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GEMMOLOGY ON A SHOESTRING

*By B. W. ANDERSON, BSc., F.G.A.**

ON several occasions I have given talks to post-diploma students under the title "Gem-testing Without Instruments", which I believe have been helpful in warning the student, fresh from his examinations, against an over-dependence upon instruments in his endeavours to identify gemstones. "Gemmology on a Shoestring" is intended to follow much the same theme, but the title purposely suggests a little latitude in allowing for the use of quite simple pieces of apparatus, liquids, and so on, which can aid considerably in making firm decisions instead of merely forming opinions in certain cases.

First I must make it quite clear that to solve many of the problems that confront the gemmologist in these days every available instrument may be valuable and necessary if a correct answer is to be ensured. My present intention is not so much to provide easy recipes for individual cases of identification as to persuade those who have gemmological training to use their powers of observation to the full and interpret what is seen in the light of their special knowledge. It has often been said that the limited amount of scientific knowledge absorbed in the two-year course can actually be a handicap to a young jeweller: into every yellow zircon he dreams a sphene, and in viewing a parcel of tourmalines his mind is cluttered with thoughts of kornerupine. There is enough truth in this to sting a little; but

*The basis of a lecture given to the West of Scotland branch of the Gemmological Association in March, 1966.

I strongly maintain that in a "lens only" identification-test a on mixed series of gemstones, the man with a gemmological training should be far more sure of his ground than a colleague of otherwise equal ability and experience. As any good artist knows, it is a fallacy to think that any two people of normal eyesight gazing at a given object are necessarily seeing the same thing. It is the *interpretation* of the image falling on the retina that may enable the artist to see a significant and exciting pattern of shapes, shadows and colours, where his friend may see nothing of any interest whatsoever. In like manner a jeweller who is not a gemmologist, when confronted by a mounted and well-cut white zircon, may well feel that it "doesn't look quite right" for a diamond, but his gemmologist friend, noting the strong double refraction in the stone, will be able to make a quite positive identification.

Sheer economic necessity may deprive the average young gemmologist of the three really essential instruments for gem identification—the microscope, refractometer and spectroscope. Ten years or so ago less than fifty pounds would have been required to buy the lot: to-day one may have to pay at least twice as much as this. Indeed the simple liquids which will be recommended in this talk are now so costly that one must ruefully admit that even "shoestrings" have become expensive. Against this one must realise that in the precious stone trade a mistake may mean a loss of hundreds of pounds or a damaged reputation, and the cost of any instrument which can save such mistakes, or a fee for a laboratory test, is money wisely spent.

To start with, I shall assume that the jeweller has only one "instrument"—a pocket lens, and proceed to consider what he can learn about gems with this as his only aid. A good lens is so vitally important that I do insist—make it a good one, magnifying eight or ten diameters. Lower powers are of comparatively little use, however suitable for the scrutiny of watches or hallmarks—while higher powers are difficult to handle and not nearly so flexible in their application.

In our first assessment of any gemstone we are all inevitably influenced in our thinking by its general appearance, which, when analysed, depends chiefly upon its colour, lustre, degree of transparency, and "fire". If the stone is unmounted, we may notice from our first "feel" of it that it is cold or relatively warm to the touch, that it gives a slippery or a harsh impression when handled,

or that it strikes one as "heavy" or "light" in the hand. Then may follow close examination with a lens. The back facet edges may appear doubled, there may be characteristic inclusions, cleavage chips may appear on the girdle, and so on. All these phenomena may either be accurately measurable or more closely investigated with instruments: our task is to learn all that we can without them—even if later some form of instrument may have to be used as a final court of appeal.

It is a worth-while exercise to make a list of all those gem materials which you believe you can confidently identify by lens inspection only—provided the specimens are clean, not too small, and that the lighting is good. The following list of "recognizable" gems would probably be agreed to by most experienced gemmologists, and could, I am sure, be extended: Diamond, zircon, demantoid, peridot, opal, amethyst, star-sapphire and ruby, chrysoberyl cat's-eye, quartz cat's-eye, iolite, tourmaline, haematite, marcasite, lapis-lazuli, "Swiss" lapis, aventurine quartz, bloodstone, ivory, pearl, pink pearl, cultured pearl, imitation pearl, paste, "goldstone", doublets, synthetic star stones, synthetic rutile, strontium titanate, blue sinter spinel. Such a list of thirty materials at least makes an encouraging start; I shall suggest later the basis on which some of the above determinations may rest, and a few simple accessories which may make these and further identifications more simple and more sure.

That the stone examined should be clean (and here I am not referring to "inner cleanliness") was stipulated just now, and it is certainly well worthwhile before examining a stone or stones to do a thorough job of cleaning. This is usually quite a simple matter in water containing a little liquid detergent, using a soft toothbrush to get into any nooks and crannies of the setting if the stones are mounted. If the stones are then rinsed and shaken, and placed on blotting paper close below the bulb of a desk lamp, they will soon dry. Loose stones, if large, can be handled most safely in the fingers. With small stones, tongs are necessary: these should not be too sharp-nosed, and should have a mild spring. Those who have difficulty in maintaining the correct gentle pressure on the tongs to grip the stone safely while it is being examined may find tongs fitted with a "slide" helpful, as these maintain a fixed pressure. An adjustable desk lamp with an opaque shade is a virtual necessity, enabling a strong light to shine on the specimen without dazzling

the eye of the observer. In using a lens, a light interlocking of the left hand holding the specimen and the right hand holding the lens is essential to maintain steadiness and constant focus.

Let us now consider some of the main attributes which enable gemstones to be recognized for what they are.

(1) *Colour.* This is unquestionably the greatest aid of all, though of course it can sometimes be misleading. An attempt to sort out a parcel of mixed colourless stones will soon convince the sceptic how helpful colour can be. The gemmologist must also be on the look out for parti-colouration, as in many tourmalines; zoned or patchy colour as in amethyst, "burnt amethyst", sapphire; dichroism or change of colour with direction as in ruby, tourmaline, andalusite, iolite, aquamarine.

(2) *Lustre.* This depends, of course upon refractive index, but also upon the perfection of polish, which in turn depends largely upon hardness. The polished surface of a diamond will reflect 17% of a ray of light at perpendicular incidence, whereas quartz under the same conditions reflects only $4\frac{1}{2}\%$ of the light. Stones of intermediate refractive index, of course, reflect to extents between these two extremes, in accordance with Fresnel's well-known formula. The lustre of a diamond is certainly one of its outstanding characteristics, and lustre can often play a part in distinguishing between similar gems, e.g. between chrysoberyl cat's-eye and quartz cat's-eye.

(3) *Fire.* The gemmologist will know that the effect known as "fire" depends upon the "dispersion" of a stone, which can be stated numerically as the difference between its refractive index for red light of chosen wavelength and for a chosen wavelength of violet light. Fire is most necessary in a colourless stone, if it is to have any beauty and liveliness. Diamond, of course, is our standard here, though considering its high index of refraction its dispersion is decidedly low. By comparison synthetic rutile and even strontium titanate seem to show a rather gaudy display of flashes of spectrum colours. Demantoid garnet owes its lively appearance both to its high lustre and its fire: these features should serve to distinguish it at once from either emerald or peridot, even if its colour did not. Although the dispersion of synthetic white spinel is only a little higher than that of white sapphire, it does show perceptibly more fire and this makes it a more plausible substitute for diamond, particularly in step-cut form.

(4) *Transparency.* This is a contributory factor in the appearance of gemstones which is insufficiently appreciated. Most of the stones used in jewellery would be listed as "transparent", and this would be true insofar as one could read print through a polished block of the stones concerned. But perfect transparency is possessed by very few minerals—diamond, synthetic spinel, and white topaz amongst them—while others, such as zircon, are almost always marred by a slight touch of milkiness. Perfect transparency is, of course, more important in colourless than in coloured stones.

(5) *Double refraction.* The detection of double refraction in transparent gemstones, and the approximate assessment of its strength, are matters of prime importance in the lens identification of a given specimen, and it is here that a gemmologist should score heavily over his unscientific colleagues. The "doubling of the back facets" when viewed through the front of a stone with a lens is very easily seen in zircon (double refraction ·06) and sphene (·13), also in peridot (·036) and even tourmaline (·02): but one may need considerable skill in detecting it in quartz and in topaz (·01, approx.) unless the stone be a large one. It is very important to remember that in all doubly refracting stones there are either one or two "optic axes" along which no double refraction can be observed, and that at right angles to these directions the doubling cannot be seen either, since one image is directly behind the other. Thus one must turn and twist the stone, peering through it at the further facet junctions in all possible directions before deciding whether or not D.R. is present, and if so, approximately how strong. Naturally, the larger the stone the greater the effect, and this must be taken into consideration in any assessment made.

(6) *Hardness.* Hardness as a test has always been considered taboo amongst gemmologists, partly because of the danger it implies of damaging the specimen tested, and partly because of its inexactness compared with refractive index or density determinations. But hardness has a marked influence on the degree of polish that a stone can take and maintain and thus affects the appearance of a stone. The sharp facet edges in diamond, for instance, help one to distinguish it from strontium titanate, where the edges often have an almost moulded appearance. It is as well to realize that hard stones such as sapphire or even diamond may show an astonishing degree of wear, and one should be careful to avoid jumping to

conclusions on this evidence alone. Since the hardness of diamond is unique, a careful trial with an edge of a suspected diamond on a piece of synthetic corundum is sometimes justified. If the specimen "bites" on the corundum and leaves a definite mark, there is nothing else but diamond that it can be. Before the test is done, the corundum surface should be examined with a lens to ensure that no scratches are already there on the part that is to be used; and any mark made by the diamond should be rubbed with the finger and examined with a lens to ensure that it really is a scratch. With jade and the jade-like minerals gentle trials with a knife blade or needle point may yield valuable information, but should only be used where other tests fail, and when one can be sure that no damage results to the specimen. One should also recognize that there may be considerable variations in the hardness of such materials.

(7) *Density.* Before the coming of the jeweller's refractometer devised by the late Dr. Herbert Smith, tests for specific gravity (density) were the only accurate means of determining the nature of any unmounted gemstone. It remains a thoroughly useful test for any stone free from its setting. Every gemmologist knows that a simple trial in a heavy liquid will distinguish at once between yellow quartz and true topaz, or between quartz or chrysoberyl cat's-eyes. To make these distinctions by the "feel" or "heft" of the stone in your hand is a decidedly tricky business, but worth practising. Even when strung as a necklace, the extreme "lightness" of amber can be noticeable, when compared with bakelite or other synthetic resins. The judgement of the weight of a stone in relation to its "spread" is, of course closely bound up with a knowledge of its specific gravity, and here again the gemmologist scores.

