ireland.
Oosterwaal, Frans T. G. J., Loon op Zand, Netherlands.
Owen, Neil T., Romford.
Parr, Dorothy M., Toronto, Ont., Canada.
Pascual Armengou, José, Barcelona, Spain.
Payne, Nicholas G., Bournemouth.
Perera, Priyani A. M., Colombo, Sri Lanka.
Perkins, Joanna C., London.
Perrella Estelles, Loto, Barcelona, Spain.
Pine, Michelle Ann, London.
Piunno, John C., Heidelberg, W.Germany.
Poff, Stephen G., Invercargill, N.Z
Potter, Matthew S., Tokyo, Japan.
Riedl, Inge, Barcelona, Spain.
Robbins, Susan C., Vancouver, Canada.
Rogers, John, Portrush, N.Ireland.
Rosen, Elly, Brooklyn, N.Y., U.S.A.
Ross, Rosemary D., London.
Rutzler, Nigel P., Twickenham.
Ruÿten, André G. F., Woerden, Netherlands.
Salvat Alegre, José, Barcelona, Spain.
Samaratunga, Edith K., Heidelberg, W.Germany.

Sever, Katherine M., Altrincham.
Shackley, Ian W., Christchurch, N.Z.
Shah, Paresh N., Bombay, India.
Shanmuganathan, Kathirithamby, Colombo, Sri Lanka.
Shibataka, Yasuhiro, Osaka, Japan.
Sibtsen, Johannes C., Heerjansdam, Netherlands.
Sjöström, Bjarne J., Stockholm, Sweden.
Smith, Alan J., Birmingham.
Smith, Shirley M., St Albans.
Spence, Lynette M., Sydney, Australia.
Stalman, Margareth A. E., Susteren, Netherlands.
Sweeney, Patrick J., London.
Tajika, Kazutaka, Tokyo, Japan.
Takahashi, Toshio P., Tokyo, Japan.
Takai, Toshisuke, Shizuoka, Japan.
Takayama, Tetsuo, Ooita, Japan.
Tamai, Hideo, Osaka, Japan.
Tan-Bouman, Els, Schoonhoven, Netherlands.
Taylor, Richard P., Mold.
Thomas, Judy, Skipton.
Timms-Hackworthy, David, Majorca, Balearic Is.
Tolin, Harvey S., New Canaan, Conn., U.S.A.
Tomas Soler, Ma Rosa, Barcelona, Spain.
Tormino, Frederick J., North Brunswick, N.J., U.S.A.
Toshima, Tetsuo, Fukuoka, Japan.
Tsujikawa, Kayoko, Kobe, Japan.
Uematsu, Yasuo, Kobe, Japan.
Underwood, Barbara C., Manchester.
Uren, Derek C., Aylesbury.
van der Riet, Diane M., Stellenbosch, S.Africa.
van Kalleveen, Allard, Paris, France.
Versendaal, Johannes, Hendrik Ido Ambacht, Netherlands.
Vlaun, Mirela C. E., Willemstad, Curaçao, N.A.
Wakefield, Raymond S., Durban, S.Africa.
Wall, Stephanie, Alcester.
Waller, John R., Toronto, Ont., Canada.
Welch, Mark G., Cardiff.
Wickramaratna, H. P. D., East Croydon.
Wieman, Jacob, Amsterdam, Netherlands.
Wijesuriya, Guthila, Moratuwa, Sri Lanka.
Wilkinson, Ben R., Nanaimo, B.C., Canada.
Wilson, Andrew R., St Ives.
Wright, Michael W., Epsom.
Yielding, Daniel N., Toronto, Ont., Canada.
Yoshida, Katsuji, Wakayama, Japan.
Zimmermann, Ursula Th., Hong Kong.
Zoysa, Gamini E. G., Colombo, Sri Lanka.

PRELIMINARY EXAMINATION

QUALIFIED

Absalom, Christine S., Effingham.
Acheson, Michael A., Geneva, Switzerland.
Adlestone, Mark I., St Annes-on-Sea.
Ahmad, Zaheer, Nairobi, Kenya.
Akizuki, Haruo, Ichikawa, Japan.
Aliprandi, Riccardo, Ostia, Italy.
Almazan Gurumeta, Francisco J., Madrid, Spain.
Alvis, Alayne, Colombo, Sri Lanka.
Anderton, Duncan M., Glasgow.
Angelo, Luiz, Rio de Janeiro, Brazil.
Ansell, Martin F., Epping.

