THE JOURNAL OF GEMMOLOGY

AND PROCEEDINGS OF THE GEMMOLOGICAL ASSOCIATION OF GREAT BRITAIN

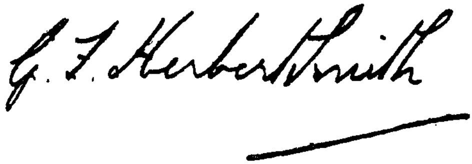
Vol. I No. 2 APRIL 1947

AT the time when the diploma scheme was being formulated there was no question but that the correct name for the science of gemstones was *gemmology*, inasmuch as this word was introduced with this meaning early in the nineteenth century, though it is only since the inception of the examinations and especially the foundation of the Gemmological Association of Great Britain that it has come into common use. There is an alternative word, *lithology*, which etymologically might have been considered apt, meaning as it does the science of stones, but it was at one time in fairly general use for the science of stones or rocks, though it has been displaced by *petrology*.

The only point at issue, which did give rise to discussion, was the spelling. In America the form *gemology* is preferred. This, however, is a hybrid word, being composed of an English word and one derived from the Greek, and is the kind of word which, according to the canons governing the formation of composite words recognized in Britain, should be avoided. *Gemmology*, on the other hand, is a combination of a Latin word, but of Greek origin, and a Greek word. It may be remarked that it is invariably pronounced with a double *m*.

The Latin word *gemma* appears to have been based upon a Greek word meaning to be full or to swell up, and was first applied to the bud of a plant—indeed, such words as *gemmate* and *gemmation* were once common in English in that sense—and was later applied to precious stones, especially when fashioned, the treatment accorded to them apparently suggesting to the Romans the effect of budding, and subsequently, as with our *gem*, it was used to denote an ornament of specially high quality. In the sense of precious stone the word passed into French as *gemme* and was absorbed into English with some such spelling as far back as the ninth century, the simplified form not being introduced until the eighteenth century.

The second part of the word is directly based upon a Greek word, which is derived from one meaning to say or to speak, and is used in two distinct senses: saying or speaking, and the matter said or spoken (sciences or subjects of study). The former group, which is much the smaller, includes words such as *eulogy* (speaking well of a person) and *tautology* (saying the same thing). The latter group includes words such as *theology* and *astrology*, which are taken from actual Greek words, and others such as *geology* and *zoology*, which might have been similarly taken had such words existed. Many words, such as *sociology* and *terminology*, are hybrids. *Mineralogy* also must be accounted a hybrid, since the first part comes from the medieval Latin word *minerale*. The Romans used for minerals of all kinds *metallum*, a word taken from the Greek which originally meant the place of searching, and later acquired the meaning of mine or quarry, and finally also the extracted material. The different termination *-alogy* is explainable by the fact that the word is a contraction of *mineralology*.



WORLD GEMMOLOGICAL ORGANIZATIONS

Swedish Gemmological Association.
Founded 1946.

The Gemmological Association of Australia.
Founded 1946.

The Swiss Gemmological Association.
Founded 1942.

Gemological Institute of America.
Founded 1931.

The Gemmological Association of Great Britain.
(Founded in 1908 as the Education Committee of the National Association of Goldsmiths, reconstituted in 1931 as the Gemmological Association.)

EQUIPPING a Gem Testing Laboratory

by F. E. ULLMAN, F.G.A.

HAVING closed my business at the outbreak of war in order to take up a Government appointment, I disposed of nearly all my gem testing instruments. On restarting to trade one of my first tasks, after finding suitable office accommodation, was to set about re-equipping my laboratory, as I consider scientific gem testing to be even more important now than it was previously owing to the prevailing conditions of being compelled to deal almost entirely in merchandise purchased from the public. The proof of this fact is clearly demonstrated by an experience I had recently. One day a lady called at my office with a view to selling me some coloured stones. She approached the matter in a most business-like way and produced a neatly typewritten valuation which she had obtained from a large provincial jeweller, to whom she had paid the full scale valuation fee. The amount involved was not inconsiderable. Imagine the lady's consternation when I was obliged to tell her that all her specimens were synthetic spinels!

My first post-war purchase was a Chelsea colour filter at a cost of 5s. At that time a good second-hand dichroscope came my way for £2, and I was also fortunate enough to acquire from a friend of mine a really accurate and almost new balance for £10. My next purchase was some laboratory glass, half a dozen wide-necked stoppered bottles, a few glass mixing rods, a funnel, three glass cells, some microscope slides, a beaker or two, and one or two other odds and ends completed my requirements in this line. I also bought small quantities of benzine, bromoform, bromonaphthalene, methylene iodide, and clerici solution, the latter at that time costing £2 per ounce. My total expenditure on laboratory glass and chemicals ran into some £10. It is now possible to purchase, I believe, the heavy and highly refractive liquids needed for gem testing at much lower prices than I was obliged to pay.