(8) *Cleavage.* Where a stone has a marked cleavage, traces of this can often be noticed as flaws or incipient flaws within the stone or on the surface, where any nicks or chips may be seen to have flat sides instead of curved surfaces as in a conchoidal fracture. Cleavage nicks can often be detected round the girdle of a brilliant-cut diamond, especially if the stone had been removed from a setting. This adds one more to the many revealing signs that one can find when examining a diamond.

(9) *Surface structures.* This is rather a comprehensive heading, and can be used to cover such things as the traces of untouched crystal surface ("naturals") that can often be detected on the girdle

of a cut diamond; similar structures on the rear facets (really crystal faces) of a Lechleitner synthetic emerald, where the overgrowth is purposely left to enhance the colour; the "flame" pattern which is so completely distinctive for pink (conch) pearl, and so different from the grained structure of coral; the "engine-turned" pattern on the surface of ivory; the dimpled surface of fine jadeite; the demarcation line (nearly always above the girdle) marked by a sharp change in lustre, when the surface of a garnet-topped doublet is examined in reflected light; the short, parallel crack-like markings ("fire marks") due to careless cutting, seen only in corundum, more particularly in synthetic ruby or sapphire; and so on. A complete list of such surface signs would be a very long one.

(10) *Internal structures.* Internal features or "inclusions" should not really have come so late in the batting order, since such features are often of enormous help in identifying different gemstones and in distinguishing natural stones from their synthetic counterparts. But to study inclusions in their full beauty and detail one undoubtedly needs to examine them under a microscope—preferably a binocular microscope, and immersed in a cell of suitable fluid. Even with a pocket lens some inclusions are completely distinctive: for instance, the "horsetail" inclusions of asbestos fibres which are almost invariably to be seen in demantoid garnet, and the "silk" which is so typical a feature of Burma ruby. In both these cases of course the colour and appearance of the stone will already have put you on the right track. The list of such "dead-sure" identifications by inclusions is not a very long one, however, except at the gifted hands and eyes of a master of the subject such as Dr. Edward Gübelin. One should, however, be certain of an amethyst which shows the curious "tiger-stripe" inclusions; of "goldstone" (aventurine glass) with its glittering triangles of included copper; of a paste when it shows a typical elliptical bubble or so and of a doublet when a layer of bubbles can be seen at the surface where garnet meets the glass. Hessonite garnet, of course, is usually easy to detect with its crowded inclusion-picture of diopside crystals in a treacly golden-brown setting. The curved lines in synthetic ruby may be too finely spaced for a lens to detect, but in sapphire the broader curved swathes of colour are often more visible to the lens than under the microscope. The stone should be viewed against the white background of a sheet of clean paper or blotting paper, and turned in different directions until the right angle for viewing is found.

Immersion in liquid will often help here (I am jumping ahead a little) and will also reveal the straight-sided bands of colour so typical of natural sapphire. The "feel" of a stone and its "coldness to the touch" may also on occasion provide evidence of its nature.

Further simple tests

The tests so far suggested have involved only the use of lens and tongs. I am now going to suggest the use of a few very simple "extras" which I feel can be included under our "shoestring" limit, and which will undoubtedly extend quite considerably the scope and certainty of our gem identification. The first extra is the well-known Chelsea filter, which was developed by A. Ross Popley from a formula worked out by C. J. Payne and myself in the early thirties. In knowledgeable hands, and properly used, the filter can be extremely useful. If used without any knowledge of how it functions, it can be quite misleading. Basically, it is a very efficient "dichromatic" filter, transmitting only a narrow band of deep red light and a narrow band of yellow-green. Thus, through the filter, a stone can only appear red, green, or a mixture of the two. Filters of this type were originally designed to distinguish between emeralds and pastes or doublets. Emerald, unlike most green stones, both transmits deep red light and emits fluorescent red light when it is brightly illuminated. To see the effect at its best, the stone should be held immediately under a good tungsten light and viewed through the filter held close to the eye. The snags in this simple use of the filter for emerald are that two other green stones, demantoid garnet and fluorspar, may show a reddish residual colour when viewed through the filter, that synthetic emeralds appear an even more decisive red than natural emeralds, and that natural emeralds containing enough iron to damp its fluorescence and cause absorption in the deep red do not appear red through the filter. But in my opinion the warning given by the very intense red shown by Chatham synthetic emerald when viewed through the filter is a most useful indication, while its other uses in clearly distinguishing between aquamarine (green appearance) and synthetic blue spinel (orange-red) between stained green chalcedony and chrysoprase, etc. serve to add to its value.

Next, quite another kind of filter: polaroid. This astonishing invention of perhaps the most inventive of modern men, E. H. Land,

has placed polarised light, with all its peculiar and revealing properties, within the reach of everyone, and in a form far more compact and convenient than the old Nicol prism. A number of different formulae have been employed in producing the highly dichroic substances in plastic sheets which constitute polaroid, but the effect in each case is essentially the same—that a ray of light which has passed through such a sheet is vibrating parallel to one direction only—that is, it is completely polarised. Such pieces of polarising film are capable of far more valuable and fundamental uses in the study of gemstones than any colour filter can be, and fortunately the material is quite inexpensive: about four shillings per square inch, up to virtually any size required. The most favoured type transmits 34% of incident white light, and two pieces of this in the "crossed" position give virtually complete extinction.

One of the most obvious ways of using this material in gem testing is to mount two discs of polaroid in the "crossed" position with a space between them enough to accommodate any gemstone, thereby forming that very sensitive instrument for the detection of double refraction known as the "polariscope". A gadget of this kind can be easily home-made, but there are some inexpensive types, carefully designed for convenience in use, which are commercially available. A useful pocket polariscope is one made by Rayner from a design of Dr. E. Rutland's, while the same firm make an extremely convenient table model with a built-in light, which leaves ample room for large specimens, either dry or in a cell of suitable liquid: it can also easily accommodate massive pieces of jewellery, stones in necklaces, etc. can be examined, and both hands are free for manipulation. (Fig. 1).

A gemmologist worth his salt will get much more information from such a polariscope than "four times light, four times dark—there a doubly refracting crystal". He will learn to recognize the characteristic types of "strain birefringence" shown by paste imitations (which often show a crude interference cross) by synthetic spinels, with their "tabby extinction" patterns, by diamond, which is never truly isotropic in gem sizes, but shows brilliant interference colours, usually centred on the various points where tiny inclusions can be located, and so on. He will also learn to use a pocket lens to reveal interference figures, at least in the simpler cases, and the sight of a uniaxial figure through the table facet

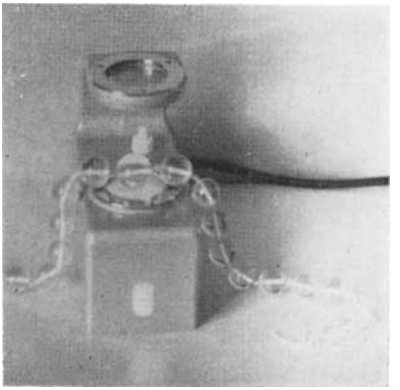


FIG. 1. *Quartz necklace on Rayner polariscope.*

of a ruby or sapphire will give him fairly strong assurance that the stone is a natural one. The unique interference figure of quartz, with its hollow coloured centre can often provide a quick proof for this mineral. This is beautifully and easily seen in beads of rock-crystal or crystal balls, in which the spherical shape makes the figure visible without the use of a lens to provide the "conoscope" effect. (Fig. 2).

Polaroid can also be used to detect dichroism in gemstones. Two pieces can be set with vibrations at right angles to each other in a pair of old spectacle frames, and a specimen viewed in rapid

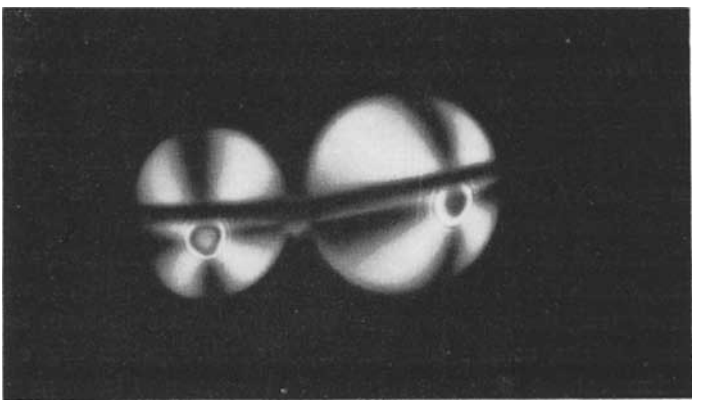


FIG. 2. *Unique interference figure of quartz seen in two beads on the Rayner polariscope. (Photo: Robert Webster).*

alternation first with one eye and then the other, often showing a marked change in colour, or narrow strips of polaroid in alternating vibration directions can be counted on a disc of plain glass which can be mounted at one end of a short metal tube with a low power lens at the other. This forms an effective dichroscope for stones that are not too tiny: a dichroic stone viewed through the tube showing alternating stripes of different colour or depth of colour. Alternatively the polaroid disc at the end of the tube can be cut into four sectors, the top and bottom sectors transmitting light vibrating, say, north and south, while the left and right hand sectors transmit only light which is vibrating east and west. In testing for dichroism it is best to use daylight reflected from a white surface if possible, and always one should turn both the specimen and the dichroscope tube before deciding on the strength of the dichroism—if there is any.

The next simple and inexpensive aids to gem testing that I want to recommend comprise liquids of various kinds, glass cells of suitable depth and diameter, a glass funnel and some filter papers. These can be used in a number of ways: to enable the colour distribution and other internal features of rough or cut stones to be studied with ease: as a rapid test for the density of unmounted stones: and as a means of assessing the refractive index of unknown specimens.

A useful stock to begin with would be two ounces each of methylene iodide, bromoform and bromobenzene, and four ounces of monobromonaphthalene, each in screw-top bottles of brown glass.

When stones are immersed in a liquid of similar refractive index the surface reflections and the effects of refraction are largely eliminated and one is able to "see into" the specimens as easily as though they were parallel-sided plates. The "frosted" effect of the surface of rough gem pebbles is also eliminated when they are immersed in a suitable liquid, and lapidaries are well advised to use this means of seeing the colour distribution, flaws, etc. of rough gems to enable them to be cut to the best advantage.

Gemmologists are familiar with the technique of placing a suspected ruby or sapphire in an immersion cell of liquid before examining it under the microscope, but they may not realize how helpful immersion may be for observations with the naked eye or with a lens. Sapphires in particular can usually be recognized as

natural or as synthetic when immersed in bromonaphthalene and viewed against a white background. Natural sapphires almost invariably show zones of colour with rigidly straight edges, while synthetics show the well-known curved swathes of colour when observed in the correct direction.