Aoussat, Claude A., Vienna, Va, U.S.A.
Ashra, Shirish, London.
Ashworth, Marie C., Toronto Ont., Canada.
Astridge, Elaine, London.
Atkinson, Jane L., Carnforth.
Avila Martinez, Vicente S., Barcelona, Spain.
Babber, Harish R., Southall
Bailey, Catalena, Colombo, Sri Lanka.
Baker, Keith R., London.
Bambrick, Joseph E., Don Mills, Ont., Canada
Bannerman, John M., Weybridge.
Barber, Anjali, Nairobi, Kenya.
Bardsley, John N., London.
Batycki, Charlene G., Toronto, Ont., Canada.
Beard, Thomas E., Jr, Atlanta, Ga, U.S.A.
Bell, Lorna M., Gronant.
Black, Grant J., Glasgow.
Bonanno, Kathryn L., Fredericksburg, Va, U.S.A.
Bond, Gerald S., Maidstone.
Boorman, Robert F., Bisley.
Bottom, Ian, Chesterfield.
Bowie, Hamish I. C., Solihull.
Boyd, Robert T., Toronto, Ont., Canada.
Braun, Leslie H., Southport, Qd, Australia.
Breau, Karen L. J., Toronto, Ont., Canada.
Brown, Allen G., Hamstall Ridware.
Buchanan, Vera A., Augher.
Bury, Stephen W., Blackpool.
Buser, Charles S., III, Michanisburg, Pa, U.S.A.
Caldwell, Sandra J., Toronto, Ont., Canada.
Cameron, Stewart J., Auckland, N.Z.
Cassim, Mohamed F., Colombo, Sri Lanka.
Cespedes Garcia, Adelardo, Barcelona, Spain.
Chandrasiri, Imiya K. N., Mirigama, Sri Lanka.
Chavan, Umesh, Bombay, India.
Choi, Yat How, Hong Kong.
Choi, Siew-Cheong, London.
Chouiki-Doorn, Jacqueline, Spykenisse, Netherlands.
Clegg, Niel F., Bridgwater.
Currie, Lynnette J., Manurewa, Auckland, N.Z.
Darmudas, Nat, London.
Davies, Angela, Gerrards Cross.
Davies, Margaret, Frinton-on-Sea.
Davis, Robert J., Margate, Tas., Australia.
Day, Ghislaine H., Arlington, Va, U.S.A.
Day, William, H. L., Arlington, Va, U.S.A.
Dayasagara, Kalupahana L. D., Colombo, Sri Lanka.
Dayrit, Jacqueline S., Metro Manila, Philippines.
de Rooy, Franciscus J. M., Tilburg, Netherlands.
de Silva, G. Ranjan J., Singapore.
Devarajah, Rajeswari, Colombo, Sri Lanka.
Dewar, Penelope S., Stockport.
Dickens, Adrian Q., Lewes.
Dolleslager, James T., Houston, Tex., U.S.A.
Dorricott, Jeffrey K. M., Ringwood.
Doughty, Suzanne M., Wembley.
Douthwaite, Elaine M., Bradford.
Dowell, Ronald A., Gloucester.
Duffin, Charline D., Denton, Tex., U.S.A.
Duke, Paul E., Vancouver, B.C., Canada.
Ebata, Taiichiro, Takaoka, Japan.
Ebelthite, Alexander, Twickenham.
Eckley, Gareth, D., Talgarth.
Ehara, Nobuyuki, Tokyo, Japan.
Ekanayake, Eileen F., Kotte, Sri Lanka.

Endean, Christine H., Hong Kong.
Enlander, Martin A., Belfast, N.Ireland.
Esteba Suquet, Carmen, Barcelona, Spain.
Etoh, Tomooki, Omuta, Japan.
Fadnes, Jane B., Stavanger, Norway.
Fell-Smith, Simon A., Brisbane, Australia.
Fernando, Edward F. W., East Malling.
Ford, Karen J., Annapolis, Md, U.S.A.
Foster, Amanda L., Toronto, Ont., Canada.
Fountain, Clair, Toronto, Ont., Canada.
Freeman, Darlene M., Belmont, Ca, U.S.A.
Froehlich, Regina, North York, Ont., Canada.
Fujiwara, Osamu, Kawanishi, Japan.
Furmage, Janet E., Hull.
Gailterie, Marie C., Geneva, Switzerland.
Gajasinghe, Ann L., Pannipitiya, Sri Lanka.
Galt, Jessie J., Scarborough, Ont., Canada.
Gand, Philippe, Villars sur Glane, Switzerland.
Ganesh, Narendran, Colombo, Sri Lanka.
Ganesh-Alingham, Sussee-Lathevi, London.
Gans, Elizabeth B., London.
Garcia Vaquero, Alfredo, Barcelona, Spain.
Garcia Ripoll, José Ma, Barcelona, Spain.
Garside, Janet, Larkfield.
Gasco Galindo, Ignacio, Barcelona, Spain.
Gea Lopez, Francisco J., Barcelona, Spain.
George, Niel, Portmadoc.
Gettings, Barbara A., London.
Gideon, Lester P., Vandenberg, Ca, U.S.A.
Girling, Matthew D., London.
Glover, Howard N. G., Wallasey.
Golby, Nicholas G. J., London.
Gold, Stephen A., Northolt.
Gowling, Leslie G., Toronto, Ont., Canada.
Grant, Judith M., Carmel, Ca, U.S.A.
Green, Margaret H., Hove.
Greenaway, Suzanne E., London.
Grima, Phillip, Zurich, Switzerland.
Grimston, Lady Iona C., London.
Grishko, Irene, Agincourt, Ont., Canada.
Grøndahl, Merete, Stabekk, Norway.
Guarne Terrado, Francesc, Barcelona, Spain.
Guillemot Boix, Nuria J., Barcelona, Spain.
Haniffa, Ahamed I., Colombo, Sri Lanka.
Harsheim, Elna F., Oslo, Norway.
Hatenboer, Willem J., Krimpen a/d Ijssel, Netherlands.
Hattori, Toshikazu, Osaka, Japan.
Hauge, Pia H., Colombo, Sri Lanka.
Hawker, Robin W. A., Kempton, Tas., Australia.
Hayes, George R., Jr, Canton, Ohio, U.S.A.
Hedges, Karen A., Kuala Lumpur, Malaya.
Heiskanen, Anu P.K., Helsinki, Finland.
Hellmark, Thorsten A., Örebro, Sweden.
Henderson, Shirley, Bothwell.
Hermans, Johannes S., Delft, Netherlands.
Hill, David R., London.
Hill-Tout, Randy M. M., Toronto, Ont., Canada.
Hinduja, Anuradha J., Bombay, India.
Hiwale, Shyla, Bombay, India.
Hogan, Ann G., London.