I then started to look for a decent microscope ; after not much trouble I picked up a good modern second-hand Beck fitted with a sub-stage condenser and iris diaphragm for £25. It has two eye-pieces and four objectives, and although not of the polarizing type, I have found it a first-class general purpose instrument. I also bought a second-hand bulls-eye condenser in mint condition for 25s.—an always useful accessory. On being shown a fine brown zircon by a colleague, I logically began to think of absorption spectra, and soon purchased a new Beck spectroscope for £5. My next worry was to obtain a good source of illumination for my spectroscopic work, and I thus acquired a 500-watt, pre-focus, miniature cinema projection lamp, which, together with a holder and a special housing I had professionally made, cost £8.

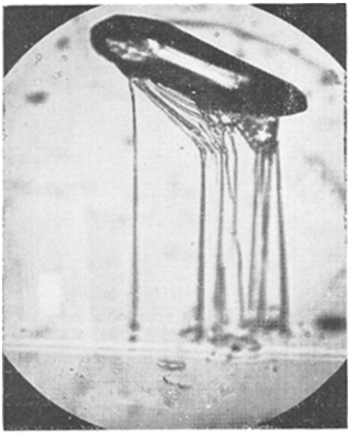
One night when working at Chelsea I was shown some new "Polaroid" discs. I was so impressed by their almost complete extinction that I ordered from an instrument maker I know a polariscope made of this new "Polaroid," mounted and arranged with a rotating stage so as to be suitable for gemmological work. As this device was especially built to my own requirements, I was obliged to pay a fairly high price for it, the whole thing costing me £10. I now had to buy a laboratory table, and after searching round for several weeks I found just what I wanted for £9 15s. in an old second-hand shop ; I also picked up a nice bench stool for 10s.

At the time of writing I have only just received my Rayner refractometer and colour filter ; with the aid of this latter one obtains what is virtually monochromatic light, so that the necessity of purchasing a sodium vapour lamp for doing accurate work no longer arises. The refractometer cost £13 and the filter 16s., and no words of mine can express my pleasure at possessing these wonderful instruments.

My greatest piece of luck was that I recently found a practically unused endoscope for £15! I bought a new filament resistance for this instrument at a cost of £6 15s. And finally, a good bench lamp at a cost of £2 10s., which, together with an electrician's bill of £8 for wiring, made a total expenditure of £127 15s. for fitting my laboratory to date.

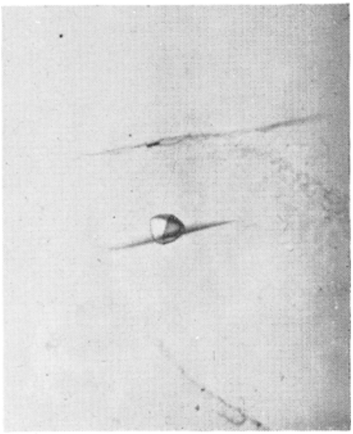
SOME PHOTOGRAPHS FROM THE LABORATORY

No. 2.—INCLUSIONS IN GEMSTONES



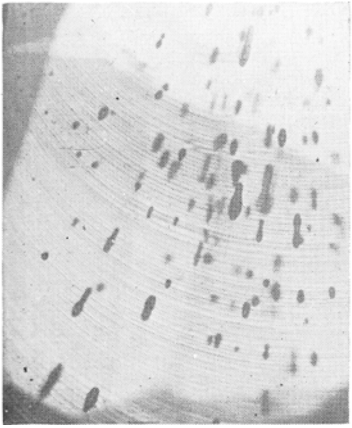
"The Barrage Balloon"

An inclusion in Emerald.



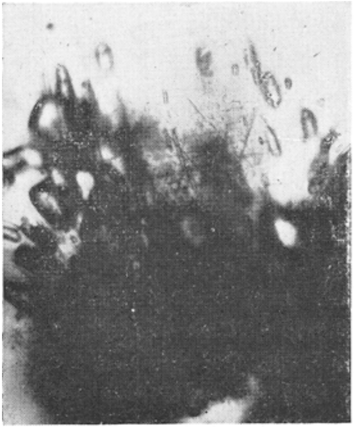
"The Raider"

Zircon crystal in Ceylon Yellow Sapphire.