A simple and effective means of illumination is to place the stone in its immersion cell on the base of another, inverted glass cell of rather larger size, and direct the light from a bench lamp on to the white blotting paper on which this stands.

For density tests a stone must of course be free from its setting. Granted this, there is no simpler or more decisive way of distinguishing, for instance, between chrysoberyl and quartz catseye, between aquamarine and synthetic blue spinel, or topaz and yellow quartz, than to put the stone in question into a tube of methylene iodide and seeing whether it floats or sinks. On the whole it is advisable to keep your liquids as pure compounds rather than as mixtures, as in that way their densities and refractive indices remain constant, except for slight variations with temperature. A very useful mixture, however, is one of bromoform diluted with monobromonaphthalene until a small clear quartz crystal remains suspended in it. So constant is quartz in its density that this will serve as a virtual identification liquid for any of the transparent quartz gems such as amethyst and citrine. But also it will serve to identify Chatham, Gilson, or Zerfass synthetic emeralds, since the density of these is almost identical to the 2·651 of quartz.

Using liquids as a guide to the refractive index of gemstones has much in common with their use in checking density. In both cases a quite crude test may be all that is required to resolve a doubt, and in both cases quite accurate results can be achieved if this is necessary by taking more time and refining one's techniques. Even with mounted stones liquids can quickly give useful clues to refractive index. If the small diamonds in a cluster ring, for instance, are suspect, a clear decision can be given if the entire ring be immersed in methylene iodide and the stones viewed with a lens. If the stones are diamond the refractive index is so much higher than that of the 1·74 of the liquid that the facets and edges will still appear sharp and clear, while synthetic white spinel and synthetic white sapphire will virtually disappear in this fluid. With loose stones, a very fair idea of their refractivity can be quite quickly and easily obtained by placing the stones table facet down in a fair-sized

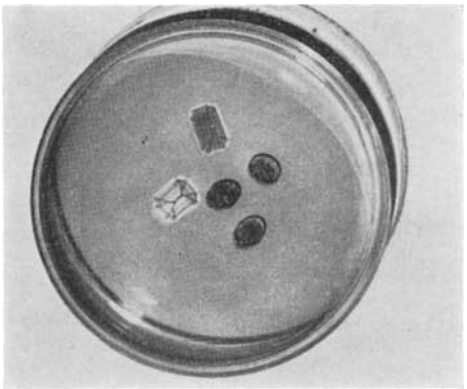


FIG. 3. *Effect seen when three (oval) yellow sapphires and two (step-cut) topaz are immersed in monobromonaphthalene and illuminated by a single overhead light.*

glass cell and pouring in enough monobromonaphthalene (R.I. 1·66) to just cover them completely. The cell should be placed on a sheet of white blotting paper and the stones viewed by the light of a single bulb some distance overhead. Those stones with an index higher than that of the bromonaphthalene will show a distinct dark rim round their periphery, as seen projected on the paper below, and the projection of the facet edges will appear white whereas with stones of lower index than the liquid a pale surrounding rim can be seen with the facet edges as dark lines. (Fig. 3). The degree to which the index of the stone is lower or higher than that of the liquid can be assessed with fair accuracy by noting the width of the dark or pale rim. Unlike the well-known "Becke" methods for gauging whether an immersed grain is more or less refractive than the liquid, this procedure leaves no doubt at all in the observer's mind about which has the higher index. A refinement of this simple test is to place the cell containing the immersed stones on a finely-ground glass sheet which is made to act as a bridge between two four-inch blocks of wood or stiff cardboard. A "handbag" mirror of suitable size is placed at 45° under the cell, enabling the projection onto the glass sheet of the stones, illuminated from above, to be seen in detail and in comfort. The effects seen are really very beautiful as well as revealing. If a permanent record is required, a contact photograph can be easily obtained in a dark room by placing the cell containing the stones over a piece of slow

film and exposing for a few seconds to an overhead light. Those who are photographers can make use of the narrow beam of light from an enlarger stopped down to f22, and thus obtain very sharp and detailed photographs. Internal features of the stones, in particular colour-zoning, show up very clearly on such photographs, particularly where the liquid and stone are of nearly the same index. I have found that the curved striae in synthetic corundums may be discerned in such photographs even if invisible under the microscope. For this, however, carefully filtered methylene iodide is necessary, and one must be lucky in hitting the right direction for showing the lines. I have only had time to give bare outline of these methods: but anyone seriously interested will find details, with diagrams and photographs, in my book "Gem Testing".

I have included bromobenzene in my short list of useful liquids because this fairly pleasant and inexpensive liquid has a refractive index of 1·56. This makes it an ideal immersion fluid for the critical examination of emerald: it enables the thin rim of dark colour to be seen at the edges and corners of the "Lechleitner" type of synthetic emerald, in which a pale, faceted beryl is used as the "seed" on which a thin crystalline layer of synthetic emerald is grown hydrothermally. Quite a few of these stones are now being used in mounted jewellery. The index of bromobenzene is also between that for synthetic emeralds of the Chatham, Gilson and Zerfass types and the indices found in natural emeralds. A good immersion contact photograph of synthetic and natural emeralds immersed in bromobenzene will reveal this. (Fig. 4).

Two pieces of advice I should like to add because I am so convinced of their importance for any budding gemmologist. The first is to start a collection of gemstones, because the ability to compare the appearance and properties of an unknown stone with known samples is of inestimable value in testing. Even a collection of all available synthetics, doublets, pastes, etc. makes a most useful and interesting beginning. For genuine stones the "shoestring" may only permit one to acquire only quite small specimens, or chipped or broken pieces, but one must realize that money spent on any fine specimen is not lost but invested, since the value of these is continually increasing. The second piece of advice is to have at hand one or two reliable reference books. Two by Robert Webster stand out by reason of their accuracy and comprehensiveness. His "Gemmologist's Compendium" contains all the necessary data on

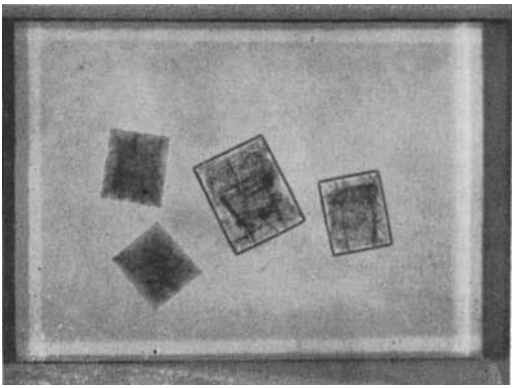


FIG. 4. *Immersion contact photograph of two natural emeralds (dark borders) and two Chatham synthetic emeralds (pale borders) in bromo-benzene.*

gemstones in condensed form, and is very reasonably priced, while his two-volume work "Gems", though expensive, contains such a wealth of information as to be well worth the money for any sizeable firm or jewellers or any serious student of the subject.

A trained gemmologist can go a long way in gem identification by intelligent use of a good lens and a few simple bits of apparatus, but I must repeat the warning that some of the problems confronting the trade to-day need more than this for their correct solution: they need all the facilities and skills of a specialized laboratory.

PHOTOGRAPHIC TECHNIQUES USED IN GEM TESTING

By ROBERT WEBSTER, F.G.A.

Reproduced from *Visual*, 1966, 4, 1 published by Ilford Limited.

A NUMBER of photographic and radiographic techniques are used in the testing of gems and associated work. In this article it is proposed to discuss the photographic techniques used, some of which have been developed by the staff of the Laboratory of the London Chamber of Commerce. These techniques have proved of great value in identifying individual gems and in proving whether they are natural or synthetic. They are frequently employed in the preparation of photographs to support expert evidence in civil and criminal court cases.

Straightforward photography of articles of jewellery and of single gemstones has little application in this field, except for requirements such as the production of pictures for identity certificates—documents giving all the features of a piece of jewellery so that it can be readily identified on recovery following loss or theft. When a photograph is needed to illustrate an article for publication it is usually taken by a professional photographer, who is better versed and equipped for this work than the normal gem-testing laboratory

The photomicrography of inclusions in the interior of gemstones is very important in the preparation of identity certificates for gemstones and jewellery, for record purposes, for teaching, and for illustrating publications. The usual method of taking these photomicrographs is to use a microscope camera which fits over the ocular of the microscope. This may be just a simple slide carrier mounted on a housing to fit the microscope; the focusing being carried out on a ground-glass screen inserted into the slide carrier in place of the dark slide. Alternatively, an eyepiece microscope camera with an independent eyepiece for focusing can be used in which the image can be observed right up to and during the exposure.

A method, although not strictly accurate, which usually works well in practice, is to use a 35-mm camera. The microscope is first focused on the specimen in the ordinary way and the camera, set at infinity with the aperture fully open, is placed squarely on the microscope ocular. A special ring fitting encloses the camera lens mount to avoid lateral displacement. If the estimated time of

FIG. 1. *Photomicrograph of an unusual inclusion in a diamond.*

FIG. 2. *Inclusions in a synthetic emerald.*

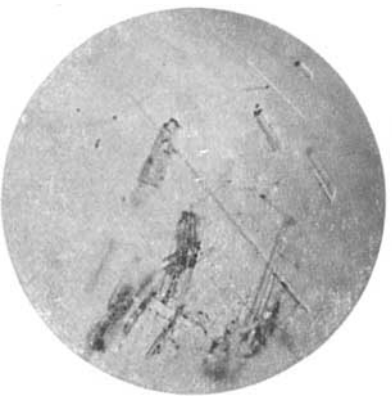


FIG. 3. *Stumpy prisms and rod-like crystals in a Rhodesian emerald.*

FIG. 4. *Flat liquid-filled film seen in tourmaline.*

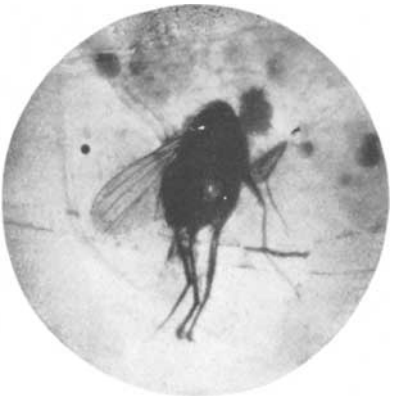


FIG. 5. *A fly in a piece of Baltic amber.*

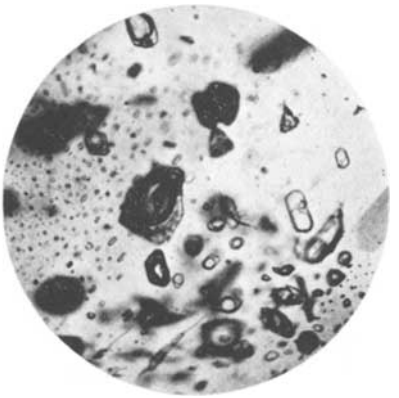


FIG. 6. *Inclusions in yellow beryl from Madagascar.*

exposure (exposure meters being of little assistance here) is in the compass of the camera shutter speeds, the use of the delayed action mechanism assists in the prevention of camera shake. If the exposure is greater than the range of the shutter speeds then the B setting is used and a cable release with a locking fitting is essential.