Hogarth, Graeme R., Perth.
Hopper, Gerald S., Boston.
Horton, David R., London.
Houseago, James A., Lowestoft.
Howe, Susan E., Taunton.
Hrynczak, Stephen M., Ilford.
Huges, Richard W., Boulder, Colo., U.S.A.
Huguette, Mourad, Lebanon.
Hurlburt, Catherine J., Willowdale, Ont., Canada.
Hutchinson, Marjorie E., London.
Hynes, James B., London.
Ickowicz, Steven, London.
Ifthikar, Ifthikar U. M., Kandy, Sri Lanka.
Illueca Domenech, Enrique, Barcelona, Spain.
Inches, Deirdre M. H., Wembley.
Ismath, Abdul M. M., Colombo, Sri Lanka.
Itoyama, Emiko, Osaka, Japan.
Iwata, Kazuyoshi, Gifu, Japan.
Jacobson, Karl F., Camarillo, Ca, U.S.A.
Janssen, Hubertus W., Rotterdam, Netherlands.
Jathar, Shripad S., Bombay, India.
Jayasekera, Mahadura C. de S., Negombo, Sri Lanka.
Jennings, Melvyn, Greetland.
Jollien, Marcel A., Zurich, Switzerland.
Jones, L. Bruce, Seattle, Wash., U.S.A.
Jones, Gwilym M., Abergavenny.
Jones, John A., Wrexham.
Jones, Maureen D., Wellington, N.Z.
Kaersenhout, George E., Amsterdam, Netherlands.
Kaleel, Abdul R. M., Mt Lavinia, Sri Lanka.
Kanokvaliwongs, Pornchai, Barcelona, Spain.
Kassamali, Shirin H., Nairobi, Kenya.
Keefe, James E., IV, Santa Monica, Ca, U.S.A.
Keegan, Dermot, Thika, Kenya.
Kelly, Susan M. B., Woodridge, Qld, Australia.
Kennedy, Karen K., Toronto, Ont., Canada.
Kettley, Helen M., London.
Keuskamp, Diederik N. G., Streefkerk, Netherlands.
Khandwani, Riyaz S., Bombay, India.
Kilburn, Kenneth, Shipley.
King, Antoinette E., Iden.
Kingsley, Ann S., Sidmouth.
Kinoshita, Kazuko, Ashiya, Japan.
Kirwin, Philip M., Cheadle.
Kitamura, Seiki, Tokushima, Japan.
Kjeldsen, Dag S., Moss, Norway.
Koralage, Sita P., Dondra, Sri Lanka.
Kosik, Thomas A., Arlington, Va, U.S.A.
Kothari, Rajan A., Bombay, India.
Krot, Johannes H., Amsterdam, Netherlands.
Kujanpää, Asko J., Helsinki, Finland.
Kumarage, Jayantha P. R., Piliyandala, Sri Lanka.
Kuruppu, Sarat L., Ratmalana, Sri Lanka.
Kwan, Yim Lin, Hong Kong.
Lacambra Pifarre, Carmen, Barcelona, Spain.
Lai, Kam Wing, Hong Kong.
Lam, Ronald, Chatham.
Lambley, Jenifer G., Hong Kong.
Landau, Sidney L., Miami Beach, Fla, U.S.A.
Law, Sheila, London.
Leaton, Colin J., London.
Lee, Chun-Sang R., Hong Kong.
Le Fevre, Robert S., Jr, Virginia Beach, Va, U.S.A.
Leggett, Andrew P., Worthing.
Lenhoff, Louis, Stellenbosch, S.Africa.

Leong, Daniel K. T., Macau.
Lewis, Kathleen A., Luton.
Liddle, Robert, Inverkeithing.
Litchfield, Anne-Marie, Northampton.
Little, Derek, Dundee.
Littlejohn, Gordon H., Tunbridge Wells.
Livstrand, Ulf R., Stockholm, Sweden.
Love, John, St Helier.
Lueking, Edward N., Costa Mesa, Ca, U.S.A.
Lundsrud, Atle, Nesøya, Norway.
Lundsrud, Randi, Nesøya, Norway.
Lupton, Elaine C., Paddock Wood.
MacDonald, Andrea C., Amersham.
McDonald, Jessie L., Riyadh, Saudi Arabia.
McDowell, Robert B., Beltsville, Md, U.S.A.
McEwan, Robert S., Perth.
McIntosh, Marsha S., Arlington, Va, U.S.A.
McKellar, John R., Evenjobb.
McPherson, Heather, Coalville.
McShane, Charles S. P., Teddington.
Maeda, Katsutoshi, Fukuoka, Japan.
Magri, John P., Northolt.
Malhar, Lateef M., Banstead.
Malpas, Robert F., Leeds.
Manamperi, Sisira D. B., Ratnapura, Sri Lanka.
Mansfield, Stephen M., Burton.
Mariathasan, Loganayagi, Colombo, Sri Lanka.
Marshall, Sarah L., West Bridgford.
Martijnse, Christiaan J., Groot-Ammers, Netherlands.
Mater, Louise H., Laren, Netherlands.
Matthews, Marguerita E., Lancaster.
Mayer, Anton S., St Saviour.
Mayor, Norah, Soham.
Meggitt, Corinna A. W., London.
Middleton, Neil M., Stoke-on-Trent.
Mikami, Akira, Tokyo, Japan.
Mills, David K., Hucknall.
Minogue, Caroline E., Leigh-on-Sea.
Misaki, Kyoko, Tokyo, Japan.
Molagoda, Tikiri B. P., Talatuoya, Sri Lanka.
Moore, Paul R., Camberley.
Morris, Kelsey S., Hayling Island.
Morrow, Lisbeth J., Mold.
Nakamura, Masanori, Osaka, Japan.
Nakamura, Takeshi, Kanazawa, Japan.
Nakayama, Keiichi, Komatsushima, Japan.
Navarro Ribero, Conrado, Barcelona, Spain.
Nelischer-Millar, Anita I. A., Toronto, Ont., Canada.
Nelson, Eunice, West Hill, Ont., Canada.
Nithiaraj, Sellappu I., Mt Lavinia, Sri Lanka.
Nooten-Boom, Apollonius, II, Kingsland.
Norton, Sharon L., High Wycombe.
Oakley, Leslie P., Toronto, Ont., Canada.
O'Brien, Peter P., Glasgow.
Oliete Artal, Ma Amparo, Barcelona, Spain.
Onodera, Noritoshi, Sagamihara, Japan.
Otsuka Nobuko, Tokyo, Japan.
Ottaway, Terri L., Toronto, Ont., Canada.
Pagliero, Margaret S. G., Edegem, Belgium.
Palanques Monteys, Alberto, Barcelona, Spain.
Paranamana, Palitha K. P., Nakulugamuwa, Sri Lanka.
Parcel, Rodney F., Jr, Perris, Ca, U.S.A.
Parry, Sarah, Wadhurst.
Paxton, Jeremy M., Fordingbridge.
Peacocke, Patrick T., Cambridge.
Peebles, Kathleen W., Johannesburg, S.Africa.
Perera, Navaratne M. R., Rajagiriya, Sri Lanka.