"The Bombs Fall"

Elongated bubbles in synthetic Ruby.



"The Bombs Burst"

Inclusions in Burma Ruby.

Gemmology and Sir Thomas Browne

by E. BURBAGE, F.G.A.

IT would be misleading to present a gemmological collage from the writings of Sir Thomas Browne as indicative of the state of knowledge of the average 17th century Englishman, for, in the width and profundity of his intellectual curiosity, Browne stands apart from his contemporaries, and would have been remarkable in any age. In a famous passage in the Religio Medici, Browne claims with justice, " I am of a constitution so general, that it consorts and sympathizeth with all things," and this catholicity of interest is reflected in his writings. One feels, however, that the good Doctor had a keener interest in living things than in inanimate nature, and that he had a livelier affection for that famous garden which Evelyn called a Paradise, and for the birds and beasts of the Norfolk fields and seashore, than for those Hungarian minerals which his son Edward contributed to the extensive Brownian collections. At any rate, the occasional notes on minerals which are scattered throughout Browne's writings are not of the first importance, but they are not without interest to the gemmologist.

Of these passages, the most considerable occurs in his Pseudodoxia Epidemica, Browne's longest work, published during the Commonwealth. In his Second Book, Browne examines " Sundry popular Tenets concerning Mineral, and vegetable bodies, generally held for truth ; which examined, prove either false, or dubious." The first of these " vulgar errors " is " that Crystal is nothing else but Ice or Snow concreted, and by duration of time, congealed beyond liquation." Following a citation of those authorities assenting to the proposition, and of those rejecting it, Browne controverts it on various grounds by arguments whose validity is often suspect in the light of later knowledge. Browne's mineralogy postulates the existence of " mineral spirits " as essential to the formation of crystalline bodies, and he makes a rigid distinction between " conglaciation " and true crystallization to which a modern physicist would be reluctant to subscribe. He further differentiates between ice and crystal by considerations of melting points (" In this way may be effected a liquidation in Crystal, but not without some difficulty ; that is, calcination or reducing it by Art into a subtle powder—but Ice will dissolve in any way of heat, for it will dissolve with fire, it will colliquate in water or warm oyl ") ; also, by specific gravity (" Crystal will sink in water, as carrying in its own bulk a greater ponderosity then the space in any water it doth occupy ; and will therefore only swim in molten Metal and Quicksilver "). But we need not pursue the Doctor further upon this subject, excepting to note that although his chemical guesses are lamentably wide of the mark, his morphological observations are correct enough.

In the second book of the Vulgar Errors, a disproportionately large section is devoted to magnetism, and it is evident that his findings are solidly based upon extensive personal observations, although the works of Gilbert, Sir Kenelm Digby, Descartes, and many others are employed. From his correspondence, it appears that amber cast up on the Norfolk coast reached Browne from time to time, and in these pages he writes about the substance with the confidence of personal knowledge. He lapses into error in discussing its origin, for he writes, " It is likewise probable the Ancients were mistaken concerning its substance and generation ; they conceiving it a vegetable concretion made of the gums of Trees, especially Pine and Poplar falling into the water, and after indurated or hardened, whereunto accordeth the Fable of Phaetons sisters: but surely the concretion is Mineral, according as is delivered by Boetius." On included insects in amber he notes that Bellabonus discovered them to be not real, but representative (reminding one of the analogous views by which Philip Gosse, the naturalist, reconciled palaeontological contradictions with the chronology of Bishop Ussher), but here Browne suspends judgment, remarking that " hereunto we know not how to assent, as having met with some whose reals made good their representments."

Of various superstitions concerning the magical properties of gemstones, Browne make short shrift elsewhere in the Pseudodoxia. " That Lapis Lasuli hath in it a purgative faculty we know ; that Bezoar is Antidotal, Lapis Judaicus diuretical, Coral Antipileptical, we will not deny. That Cornelians, Jaspis, Heliotropes, and Blood-stones, may be of vertue to those intentions they are implied, experience and visible effects will make us grant. But that an Amethyst prevents inebriation, that an Emerald will break if worn in copulation. That a Diamond laid under the pillow, will betray the incontinency of a wife. That a Saphire is preservative against inchantments ; that the fume of an Agath will avert a tempest, or the wearing of a Crysoprase make one out love with Gold ; as some have delivered, we are yet, I confess, to believe, and in that infidelity are likely to end our days." On the existence of self-luminous gemstones, he hedges, merely recording the opinions of Milius and Boetius that this is not a property of the carbuncle.