When photographing the surface structures of a stone, the specimen has to be mounted so that the features to be recorded are in a fairly level plane. This can be achieved by holding the stone on the slide with the aid of wax or plasticine and the features are brought out by top or side lighting.

The internal features of a gem are more difficult to photograph as it is necessary to overcome the reflections from the facets of the stone. This problem is solved by immersing the stone in a liquid with a refractive index near to itself in a cell with a plain glass bottom. Special cells are made which allow the position of the stone to be adjusted while immersed in the liquid. The liquids most convenient to use for stones of higher refractive index are monobromonaphthalene ($C_{10}H_7Br$; $n = 1{\cdot}66$) or methlene iodide (CH_2I_2; $n = 1{\cdot}74$). For the important gemstones of the beryl group (emerald and aquamarine) and the quartz group (amethyst, citrine and rock crystal) which are of lower refractive index, bromobenzene (C_6H_5Br; $n = 1{\cdot}56$) is preferable because of its similar lower refractive index.

Light transmitted through the subject from the microscope mirror and sub-stage apparatus (sub-stage condenser or polarizer) is normally used to photograph inclusions in gemstones. Occasionally, however, dark-ground illumination will reveal features not clearly seen by ordinary transmitted light. Such features are fine growth lines and large opaque crystal inclusions which are shown only as a dark silhouette when transmitted light is used.

An unusual photographic technique came into use when B. W. Anderson (1952) devised a simple method to obtain a near approximation of the refractive index of gemstones without recourse to a refractometer—this is of especial value as the refractive index of a gem is of the highest diagnostic importance. This method is to place a sheet of white paper underneath a glass-bottomed cell containing the gemstone and a liquid of known refractive index; by viewing it under a single overhead point-source light the appearance of the rim of the stone and the facet edges will give the desired information.

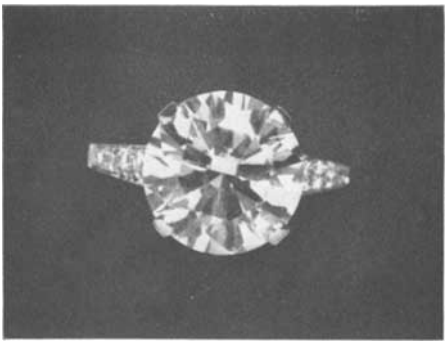


FIG. 7. *One of the photographs used for an identity certificate of a diamond ring. Taken on Ilford Line Film using an enlarger as camera.*

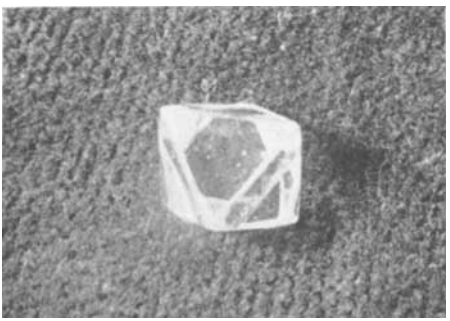


FIG. 8. *Photograph of a "glassie" diamond crystal. Taken with an ordinary camera fitted with a 3-dioptre positive lens.*

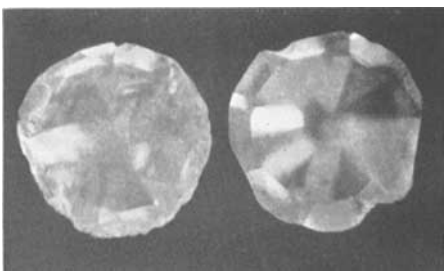


FIG. 9. *Photomicrograph of two very small diamonds showing the broken edges of the stones. This picture was used to support evidence given by an expert witness in a court case.*

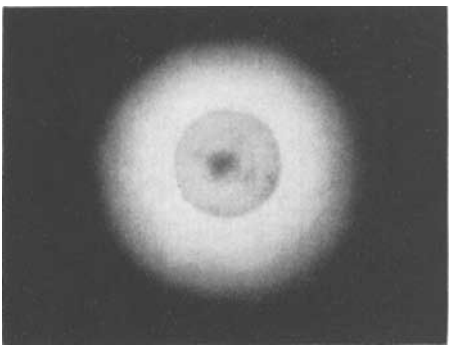


FIG. 10. *An autoradiograph of a radioactive (greened) diamond (positive print).*

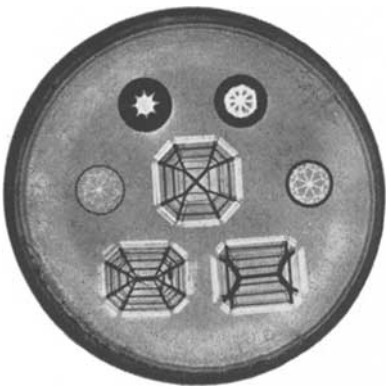
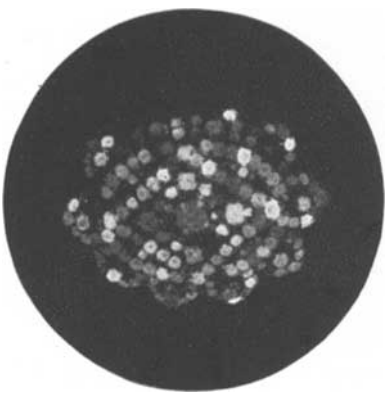
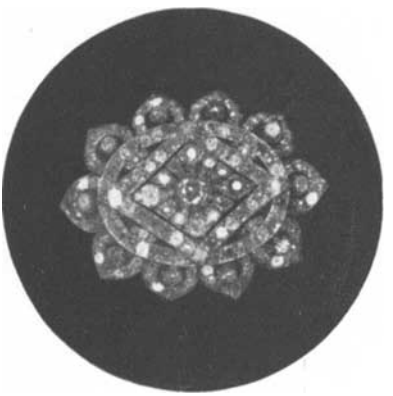


FIG. 11. *Immersion contrast picture of seven different gemstones immersed in monobromonaphthalene, which has a refractive index of 1·66. It will be noted that the four circular stones have an index higher than the liquid and the three other stones.*





FIGS. 12 and 13. *Photographs of ultra-violet fluorescence of a diamond brooch—using an ultra-violet fluorescent tube lamp (12) and using a medium pressure (Hanovia) lamp with Wood's glass filter (13). An Aviol ultra-violet filter was placed over the camera lens.*

When stones have a higher refractive index than the liquid, they will appear to have dark borders and the facet edges will show as white lines, conversely, if the stones have a lower refractive index than the liquid they will have white borders and dark facet edges. The dark or bright border widens as the difference between the refractive index of the stone and the liquid increases; thus it is possible to make some estimation of the actual index of refraction of the stone. When the liquid and stone nearly match in refractive index, the aforementioned signs tend to disappear and spectral colours are seen at the margin of the stone and liquid. This is because the liquid has a higher colour dispersion than the stone and would be obviated if monochromatic light is used.

A permanent record of this effect can be made by placing a slow photographic film or bromide paper beneath the cell and giving a brief exposure from a point-source light directly overhead. An enlarger makes a suitable set-up. It must be remembered that the result is a negative and the light and dark areas will be reversed. This is important when bromide paper is used, but with a positive print from a film it will, of course, give the correct interpretation.

The photographic materials used for this technique, i.e. Contact or Bromide paper or slow film such as Line film, are only sensitive to blue light and thus the effective refractive indices of the liquids and gemstones will be their higher blue-light values; this may affect the interpretation when the stones and the liquid have a similar refractive index.

If a stone is placed in a liquid which has a closely related index of refraction, the "immersion contrast" picture will be a "life-size" reproduction of the stone showing the distribution of the facets and the outstanding internal features. Such a picture is of value in any future identification of the stone. It has been found, too, that this method has shown up fine structures not apparent by ordinary microscopical examination; this is particularly so with the curved growth lines of difficult-to-prove synthetic stones.

Experiments have shown that most synthetic gemstones are transparent farther into the ultra-violet than stones of natural origin. An example of this is the synthetic emerald from America which transmits down to approximately 2,300Å whereas the natural emeralds absorb below approximately 2,900Å. Thus, this synthetic emerald will transmit the resonance line of mercury (2,537Å) and the natural emerald will not. Identification of the

transmission of this resonance line therefore indicates that a stone is an American synthetic emerald.

A photographic technique has been developed to show up the differences in transparency. A flat-bottomed dish is half-filled with water; water being transparent to the operative range of ultra-violet light. A piece of slow photographic printing paper such as Ilford Contact Paper C2, IP is placed at the bottom of the dish. On this paper, also fully immersed in the water, is placed the stone or stones to be tested together with known specimens to act as controls.

A short-wave ultra-violet lamp consisting of a low-pressure mercury-vapour burner with an envelope transmitting down to about 1,800Å, used in conjunction with a Chance glass OX7 filter, is held some 15 inches above the dish and an exposure of about one to three seconds duration is given. When the photographic paper is developed the natural emerald will appear as little more than a silhouette, for the ultra-violet rays will not have passed through the stone to any extent. There is always a little visible and long-wave ultra-violet light emitted by the lamp and passed by the filter so that if the exposure be unduly prolonged the longer wavelength transmissions may spoil the result. With care there should be no difficulty and the inclusion of control specimens will obviate any error in interpretation.