Perren, Llewelyn J., Worthing.
Peryer, Keith G., Barnet.
Pettit, Angela L., Keighley.
Philipou, Philip, Byfleet.
Phoenix, Susan E., Nottingham.
Pickford, Michael G., Bicester.
Pidcock, Julie M. A., Matlock.
Pitt, John R., Kingswinford.
Pitts, Carl C., Huntington Beach, Ca, U.S.A.
Piunno, John C., Washington, D.C., U.S.A.
Piziura, Irene T., Gedling.
Postma, Renate E., Breda, Netherlands.
Pothof, Helga, Schoonhoven, Netherlands.
Potter, Brian S., London.
Powell, Lori C., Newmarket, Ont., Canada.
Price, Stephen A., Ipswich.
Prince, Ann-Elise, London.
Pujol Moragas, Lydia, Barcelona, Spain.
Quincey, Mary E., Willey.
Quinn, Patrick D., Miami, Fla, U.S.A.
Rademaker, Jaap, Baarn, Netherlands.
Rajayohan, Rasiah, Mt Lavinia, Sri Lanka.
Ralls, Elizabeth L. W., Asheville, N.C., U.S.A.
Raniga, Umesh C. G., Vancouver, B.C., Canada.
Raymond, Robert S., Brentwood.
Rennie, Margaret M., Bothwell.
Renton, Valerie, Jersey.
Ridgell, Pinckney, Alexandria, Va, U.S.A.
Riseley, Madge B., Wembley.
Roberts, Ian M., Toronto, Ont., Canada.
Roberts, Sylvia, Liverpool.
Robinson, Stuart A., Norwich.
Robshaw, Hillary, Lofthouse.
Rubin, Léon P. J., Brussels, Belgium.
Sabel, Peter L. T., Lichfield.
Sadler, Philip A., London.
Saez Balsalobre, Lidia, Barcelona, Spain.
Salcman, Laurell, Downsview Ont., Canada.
Salim, Salim A., Nairobi, Kenya.
Samarakoon, Ralalage P., Kotadeniyawa, Sri Lanka.
Samuel, Diana, Aberdare.
Sanders, Sonja M., Oshawa, Ont., Canada.
Saraf, Vandna V., Bombay, India.
Sastrowidjojo, Hendro, Surabaya, Indonesia.
Schoe, Marjolein B., Bussum, Holland.
Schofield, Nicola J., Huddersfield.
Seneviratne, Maddumage K., Colombo, Sri Lanka.
Shams, Dunia M., Fetcham.
Shaw, Lesley J., Edinburgh.
Shenker, Ian L., Edgware.
Sherwin, Andrew E., Nottingham.
Shibataka, Yasuhiro, Osaka, Japan.
Shimada, Nobuo, Kashiwa, Japan.
Shingler, Tracy, Manchester.
Shiraishi, Motoko, London.
Shiouxios, Anthea, London.
Shtein, Paul, Johannesburg, S.Africa.
Simpson, Nicholas I., York.
Sinha, Purushottam, Agra, India.
Sivori, Jouko E., Espoo, Finland.
Smith, Adrian S., Southsea.
Smith, Catharine, Lutterworth.
Smith, Ian J., Royton.
Smith, Stephen, Dewsbury.
Smitherman, Susan E., Lymington.
Smythe, Richard H., St Catharines, Ont., Canada.
Sneddon, Katherine E., Hong Kong.
Soni, Ann, London.
Speed, David G., St Helier.
Spooner, Carole A., Ruwi, Oman.
Stevens, John B., New Ferry.
Steward, Annelies, Willowdale, Ont., Canada.

Stock, Cindy F. E., Wookey.
Stolarewicz,Teresa M., Birmingham.
Suguro, Norio, Tokyo, Japan.
Sundgaard, Merete F., Lillehammer, Norway.
Suzuki, Takako, London.
Swaminathan, Muthukumarasamy, Jaffna, Sri Lanka.
Swersky, Ann H., Ramat Hasharon, Israel.
Swersky, Barry R., Ramat Hasharon, Israel.
Swift, Martin, Godstone.
Syer-Postance, Penelope A., Toronto, Ont., Canada.
Takada, Fujio, Osaka, Japan.
Takahashi, Toshio, Tokyo, Japan.
Takai, Toshisuke, Shizuoka, Japan.
Takayama, Tetsuo, Oita, Japan.
Talbot, Alfred N., Frimley.
Tamai, Hideo, Osaka, Japan.
Tanada, Yasuyuki, Osaka, Japan.
Tanaka, Junichi, Yokohama, Japan.
Tanaka, Kayoko, Kawanishi, Japan.
Tang Yuk King, Alice, Hong Kong.
Thomas, Barry, London.
Tishlias, Jimmy, Houston, Tex., U.S.A.
Toole, Michael L. A., Delta, B.C., Canada.
Trinkl, André A., Vlottenburg, S.Africa.
Turatti, Maya, Versoix, Switzerland.
Tyson, Jeffrey G., Carmarthen.
Uematsu, Yasuo, Kobe, Japan.
van der Riet, Diane M., Stellenbosch, S.Africa.
van der Zwaag, Hemko, Zeist, Netherlands.
van Dijk, Peter, Leimuiden, Netherlands.
van Dommelen, Marianne, Moordrecht, Netherlands.
van Muyden, Paulus M. A., Rotterdam, Netherlands.
van Roy, Anne E. J., Brussels, Belgium.
Vaughan, Malcolm J., London.
Vermaas, F. J. M., Rotterdam, Netherlands.
Versendaal Ovimk, Beatrix E. W., Ambacht, Netherlands.
Vigo Ripoll, Leticia, Barcelona, Spain.
Vikamsey, Indira J., Bombay, India.
Vine, Jeffrey S., Ilford.
Vinets Tur, Amador, Barcelona, Spain.
Vohora, Jaswant, Nairobi, Kenya.
Wake, Barry A. P., London.
Walsh, Francine E. E., Dundas, Ont., Canada.
Walters, Raymond J. L., London.
Ward, Nicholas R., Eynsham.
Warrenberg, Jonathan M., Ilkley.
Warriner, Elizabeth R., Solihull.
Wasinski, Simon M., London.
Weerasekara, Parakrama S., Colombo, Sri Lanka.
Wellings, Hilary, Stanford-le-Hope.
Wescott, Hilkka M., Kuala Lumpur, Malaya.
Wewer-Meÿer, Margaretha M., Schoonhoven, Netherlands.
Whitrow, Patrica A., Dunedin, N.Z.
Whittingham, Jill E. A., Farnham.
Wilkie, William, Helensburgh.
Williams, Bruce M., Walla Walla, Wash., U.S.A.
Wilson, Eunice K., Salisbury, Zimbabwe.
Wols, René P., Rotterdam, Netherlands.
Wong, Helen C. Y. W., Hong Kong.
Wong, Kitty, Hong Kong.
Wong, Shui Y., Zurich, Switzerland.
Wood, Clair, Prestatyn.
Wood, Elaine, Brinsley.
Workiewicz, I. M., Toronto, Ont., Canada.
Wright, Clifford J., Chorleywood.
Wright, Ruth E., Vancouver, B.C., Canada.
Wycherley, Megan S., Formby.
Yapa, Lloyd F., Rajagiriya, Sri Lanka.

Yenson Chu, Mabel, Hong Kong.
Yoshiyama, Masaru, Chiba, Japan.
Yoshizawa, Keiko, Tokyo, Japan.
Young, Gerald G., Dunedin, N.Z.
Young, William R., London.
Zebrak, Tracy J., Hove.
Zietkiewicz, Bridget A., Stellenbosch, S.Africa.
Zipf, William T., Pittsburgh, Pa, U.S.A.

EXAMINATIONS 1981

Examination dates for 1981 are as follows:

Gem Diamond Examination: Monday, 8th June

Examinations in Gemmology:

Preliminary: Tuesday, 30th June

Diploma:

Theory, Wednesday, 1st July

Practical, Thursday, 2nd July (London: Tuesday, 30th June and Friday, 3rd July.)

The *last* date for receiving examination entry forms is Friday, 27th February, 1981.

REVISED EXAMINATION SYLLABUSES

At the meeting of Council on 30th April, 1980, revised Syllabuses for the Preliminary and Diploma Examinations in Gemmology were approved for printing as follows:

Syllabus of Examinations

Preliminary

1. *Nature of Light*
   The electro-magnetic spectrum.

2. *Units of Measurement*
   Metric carat, pearl grain. Kilogram (kg), Gram (g), Milligram (mg). Metre (m), Millimetre (mm), Micrometre (μm), Nanometer (nm). Ångstrom Å (obsolescent). Litre (l), Millilitre (ml).

3. *Nature of Gemstones*
   Formation of minerals (elementary). Qualities necessary in gems (beauty, rarity, durability).

4. *Elementary Crystallography*
   Nature of crystals: distinction between crystalline and amorphous materials. Crystal symmetry: axis of symmetry; plane of symmetry; centre of symmetry. Crystal form. Crystal habit. Seven crystal systems. Optical properties: singly and doubly refractive gems; anomalous double refraction; optic axes.

5. *Physical and Optical Properties*
   Hardness: definition; Mohs's scale, selection of reference minerals; application in gemmology; limitations of use. Cleavage: definition; description; importance in gemmology and lapidary work. Specific gravity: definition; determination—hydrostatic weighing, heavy liquids (bromoform, methylene iodide and Clerici

solution), flotation and pycnometer methods. Reflection: laws of reflection; importance in gemmology—lustre, sheen, chatoyancy, asterism. Refraction: laws of refraction; refractive index; total reflection—use in design of refractometer; measurement of RI using refractometer; birefringence and its determination. Polarized light: nature and production of polarized light; design and construction of polariscope; use of polariscope in gemmology. Nature of colour: absorption of light; allochromatism, idiochromatism; differential absorption of light, pleochroism; dichroscope—construction and use; interference; play of colour; dispersion; use of Chelsea colour filter.

6. *Apparatus*

Use of the balance. Description and use of the ×10 lens. Description of the microscope and an awareness of its other applications in addition to its use as a magnifier. Design and construction of spectroscope.