The glow of visible light given off by many minerals, gemstones and their imitations when they are bathed in filtered ultra-violet light, has been studied extensively by the author. As a result of this research the fluorescence of gem diamonds, which alone among the important gemstones show considerable variation in the intensity of their glow and even in their colour, is being put to practical use. This differential luminescence of diamonds is a means of producing additional evidence for incorporation in identity certificates, which are difficult to prepare for pieces of

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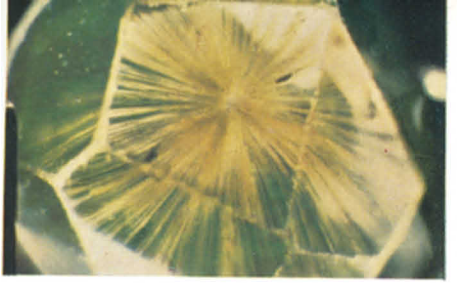
FIG. 14. *Radial asbestos fibres in a demantoid garnet.*
FIG. 15. *Goethite intrusion in amethyst.*
FIG. 16. *Pyrite crystals in an emerald.*
FIG. 17. *Manganese oxide "tree" in rose quartz.*
FIG. 18. *Flake of hematite in aquamarine.*
FIG. 19. *Zonal structure in sapphire.*
FIG. 20. *"Feathers" in sapphire.*
FIG. 21. *Inclusions in peridot.*
FIG. 22. *Crystal in blue apatite.*
FIG. 23. *Rutile crystals in ruby.*



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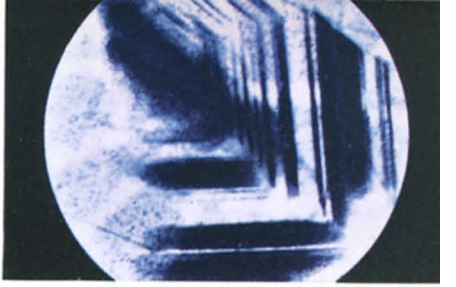

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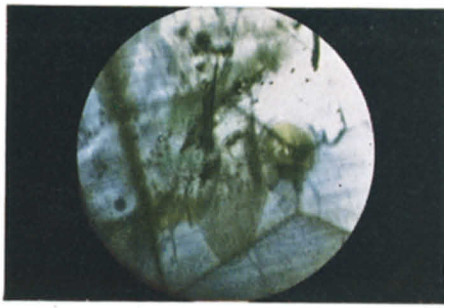

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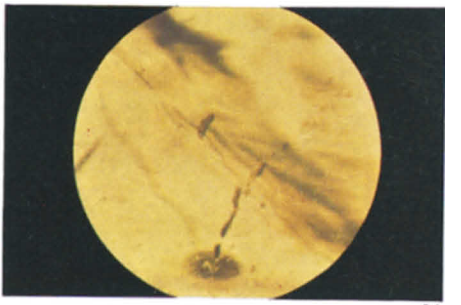

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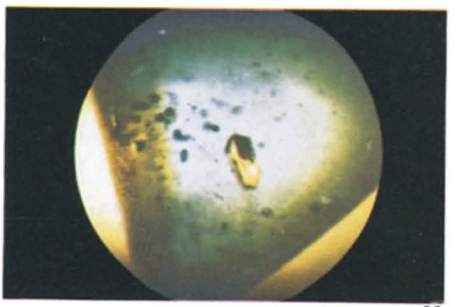

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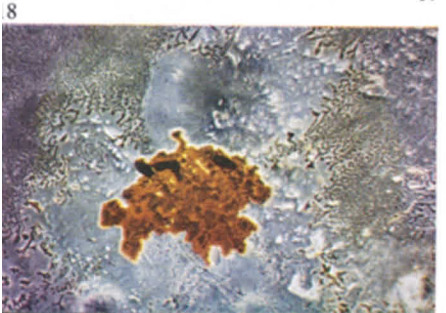

jewellery made up of a large number of small diamonds. Photographs of this type of jewellery, first under ordinary lighting conditions and then under ultra-violet light, give conclusive evidence of its identity. This is because of a facsimile piece of jewellery would not exhibit a similar degree of fluorescence in the same places. Any difference must betoken another piece of jewellery of similar design, or that some of the stones in the original piece had been changed.

The technique used to photograph these luminescent glows is as follows. The first essential is a source of filtered ultra-violet light. Modern ultra-violet lamps, all of which operate by an electrical discharge through mercury vapour, are of three main types. There is the short-wave lamp mentioned earlier, which has its emission at 2,537Å; and the long-wave lamp which consists of a medium-pressure quartz/mercury burner and has the visible and short-wave radiations filtered out by a Wood's glass (Chance OX1) screen. The latter emits strongly the powerful mercury line at 3,650Å. A third type of ultra-violet fluorescence lamp, now in considerable use, may be described as a "hybrid". This lamp consists of a low-pressure mercury burner in the form of a straight glass tube. On the inside of the tube is a coating which "fluoresces" under the influence of the short-wave radiation given off by the excited mercury vapour. It is analogous to the fluorescent tube lamps commonly used for lighting, but the coating emits ultra-violet light and does not glow very much in the visible range. The filter used in conjunction with this lamp, which gives a continuous and not a line spectrum, allows a broad range of wave-lengths to be radiated from about 3,200Å to about 4,200Å, the latter being in the visible violet.

Each of these lamps may be used for fluorescence photography, but the medium-pressure lamp with Wood's glass screen gives the best result with diamonds. The fluorescent tube lamp is unique in that, owing to the emission reaching into the visible violet, a

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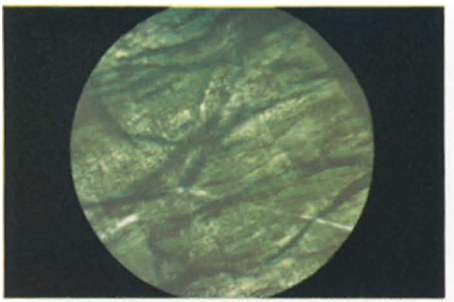
FIG. 24. *"Feathers" in synthetic emerald.*
FIG. 25. *Crystals in natural spinel.*
FIG. 26. *Iron inclusions in beryl.*
FIG. 27. *Curved colour bands in synthetic sapphire.*
FIG. 28. *Crystal and stress cracks on spinel.*
FIG. 29. *Rutile needles in rock crystal.*
FIG. 30. *Bubbles and curved lines in a synthetic ruby.*
FIG. 31. *Cavities with included bubbles in yellow beryl.*



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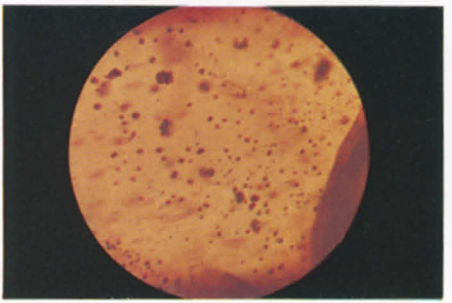

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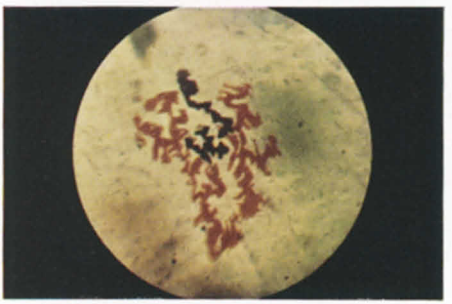

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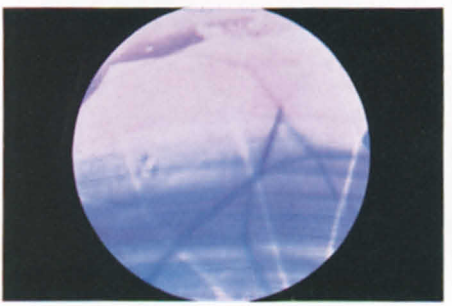

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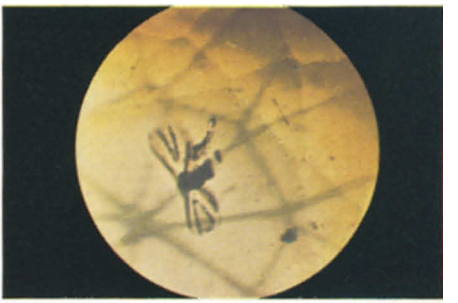

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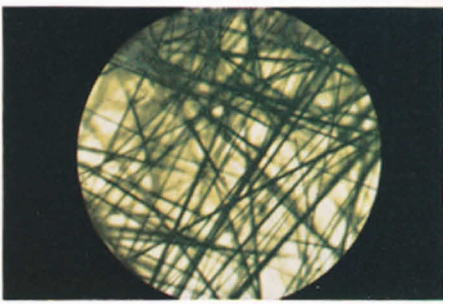

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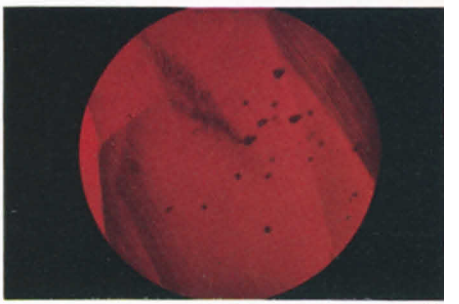

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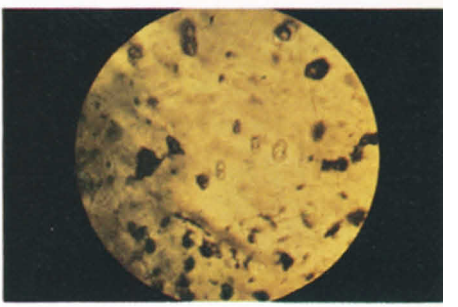

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direct (ordinary) picture is obtained of a piece of jewellery with the fluorescent glows superimposed. This may obviate the need to take two pictures, but the overall effect is not so good as with the medium-pressure lamp.

Any camera is suitable to take fluorescence photographs providing that an ultra-violet absorbing filter is placed over the camera lens. An Aviol filter is suitable. Orthochromatic or panchromatic films or plates may be used, for glows are mainly blue in diamonds. Excellent results have been obtained by the use of colour film, but the added cost is usually unnecessary for the preparation of identity certificates.

Some diamonds are altered to a green colour by bombardment with rays from a radium compound. In such cases the treated stones themselves become radioactive. These "greened" diamonds are tested for their radio-activity by autoradiography. The suspected diamond is taken into the dark room and placed in a box on a piece of X-ray film (or any fast film). To prevent movement, the diamond is lightly packed or, with the main facet upwards, is fixed with plasticine to a piece of cardboard cut to fit the box and then lowered into the box face downwards so that its main facet is in contact with the film. The box is closed, wrapped in black paper and left overnight. The film when developed will be blackened if the stone is radioactive—it will have *taken its own picture* in fact. This method of detecting radioactivity is also of value in testing other stones, and in particular the recently introduced metamict stone called *ekanite*.

In conclusion, the use of a quartz spectrograph should be mentioned. It is employed in conjunction with spectrum plates and has a number of applications: for minor spectrum analyses, for recording absorption and emission spectra, for checking the emission of ultra-violet lamps, and for measuring the degree of transparency of gemstones to ultra-violet light.

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HYDROTHERMAL RUBY

In an earlier issue of this Journal[1], Dr. E. Gübelin described the process of producing hydrothermal ruby and gave details of samples that had been produced in the U.S.A., which he had examined.