7. *Description of Gem Materials*

(a) Natural gemstones:

Occurrence and localities, Colour, Chemical composition, Crystal system and habit, Cleavage, Hardness, Specific gravity, Refractive index (with birefringence), Pleochroism and lustre of all gem varieties of the following: beryl, chrysoberyl, corundum, diamond, garnet group, jadeite, moonstone, nephrite, opal, peridot, quartz (including chalcedony), spinel, topaz, tourmaline, turquoise and zircon. Elementary methods of identification.

(b) Synthetic and imitation stones:

Synthetic corundum and spinel—their manufacture by the Verneuil process. Elementary methods of identification of composite and paste stones. Elementary methods of identification of synthetic stones including corundum, spinel and emerald. A brief outline of other methods—flux melt, hydrothermal and Czochralski 'pulling' methods.

(c) Organic products:

Native, cultured and imitation pearls—their formation and structure. Amber. Coral. Jet. Including an elementary knowledge of the formation, nature and properties of this group.

8. *Fashioning of Gemstones*

Description of the following cuts, including diagrams: brilliant; step; mixed; rose; cabochon; scissors or cross. Including ideal proportions for diamond.

Note: The Preliminary Examination consists of theory papers only.

Diploma—Theory

The Diploma syllabus comprises the whole of the Preliminary syllabus and:

1. *Elementary Crystallography*

Twinning, parallel growth. Massive, cryptocrystalline and metamict states. Isomorphism and isomorphous replacement.

2. *Physical and Optical Properties*
   Specific gravity. Optical properties of crystals. Refractive index and birefringence: their measurement by refractometer and by other methods. Colour: its causes and artificial alteration. Spectroscopy and absorption spectra. Luminescent and electrical properties. Application of x-rays and ultraviolet light to gem testing. Inclusions and other internal features.

3. *Apparatus*
   Principles and use of: microscope, polariscope, refractometer, dichroscope, spectroscope, ultraviolet lamps, thermal conductivity and reflectivity meters. Principles of endoscope and table spectrometer.

4. *Description of Gem Materials*
   (a) Natural gemstones:
   Occurrence and localities, Colour, Chemical composition, Crystal system and habit, Cleavage, Hardness, Specific gravity, Refractive index (with birefringence), Pleochroism and lustre of all gem varieties of the following: all species listed in the preliminary syllabus with the addition of andalusite, apatite, benitoite, bowenite, chrysocolla, danburite, diopside, enstatite, feldspar (in addition to moonstone), fluorite, hematite, idocrase, iolite (cordierite), kornerupine, lapis-lazuli, malachite, natural glasses (particularly moldavite and obsidian), phenakite, pyrite, rhodochrosite, rhodonite, scapolite, sinhalite, sodalite, sphene (titanite), spodumene, steatite and zoisite.

   (b) Synthetic and composite stones, glass and plastic imitations:
   Methods of manufacture where generally published and identification of synthetics (including synthetic alexandrite, corundum, diamond, emerald, opal, quartz, rutile, spinel, strontium titanate, turquoise, YAG, GGG and cubic zirconia).

   (c) Organic products:
   Pearls, native and cultured (both nucleated and non-nucleated), their formation and structure. Imitation pearls. Amber, copal, coral, jet, ivory, odontolite, shell (cameo, mother-of-pearl), tortoiseshell, and their simulants. Occurrence and methods of identification of all groups.

5. *Fashioning of Gemstones*
   Outline of methods used by diamond cutters and lapidaries.

Diploma—Practical

The determination of the refractive indices and birefringence. Dichroism. Specific gravity. Absorption spectra of gemstones. Identification of gem materials and gemstones (both cut and uncut, mounted and unmounted). Estimation of weight of gemstones. *(Tables of constants are provided for this section of the examination.)*

Note: The gem materials likely to occur in refractive index determinations in the practical examination are not restricted to those listed in the syllabuses for the Preliminary and Diploma examinations.

C.I.B.J.O. DIAMOND RULES

Set out in detail below are Articles 1 to 6 of the second edition (1980) of the C.I.B.J.O. Rules of Application for the Diamond Trade:

Art. 1
Definition of the diamond

(1) A diamond is a natural mineral of crystallized carbon with cubic or pseudo-cubic structure.

(2) The genuineness of a diamond must not be specifically mentioned because the use of the word 'diamond' by itself is automatically a statement of its genuineness.

(3) It is prohibited to use the word 'diamond' to describe such products that have either partly or wholly crystallized due to human intervention, no matter which basic-material or methods are used. Products made in this way can only be named as 'synthetic diamonds' when their structural, physical and chemical properties correspond in their total mass to diamond. The word 'diamond' must then be clearly preceded by the term 'synthetic' or 'artificial'.

(4) Trade marks or fancy names must not use words similar to 'diamond' (e.g. Diamantine, Diamlite).

Names of firms, manufacturers or trademarks are not to be used in connection with synthetic or artificial diamonds, unless such names are clearly preceded by the word 'synthetic' or 'artificial'. Example: The definition 'GE-diamond' (General Electric) is inadmissable and should be reworded into 'synthetic diamond GE'.

Art. 2
Weight of the diamond

(1) The weight of the diamond is always expressed in carats (international abbreviation 'ct') to at least two decimal points. It can be rounded off upwards to two decimal figures only if the third decimal figure is a nine.

(2) If the total weight of all the diamonds contained in an article is given the weight must be specified clearly and unambiguously by the terms 'total weight' or words of similar importance.

Art. 3
Colour

(1) The diamond colours are determined by the seven C.I.B.J.O. masterstones (see Art. 8)* these describe the lower limit of each colour.

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*According to Art.8:—'A set of seven diamonds has been selected and aproved . . . . as the official set of masterstones for determining the colour-grades. These are the diamonds 1.00, 1.17, 1.07, 1.03, 1.00, 1.17, 1.09. The same has been done with three reference-stones 0.33, 0.30 and 0.31 ct. for determining the intensity of the fluorescence . . . . National duplicates of masterstones are to be compared and chosen equivalent to the official C.I.B.J.O. set . . . .'—Ed.

(2) The colours have to be named as follows:

C.I.B.J.O.— International Colour Grading Scale	(1)	(2)
Exceptional White (4)	D	River
Exceptional White	E	
Rare White (4)	F	Top Wesselton
Rare White	G	
White	H	Wesselton
Slightly tinted white	I J	Top Crystal/ Crystal
Tinted White	K J	Top Cape
Tinted Colour (3)	M Z	From Cape to Yellow
Fancy Diamonds		

(1) G.I.A. terms as comparison
(2) Transitional use until 1984
(3) Optional subdivision for some countries (i.e. South Africa)
(4) The subdivision of the colours Exceptional White and Rare White into two further subdivisions may only be done for sizes of 0.47 ct. and larger.

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(3) Colour specification must be made by an experienced professional, carried out by comparison to a masterset chosen according to the original C.I.B.J.O. masterstones, under normalized artificial light equivalent to approx. 5.500° Kelvin (D55).

If no difference is observed between one of these masterstones and the diamond to be graded, the colour of the masterstone is conclusive. If the colour lies between those of two masterstones, the colour of the darker one is conclusive.

(4) Non-yellow hues (i.e. brownish) are graded according to the intensity of the colour compared to the masterstones.

(5) Fancy-coloured diamonds which have a clear and distinct colour are separately described.

(6) Photometric measurements have no determinative value.

(7) The fluorescence of a diamond has merely a descriptive value and is to be expressed as either:

none—slight—medium—strong

as seen under longwave UV (366 nm). These degrees are defined by the three C.I.B.J.O. fluorescence-reference-stones described in Art. 8.

(8) The body-colour of fluorescent diamonds must be determined under normalized light (D55 CIE).

(9) If an offer contains the quality of a diamond, the colour may not be mentioned without the purity and vice versa.

Art. 4
Purity

(1) All internal characteristics belong to the inclusions which are internally perceptible. These are:

— crystalline and solid inclusions, clouds, pin points,
— fissures, feathers, fissures at the girdle (bearding),
— structure phenomena (only in the case of clear visibility inside the stone, i.e. brown-coloured growth-lines, reflective grain-planes).

(2) The purity of a diamond must be examined by an experienced professional under 10-power magnification in normal light by means of an achromatic, aplanatic lens and described as follows:

loupe-clean (lc)	A diamond is called loupe-clean if, under these conditions, it has been found absolutely transparent and free from inclusions.
vvs (vvs 1, vvs 2)	Very very small inclusion(s), very hard to find with a 10× loupe.
vs (vs 1, vs 2)	Very small inclusion(s) which can hardly be found with a 10× loupe.
si	Small inclusion(s), easy to find with a 10× loupe, not seen with the naked eye through the crown-side.
PI (Piqué I)	Inclusion(s) immediately evident with a 10× loupe, difficult to find with the naked eye through the crown-side, not imparing the brilliancy.
PII (Piqué II)	Large and/or numerous inclusion(s), easily visible to the naked eye through the crown-side and which slightly reduce(s) the brilliancy of the diamond.
PIII (Piqué III)	Large and/or numerous inclusion(s) very easily visible to the naked eye through the crown-side and which reduce(s) the brilliancy of the diamond.

Terms such as 'pure', 'pure to eye', 'Commercially pure' or other misleading expressions or definitions are not to be used.

The subdivision of the degrees vvs and vs into two further subdivisions may only be done for sizes of 0.47 and larger.

(3) External characteristics do not impair the purity. This applies particularly to:

- polishing lines, rough edges, burn marks and very slightly bearded girdle.
- externally located damage such as scratches and pinpoint-shapes damage,
- extra facets and the remaining parts of the rough diamond (naturals),
- twinning-lines, growth-lines, knot-lines, surface grain-lines.

Major external characteristics which cannot be removed by repolishing without considerable loss of weight should be taken into account when the purity grade is determined.

(4) Interim Rules: France:
During a transition period until 1984 France will endeavour to adopt these international purity regulations and to use none but the 10-power magnification for purity determination after this period at the latest. Until then the following will apply:

(a) If any other than 10-power magnification has been used for purity determinations, it must be clearly indicated; e.g. '3-power magnification', etc.

(b) Foreign branches of French companies have to comply with the regulations of the host country, i.e. to use exclusively the 10-power magnification and to dispense with the 2- and 8-power loupe for determinations or definitely to point out the difference to their customers.

Scandinavia:
The Scandinavian countries are using the 'clarity grading' only for a transitional period until 1984.

Art. 5

Cut and Shape

(1) It is inadmissible to describe diamonds as 'correctly cut' if the proportions and symmetry of the diamond do not correspond to the norms in common usage. These norms take into account the general proportions of the stone and, following the laws of optics, allow a maximum of brilliance for the modern cut of a diamond.

(2) A modern brilliant cut is based on specific optical calculations aiming at a maximum of beauty which is a result of brilliancy and dispersion. Different combinations of proportions can give an equally good result and the evaluation of the quality of the cut can therefore not be determined by measurements only.

On the other hand, the finish is independent of the proportions and of minor importance as to the quality of the cut. Two separate indications are given to which extent deviations are observed concerning symmetry and polish. These do not pertain to the brilliancy.

(3) The term 'brilliant' without any additional description of the material may only be applied to round diamonds with brilliant cut.

(4) The brilliant cut or 'fullcut' is the round form consisting of an upper portion (crown) with at least thirty-two facets (excluding the table) and a lower portion (pavilion) with at least twenty-four facets (excluding the culet). The other cuts (8/8, 16/16, etc.) must be designated as such.