Recently the Association acquired a hydrothermal ruby, which had a relatively thick coating of synthetic material deposited onto the seed of natural ruby. When examined by Dr. Gübelin it confirmed the observations which he had previously published.

Observed in dark-field illumination the seed crystal is very easy to see and to distinguish from the hydrothermal surround. The seed contains typical natural inclusions consisting of liquid films surrounding microlites. From the appearance of these natural inclusions Dr. Gübelin suggests that the seed is probably a Siam ruby. In the hydrothermal layer surrounding the seed there are typical gaseous markings, already described[1]. By using dark-field illumination the difference between the natural seed core and the hydrothermal overlayer of synthetic ruby is seen distinctly.

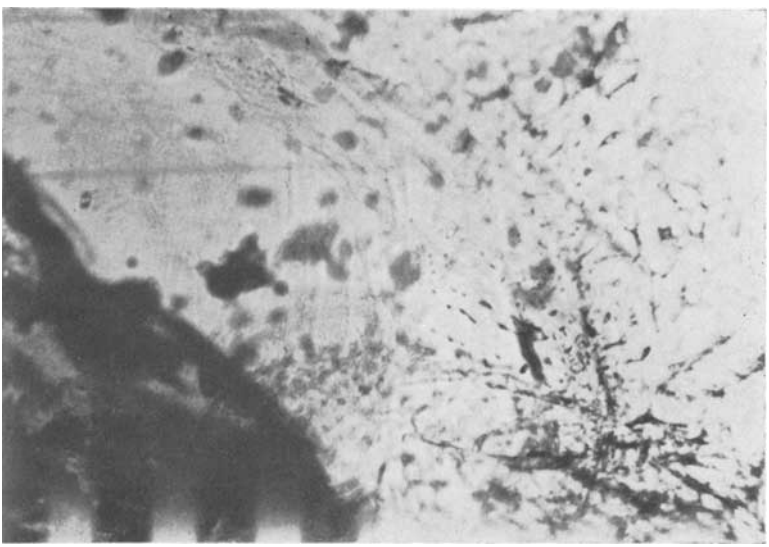


FIG. 1. *Gaseous inclusions consisting of irregular tubes and hoses. The natural inclusions consisting mainly of microlites are out of focus. Photo in transmitted light.*

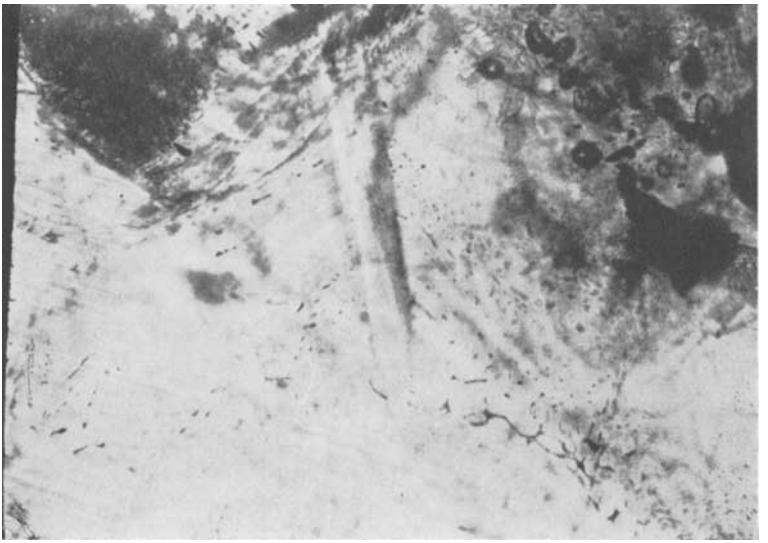


FIG. 2. *Gaseous inclusions in the hydrothermal overlayer, which are distinctly separated from the seed by dark pairs of growth lines, which meet at angles. This is distinct and characterizes the natural core, while in the lower part along the demarcation line between the natural crystal and hydrothermal overlayer there are numerous gaseous inclusions. Photo in transmitted light.*

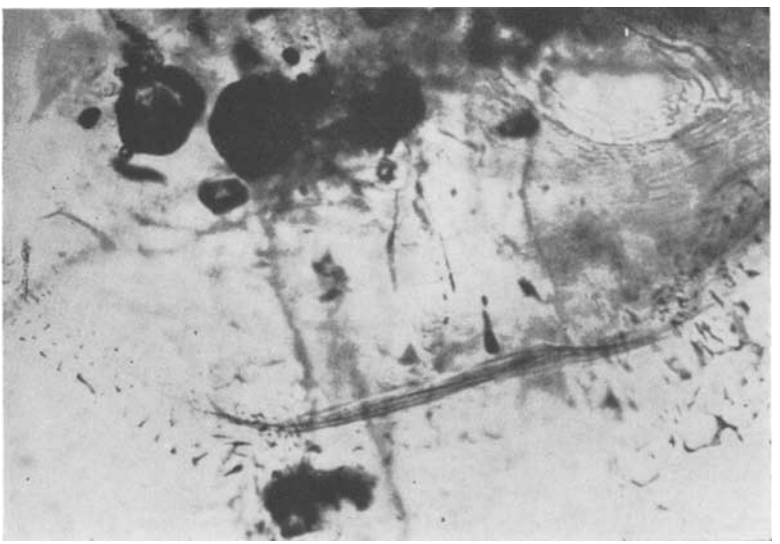


FIG. 3. *Top part of the phenomenological appearance of natural inclusions in Siam rubies. Photo in transmitted light.*

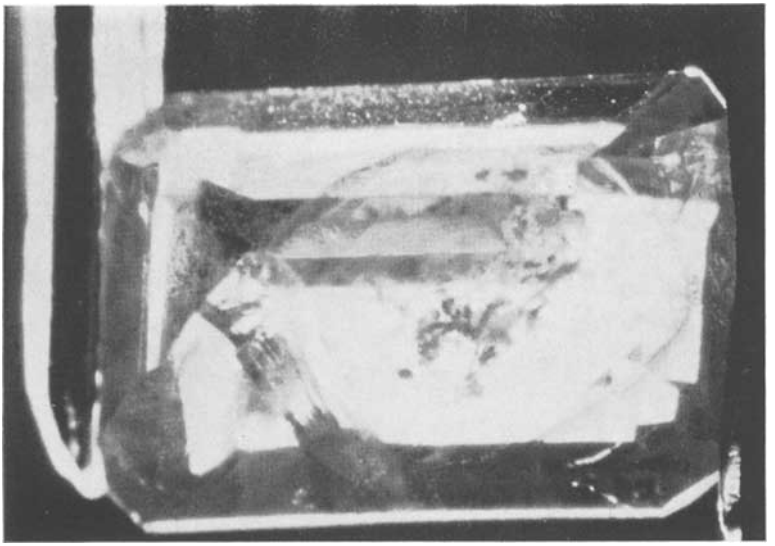


FIG. 4. *Showing difference between hydrothermal overlayer of synthetic ruby and seed core with its natural inclusions.*

The physical data of the stone corresponded to those given by Gübelin in 1961, but the colour of the stone was a dark red. This colour would invite suspicion but one gemmologist, after a cursory glance down a microscope, unwisely concluded that the stone was natural, thus emphasizing the need for caution and careful observation before making a decision as to a stone's nature.

REFERENCE

1. Journ. Gemmology, 1961, 8, 2.

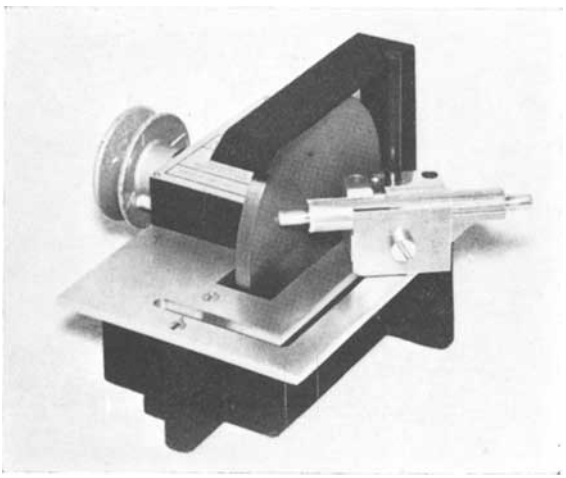
A NEW FACETING MACHINE

Following the development of his successful Beach Gem Master, Mr. M. L. Beach, F.G.A., of Twickenham, has devised a competent and inexpensive machine, called the Facet Master, with which cabochon work and faceting can be carried out.

The machine requires a small electric motor, with a pulley arranged so that the machine will run at about 1,000 r.p.m. In addition to free-hand cabochon cutting, the machine can be used for sawing. Faceting is the most difficult type of lapidary work and requires considerable practice and patience. The head of the Facet Master has been designed to give good results, but at all types great care in operation is needed. A few hours spent with inexpensive gem material will assist more than the text books, though these are a necessary background to the art of lapidary work.

The accompanying illustration show the simple yet robust construction of the machine, which costs £18 10s. 0d., complete with faceting head. Accessories for the Facet Master are also not expensive and range from cerium oxide polishing powder at 5s. to 4″ diamond-charged copper laps, coarse, medium and fine, at £7 each. A 4″ lapidary diamond saw costs £6 19s. 0d.

The Facet Master is a precision instrument and responds to intelligent treatment, and will give many hours pleasure to many interested in lapidary work.



IRIS-OPAL FROM MEXICO

*By JOHN SINKANKAS**

HYALITE opal exhibiting iridescence similar to that observed in chalcedony ("iris-agate") has recently been found at one or more unspecified localities in the State of San Luis Potosi, Mexico. There appears to be no mention in the mineralogical or gemmological literature of the iris-effect in opal and for this reason it is deemed worthwhile to report the results of an investigation into the nature of this new variety of opal.

Specimens of hyalite obtained from Mexico by Mr. and Mrs. Robert Sanchez, of Vista, California, and by Dr. Ronald Olson and Dr. Harry Miller, of Valley Center and Vista, California respectively, were kindly provided to me for examination. The Sanchez' specimens were purchased from a prospector in the city of Durango and were said to have come from alluvium upon the side of a hill near that city. Specimens provided by Drs. Olson and Miller were purchased by them in a parcel of brownish topaz crystals of unspecified provenance; the latter, however, appear to be identical with those described by Barbour (1964) as coming from cavities in volcanic rock near Tepetate and Lourdes, San Luis Potosi. It is probable that the hyalite furnished by Olson and Miller occurs in similar cavities containing topaz because one of the specimens consists of a small topaz crystal incrusted on one termination by a mushroom-like growth of transparent hyalite. All specimens of hyalite are fragments of botryoidal crusts which have broken apart at junctions between adjacent spheroidal growths. Several of the Olson and Miller specimens are stalactitic, consisting of clear hyalite deposited concentrically in cylindrical masses. However, no central filament or acicular crystal could be seen within them about which the opal grew. Within such specimens, and in a few others of non-stalactitic shape, can be seen transparent pale smoky zones. On the other hand, the Sanchez specimens are largely smoky except that in several which were sliced through, the outer zones are colourless while the cores are smoky. An interesting feature of the hyalite is the presence of small white spherical inclusions, some of which have equatorial bulges. These have not been identified but are described and figured by Leiper (1965).