(5) Other common shapes are marquise, pear, oval, heart, emerald-cut, triangle, baguette, etc.

Art. 6

Designation of treatments and combinations of stones

(1) If the natural colour of a diamond has been artificially altered, it has to be clearly declared as 'treated', 'artificially coloured' or 'irradiated'.

(2) Diamonds that have been artificially treated to alter their purity by means of laser-drillings or other techniques must be clearly declared as 'drilled' or 'laser-drilled'. The classification should correspond to the original purity degree. The drilling hole itself is also graded as an inclusion.

(3) Any piece of jewellery put on display or presented for sale, composed of natural as well as synthetic or artificial elements must be accompanied by an obvious legible label, showing composition details according to the rules of the nomenclature. When diamond (or pieces of jewellery thereof) are displayed together with artificial or synthetic products (or pieces of jewellery thereof), an easily visible label must indicate the nature of the objects shown.

FOR SALE

One (only) Rayner Blende Refractometer. Brand new condition - unused. Complete with case but no contact liquid. Scale reads 1.6 - 2.2. Price £125. Postage and V.A.T. (if applicable) extra. Apply to G.A., Saint Dunstan's House, Carey Lane, London EC2V 8AB.

CORRIGENDA

On p.209 above (line 17), for 'Mr Geoffrey Toombs' read 'Mr Geoffrey Tombs'.

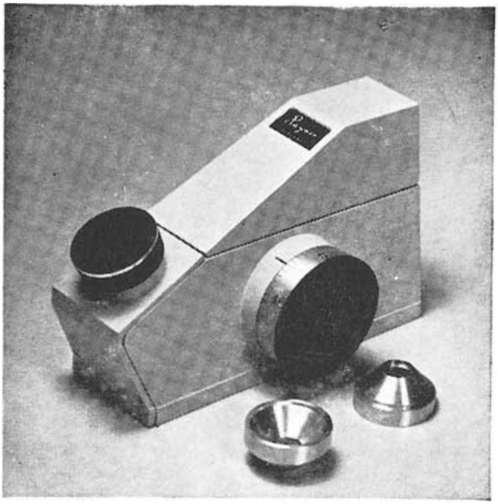
On p.248 above (line 12), for 'band' read 'baud'.

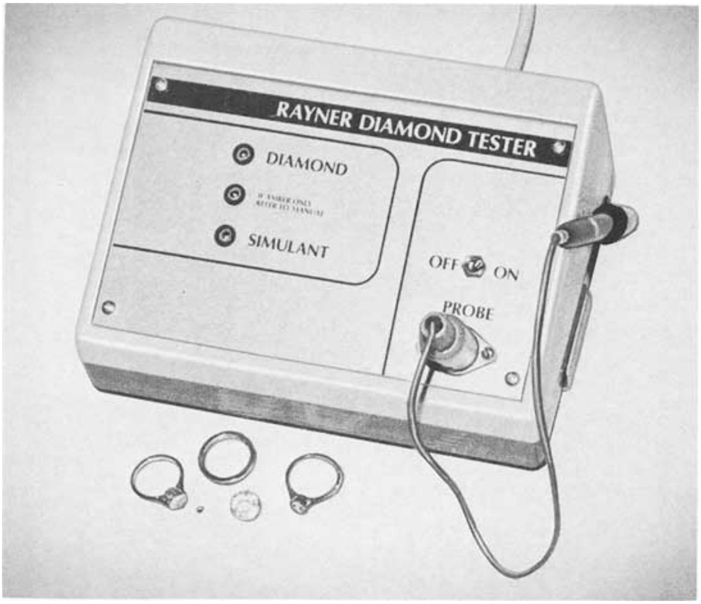
On p.259 above (line 18), for 'anisotrophy' read 'anisotropy'.

On p.263 above (line 6), for 'emenate' read 'emanate'.

On p.267 above (line 28), for '179-83' read '179-82'.

On p.272 above (line 5), for 'or' read 'of'.

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Historical Note

The Gemmological Association of Great Britain was originally founded in 1908 as the Education Committee of the National Association of Goldsmiths and reconstituted in 1931 as the Gemmological Association. Its name was extended to Gemmological Association of Great Britain in 1938, and finally in 1944 it was incorporated in that name under the Companies Acts as a company limited by guarantee (registered in England, no. 433063).

Affiliated Associations are the Gemmological Association of Australia, the Canadian Gemmological Association and the Rhodesian Gem and Mineral Society.

The *Journal of Gemmology* was first published by the Association in 1947. It is a quarterly, published in January, April, July, and October each year, and is issued free to Fellows and Members of the Association. Opinions expressed by authors are not necessarily endorsed by the Association.

Notes for Contributors

The Editor is glad to consider original articles shedding new light on subjects of gemmological interest for publication in the *Journal.* Articles are not normally accepted which have already been published elsewhere in English, and an article is accepted only on the understanding that (1) full information as to any previous publication (whether in English or another language) has been given, (2) it is not under consideration for publication elsewhere and (3) it will not be published elsewhere without the consent of the Editor.

Articles published are paid for, and any number of prints of individual articles may be supplied to authors provided application is made on or before approval of proofs. Current rates of payment for articles and terms for supply of prints may be obtained on application to the Secretary of the Association.

Although not a mandatory requirement, it is most helpful if articles are typed (together with a carbon copy) in double spacing on one side of the paper, with good margins at sides, top and foot of each page. Articles may be of any length, but it should be borne in mind that long articles are more difficult to fit in than short ones: in practice, an article of much more than 10 000 words (unless capable of division into parts or of exceptional importance) is unlikely to be acceptable, while a short note of 400 or 500 words may achieve early publication.

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