*University of California, La Jolla, California.

A remarkable brilliant-cut faceted gem shown to me by Mrs. Sanchez exhibited flashes of colour reminiscent of the play of colour in precious opal, but much weaker. The colours suffuse the stone momentarily only when the stone is held in certain positions beneath a strong light. They do not seem to be confined to patches, as is the case in most precious opal. The colour display, plus a faint but unmistakable iridescence observable upon the sides of some of the rough fragments, at once suggested that the cause of colour might be due to diffraction from growth bands as in iris-agate. Closer examination of some pieces showed that weathering had differentially etched exposed opal bands, producing a series of minute striae from which light was being diffracted. This further suggested that the growth bands were spaced sufficiently close together to cause the iris-effect investigated and described by Jones (1952) in certain translucent chalcedonies. A similar effect in the Mexican opal could account for the weak colours observed in the faceted gem mentioned above. The iris-effect was confirmed as soon as a cross-section slice of about 2 mm in thickness was taken from one of the rough specimens and polished to remove surface irregularities. As in iris-agate, the effect appears to best advantage when the slice is held at about arm's length before a pinpoint source of light.

Specific gravity determinations were made upon several nodules selected for their freedom from inclusions, cracks, and adhering foreign matter. Determinations were made with a reliability of 0·02 mg by suspension in distilled water; corrections were made for temperature and for the slight buoyancy of the thin platinum wire used to hold the specimens. Three trials were made on three specimens, the average being S.G. 2·257. This is one of the highest specific gravities on record for hyalite (Frondel, 1962).

A polished slab was used for measurement of refractive index upon a Zeiss-Abbe refractometer previously calibrated with distilled water at 23·5°C. Three trials gave $n = 1{\cdot}4625 + 0{\cdot}0003$. This is also one of the highest values recorded for hyalite (Frondel, *op. cit.*). Rotation of the slab upon the prism of the refractometer produced no change in index and indicated that birefringence was absent or too small to measure.

Two trials were made on a General Electric x-ray diffractometer to determine if peaks of quartz, cristobalite, or tridymite could be detected. One trial was made upon a powder sample

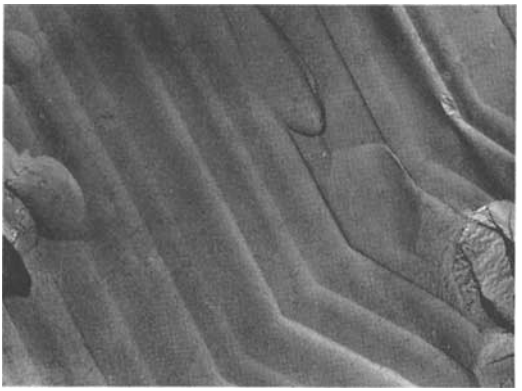


FIG. 1. Layer edges of Mexican hyalite; polished surface etched with HF. 7,800×. Replica slightly torn at top and bottom.

and another upon a thin slab which was ground flat with loose 1200 silicon carbide abrasive grain. This slab was fixed in the specimen plane of the instrument. No peaks were found, indicating that the silica crystallites were very small and randomly oriented.

Several smoky specimens were heat-treated to determine if the colour was fugitive. It was expected that such would be the case because a slice taken from one specimen showed it to be surrounded by a layer of colourless material about 2 mm thick, which suggested that the colour had been destroyed in the outer zones by exposure to daylight. The specimens were placed in an oven at room temperature and brought to about 460°C in 30 minutes. At about 200°C it was noted that the intensity of the brownish hue had materially diminished. At the end of 3 hours and 40 minutes the specimens were removed and found to be colourless.

Dehydration experiments indicate that free water in this hyalite is practically absent. A transparent, flawless specimen, free of inclusions or adhering matter, was selected for testing. Initially the specimen weighed 1·908 gm. Three runs were made, the first for 147 hours at 120°C with a negligible weight loss, the second for 4 hours at 200°C, again with a very slight weight loss, and the third for 2 hours at 400°C. At the end of the last run the total weight loss amounted to only 0·001 gm. The specimen did not crack.

Electron-photomicrographs were taken upon a slice of the

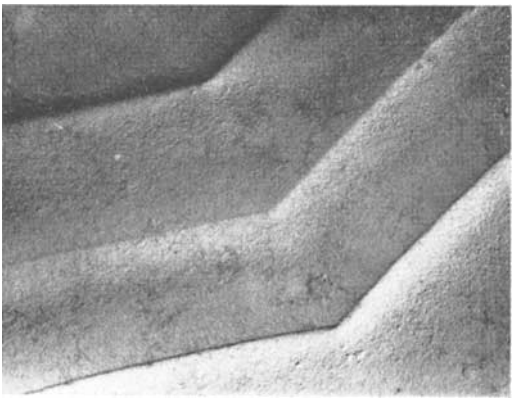


FIG. 2. Layer edges of Mexican hyalite; polished surface etched with HF. Each layer is approximately 2μ thick. 24,000 ×.

hyalite with the plane of the surface oriented across the bandings. The polished surface of the slice was etched for 30 seconds in the fumes of 49% HF to remove the disturbed polish layer and to expose the undisturbed opal beneath. A number of replica photographs were obtained from three different areas in order to count the growth bands and determine the average growth band width. A typical area is shown in Figure 1. A magnified portion of the same specimen is shown in Figure 2, to show how the acid selectively dissolved the opal and by so doing demonstrated slight but important differences in the nature of the opaline material depending upon its position within any band. Figure 3, now much magnified, indicates that the surface of the opal is conglomeritic in texture, each protuberance appearing to be composed of a number of smaller spherules of opal similar to those revealed by the recent work on Australian precious opal by Dr. J. V. Sanders of the University of Melbourne (1964). While Sanders' specimens show a regular cubic packing of spherules, which arrangement is believed to give rise to the intense diffraction effects in precious opal, the spherules in the Mexican material appear to be of widely different sizes and randomly packed. In this respect their appearance corresponds fairly well to the disorder of spherules in Australian potch as shown in Figure 6 of Sanders' report. However, in respect to spherule diameter, those of the Mexican opal are much smaller, approximately 40Å in diameter, while those of the Australian

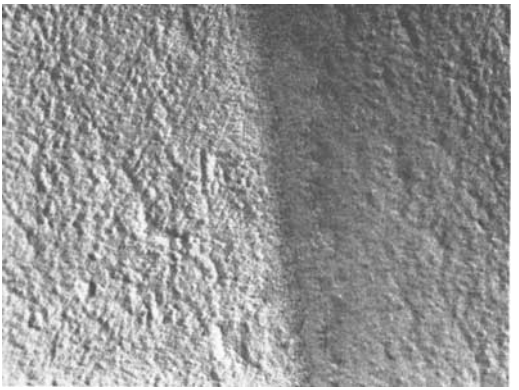


FIG. 3. Junction between layers in Mexican hyalite; polished surface etched with HF. 120,000 ×.

precious opal are 1,500-4,000Å (Sanders, *op. cit.*). The larger aggregates of spherules in the Mexican opal are still only about 250Å in diameter. Thus, if the cause of colour in precious opal is due to diffractive effects from cubic close-packed spherules it cannot be the cause of the diffractive effects in the Mexican hyalite. This leaves diffraction from growth bands as the only likely remaining cause of the iris-effect.

From Figure 3, it appears that the narrow junction zones between layers are occupied by very small opal spherules of uniform size. These are not agglomerated into the larger protuberant structures noted within the bands. It is therefore possible that slight differences in density and hence in average refractive index exist between the junction zones and the bands to account for diffractive effects. However, before diffraction can take place, the spacings between bands must be of the proper order. Jones (*op. cit.*) indicates that any spacing in the range 400 to 15,000 lines per inch, that is from about 160 to 6,000 lines per centimetre, is sufficient to produce the iris-effect if the material is sufficiently translucent; he also states that he has observed the iris-effect in some crystalline organic materials in which the band spacing has been as fine as 30,000 lines per inch, or, 11,800 lines per centimetre. Figure 1, and other photographs not reproduced here, were used to determine band spacings in the hyalite. The average spacing is approximately 2·24μ, or about 22,400 lines per centimetre (56,900

lines per inch). While the spacing of bands in the iris hyalite is approximately three times as close as that observed in iris-agate, it is still capable of producing the iridescent effect.

ACKNOWLEDGEMENTS

I wish to thank Mr. and Mrs. Robert Sanchez, Dr. Ronald Olson, and Dr Harry Miller for kindly providing specimens of the Mexican hyalite opal. I also gratefully acknowledge the assistance of Mrs. Steven Blankenburg for x-ray work and Mrs. Kurt Boström for electron micrographs of the opal. Dr. Gustaf Arrhenius provided helpful suggestions in the preparation of the manuscript.

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Barbour, Joyce (1964). Mexican topaz and where it comes from. *Gems & Minerals*, No. 316; 22, 23, 61, 62, 63; Jan. 1964.
Frondel, C. (1962). The system of mineralogy, III. 292.
Jones, Francis T. (1952). Iris agate. *Amer. Min.*, **37,** 578-587.
Leiper, Hugh (1965). New type of opal with spherulitic inclusions discovered in Mexico. *Lapidary Journal*, **19,** 3; 407; June 1965.
Sanders, J. V. (1964). Colour of precious opal. *Nature* **204,** 4964; 1151-53.

Gemmological Abstracts

. . . *Neuw Synthesen und Imitationen.* New synthesis and imitations. Zeitschr. d. deutsch. Gesell. f. Edelsteinkunde, autumn 1965, 53, pp. 55-58.

A new doublet is being used as a diamond imitation. The upper part is colourless synthetic spinel, the lower synthetic strontium titanate (fabulite). The parting line parallel to the girdle is clearly visible.

Synthetic quartz crystals are now produced in three weeks. The vessel is half filled with natural quartz and some seed crystals (square quartz plates of a good quality) are hung above this. Then caustic soda is added. The temperature used was 350-400°C, the pressure up to 2,000. Large quartz crystals of good quality result.

A new amber imitation was shown on the Ge man market, called "Polybern", consisting of small pieces of natural amber and amber-coloured polyester. The material has a soft, deep polish.

E.S.

BUTLER (W. C. F.). *Diamond synthesis.* Gesa (Babcock and Wilcox Graduates Assn. Journ.), 1964, 27, 1965, 28 and 29.

A detailed survey, based on a paper given before the West of Scotland Branch of the Gemmological Association in 1963.

A.G.

THEISEN (V.). *Regenerieren von Turkisen mit der Soxhlet-Apparatur.* Regenerating turquoises with the Soxhlet apparatus. Zeitschr. d. deutsch. Gesell. f. Edelsteinkunde, 1965, 53, pp. 22.

Through constant use the colour of turquoise usually suffers. The grease of the skin, cosmetics and various sun-tan oils are contributory factors. A Soxhlet apparatus may be used to regenerate stones so affected. A table describes the original colour, details of treatment and resulting colour.

E.S.

GÜBELIN (E.). *Die Lagerstaetten der Rubine und Saphire Thailands.* The occurrences of rubies and sapphires in Siam. Zeitschr. d. deutsch. Gesell. f. Edelsteinkunde, 1965, 53, pp. 27-29.

A description of the mining operations producing sapphires in the valley of the river Kwai and near the hill of Khao Ploi Van, which is about 15 miles west of the town Chantaburi. The latter produces mainly sapphires, but also rubies, spinels, garnets an zircons. The area around the town of Chantaburi has two further ruby-mining areas, namely Klong Van, which has been worked since 1885, and Ban Mai Navang, which has been worked since 1875, and is to-day the most important occurrence.

E.S.

SCHIEBEL (W.). *Kennzeichnung der Edelsteinfarben nach Farbnormen mit Messungen und Berechnungen an synthetischen Steinen.* Determinations of the colour of gems according to colour standards with measurements and calculations on synthetic stones. Zeitschr. d. deutsch. Gesell. f. Edelsteinkunde, 1965/66, 54, pp. 6-30.

The article deals with the difficulties of determining the colour of a gem; this is made especially difficult as the individual eye varies in its sensitivity to recognising colour. There are two standards for recognizing and comparing colour values, the CIE-system (commission internationale de l'Eclairage) and the German standard DIN 6164 for colour cards and DIN 5033 for measurement of colour. All these standards can only with difficulty be applied to the colour of gems. The author deals with the physical nature of light and colour, the alteration of the colour of light and explains how the eye sees colour and is subjectively influenced. The need for a colour comparison method is argued, which can be used in the laboratory making use of colour filters in the colours of transparent stones. Nine diagrams explains the text and there are various tables showing the results of measurements and calculations.
Bibl. E.S.

GUNARATNE (H.S.). *The discovery of a diamond from Ceylon,* Spolia Zeylanica, 1965, 30, 2.

A crystal of diamond was found in a conglomerate of ferruginous pebbles and quartz, collected at Bambarabotuwa in Sabaraga-

muva province. The discovery is the first record of a diamond from the rocks of Ceylon. No details are given about the time or circumstances when the conglomerate was obtained.

S.P.

BOOK REVIEWS

ARGENZIO (V.). *The fascination of diamonds.* McKay & Co., New York, 1966, 184 pp., illus. $5.50.

A short account by a jeweller about the origin and history of diamonds and how they are mined, cut and marketed. An interesting chapter of the evaluation of diamonds contains a lot of commonsense, which should be of use both to jeweller and the lay reader. The author condemns as meaningless such terms as "eye perfect", "blue white" and "commercial white". He also demolishes the "buy it wholesale" myth. A simply written and refreshing book, which should become a useful introduction for the lay reader to the story of diamonds.

S.P.

FRANCO (R. R.) and CAMPOS (J. E. DE S.). *As pedras preciosas.* San Paulo University, Brazil, 1965.

A Portugese text providing a useful introduction to gemmology. The section dealing with physical properties is too brief to give other than a bare outline, and there is no reference to the importance of spectroscopic diagnosis.

S.P.

ASSOCIATION NOTICES

GIFTS TO THE ASSOCIATION

The Council of the Association is indebted to Mr. Peter Wilding, F.G.A. of Liverpool, for kindly presenting to the Association an early optical instrument for detecting imitation diamonds. The Council is also indebted to Dr. G. F. Claringbull, Keeper of Minerals, British Museum (Natural History), London, for assistance in tracing the patent specifications.

Miss Kyoko Igarashi, of Tokyo, has kindly presented a synthetic ruby (hydrothermal type) and a piece of green grossular garnet, and Mr. A. W. Radcliffe, of Johannesburg, has kindly sent a donation of £5 5s. 0d.

The Westland Greenstone Limited of New Zealand has given the Association six specimens of nephrite from the Griffen Mountains in the South Island of New Zealand.

Dr. W. Campbell Smith has kindly presented the Association with some back issues of the *Journal*.

MEMBERS' MEETINGS

24th October, 1966. Reunion of members and presentation of awards, London.

8th November, 1966. Herbert Smith Memorial Lecture, London.

10th November, 1966. West of Scotland Branch Meeting. Speaker: Mr. Robert Webster.

TALKS BY MEMBERS

CAIRNCROSS, A., Northern District P.T.A., 11th January; Perth Business and Professional Women, 13th January; Strathtay and Grandtully W.R.I., 18th January; Blairgowrie Young Wives' Club, 1st February; Letham Kirk Young Mothers' Group, 10th February; Monzie and Gilmerton W.R.I., 5th April; Inner Wheel of Kirkcaldy, 12th April; Bridge of Earn W.R.I., 13th April; Caputh and Murthly Youth Fellowship, 17th April; Perth Child Guidance Centre, 20th April, 1966.

P. Benson-Cooper, "Gems", St. Mary's Church Young Wives, Ash Vale, 8th June, 1966.

COUNCIL MEETING

A Meeting of the Council of the Association was held on Monday, 6th June, at Saint Dunstan's House, Carey Lane, London, E.C.2. Mr. Norman Harper, Chairman, presided.

The following were elected:—

FELLOWSHIP

Howarth, Harry, Hale Barns, Nr. Altrincham, Cheshire. D.1965

ORDINARY MEMBERSHIP

Altermatt, Edgar Curtis, Berkeley, California, U.S.A.

Blackburne, James W., Northampton

Chow, S. K., Hong Kong

Davis, Anthony J., London, W.1.

Font-Altaba, Manuel, Barcelona, Spain

Ford, Ernest S. P. F., Gerrards Cross, Bucks.

Guthu, Steinar, Sandefjord, Norway

Hadate, Shushi, Tokyo, Japan

Hirose, Mitsuo, Tokyo, Japan

Ismail, Mohamed F., Colombo 1, Ceylon

Kelly, Farrol, Keighley, Yorks.

Ketterer (Mrs.), Helene, Geneva, Switzerland

Mann, Bart W., San Angelo, Texas, U.S.A.

Matsuzaki, Shigeru, Tokyo, Japan

Patterson, C. Richard, Garden City, Kansas, U.S.A.

Pattni, C. M., Mombasa, Kenya

Richardson, Sydney H., Auckland, N.Z.

Saleh, Mahmoud A., Cairo, U.A.R.

Talbot, Peter E., Crayford, Kent.

Thomas, Arthur E., Luanshya, Zambia

Uchihara, Keisuke, Osaka, Japan

Wallbridge, Norman W., London, S.E.6.

Webb, Eric W., London, W.3.

PROBATIONARY MEMBERSHIP

Bansept, David A. J., Tunbridge Wells, Kent

Cadman (Miss), Anne Norma, Upminster, Essex

Collier, James E., Chislehurst, Kent

Dingley, Richard M., London, S.W.7.

Hilton, John D., Macclesfield, Cheshire

Lee, Tommy L., Michigan, U.S.A.

Litchfield, Mark E., Chalfont St. Peter, Bucks.

Sutton, Robert M., Bramley, Nr. Guildford, Surrey

Vad (Mrs.), Meena S., Andhra Pradesh, India

A reference from the Annual General Meeting that some form of Association tie should be made available to members was considered. On two previous occasions the suggestion had been submitted, but the Council had found no great support for the idea. It was decided that it would be preferable in the first instance, for the Association to consider obtaining a Grant of Arms. It was agreed that if the matter progressed some reference to the Association's link with the National Association of Goldsmiths should be indicated in the Arms.

Work in connection with the gemmological courses and examinations generally and the Gem Diamond examination was considered.

MIDLANDS BRANCH MEETINGS

The annual general meeting of the Midlands Branch of the Association was held at the Auctioneers' Institute, Birmingham, on 29th April, 1966. The Branch Chairman, Mr. Norman Harper, who is also the national Chairman, presided.

The following were elected as Officers for the ensuing year:—

Chairman, Mr. D. N. King, F.G.A. Deputy Chairman, Mr. Norman Happer, F.G.A. Vice-Chairman, Mr. P. Stacey and Secretary, Mrs. S. E. Hiscox, F.G.A.

Mr. D. N. King thanked Mr. Norman Harper for his interesting year as Chairman of the Midlands Branch and for the many years which he had devoted to the furtherance of the study of gemmology.

On 19th May, 1966, members of the Midlands Branch visited an exhibition of diamonds and special pieces of jewellery set with diamonds at the Birmingham showrooms of Mappin and Webb, Ltd., by courtesy of the directors.

The Midlands Branch held a conversazione on 25th February, 1966, at the Imperial Hotel, Birmingham. Exhibits and talks were contributed by Messrs. H. Tisdall, C. Bereford, D. N. King, J. Marshall G. Porter and N. Deane.

LONDON GEMMOLOGY CLASSES

The gemmology classes which have been held for the past nine years at Northern Polytechnic, Holloway Road, North London, are being transferred to The Sir John Cass School of Art in Whitechapel Road, London, E.1.

As far as is at present known classes will be held at the new college during the 1966/1967 Session on the following days and times:—

1st year (lecture)	-	Monday or Wednesday as directed. 7 to 9 p.m.
2nd year (lecture)	-	Thursday. 7 to 9 p.m.
(practical)	-	Tuesday or Wednesday as directed. 6 to 9 p.m.
3rd year (Post-diploma)	-	Thursday. 6 to 9 p.m.

Enrolment evenings are to be held on Monday, Tuesday and Wednesday, 19th, 20th and 21st September, 5.30 to 8 p.m. Accommodation is limited and applications should be made by letter to The Principal, Sir John Cass College, School of Art, Whitechapel Road, London, E.1, and not to the Association.

GEMMOLOGY CLASS

A class in gemmology will commence at the end of September at the College of Arts and Crafts, Meeting House Lane, Lancaster. All inquiries should be made to the Principal of the College

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