Purists whose ears are offended by the pinchbeck sound of that much-debated substantive "gemmologist" may prefer Browne's variant in "Plants in Scripture," although Time has falsified the general truth of the passage in which it occurs: "Gemmarie Naturalists reade diligently the pretious Stones in the holy City of the Apocalypse: examine the Breast-plate of Aaron, and various Gemms upon it, and think the second Row the nobler of the four: they wonder to find the Art of Ingravery so ancient upon pretious Stones and Signets ; together with the ancient use of Ear-rings and Bracelets."

In another posthumous tract, "An Account of Island, alias Ice-Land, in the yeare 1663," we are told that "They have some large well grain'd white pebbles, & some kind of white cornelian or Agath pebbles on the shoare, which polish well. Old Sr. Edmund Bacon of these parts made use thereof in his peculiar Art of Tinging & colouring of stones." It would be interesting to know more of the technique employed by the ingenious Sir Edmund ; possibly some Norfolk gemmologist of antiquarian tastes can inform us on this point.

The diverse and uneven character of Browne's occasional notes about gemstones form too insecure a basis to venture any generalizations about the level of gemmological knowledge in his day. Although sharing the Baconian ardour for experiment, Browne retained too much of a scholar's respect for authority fully to subscribe to that novel and daring maxim, "Nullis in verba," and by reason of this he ranks, on a strictly scientific assessment, below contemporaries of lesser versatility and learning. (It is significant that in spite of painstaking services performed for the new Royal Society, and several none-too-subtle hints conveyed to its Secretary in the correspondence which passed between Browne and Oldenburg, the former never realized his ambition of election to membership—possibly this residual deference to authority may have been a major factor in his rejection.) Although Browne's supreme contribution is to literature rather than to science, in that wonderful Renaissance of the spirit of free enquiry which flowered between the Restoration and the death of Newton, his name merits consideration for his work in the exantlation of truth (to borrow his own characteristic Latinism). To return to gemmology, it is fervently to be wished that a general survey might be undertaken to collect and discuss the investigations made during this period into the gem minerals, for the wide field of enquiry presented by the history and progress of gemmological knowledge has had far less attention than it merits.

OUR AFFILIATED ASSOCIATION
THE GEMMOLOGICAL ASSOCIATION OF AUSTRALIA

The Gemmological Association of Australia, which became affiliated to the Gemmological Association of Great Britain in 1946, is broadening the scope of its activities in a most encouraging and enterprising manner. Branches are being established in selected centres of the Commonwealth, and classes will be conducted in Sydney and Melbourne. 1947 will see the holding of the first Diploma Examinations.

The Australian Association has decided upon the affix "F.G.A.A." for its Fellowship, thus wisely avoiding confusion with the "F.G.A." of the British organization.

Reports of the G.A.A.'s proceedings are contained in "Gemmology Review"—a section of the "Commonwealth Jeweller and Watchmaker." The institution of lectures, formation of a reference library and the appointment of further qualified instructors indicate the enthusiasm and determination of those interested to ensure that Australia adequately caters for all concerned with Gemmology.

The following have been appointed Officers for the ensuing year:—

Patron : G. D. Osborne, D.Sc., Ph.D., Sydney University.
President : D. P. Mellor, D.Sc., Sydney University.
Vice-Presidents : Messrs. A. E. Tombs, G. Proud, L. Goldring, J. T. Hinkley, W. J. Saunders and J. H. Pope, F.G.A.
Chairman : Mr. A. E. Tombs.
Treasurer : Mr. F. Kirkby. *Secretary :* Mr. J. S. Taylor.
Librarian : Mr. A. Wirth.
Instructors : H. F. Whitworth, M.Sc., and R. O. Chalmers.

The Chelsea Filter

WHEN the " Chelsea " Colour Filter was devised it was primarily intended to provide a rapid aid in distinguishing between genuine emeralds and the pastes and doublets which resemble them. Subsequent investigation showed that the filter was also useful in other ways.

The filter is designed to transmit only deep red and yellow-green light, and the best results are obtained when stones are examined under a strong electric light. It is sufficient to hold the filter close to the eye with the stone or stones (for a number can be examined at one time) receiving as much light as possible.

Under these conditions emeralds (absorbing in the yellow green) usually appear distinctly red or pinkish in colour, the actual tint varying from merely pinkish in the case of pale stones, to a rich almost ruby red for better coloured specimens. On the other hand, most imitations of the genuine stone (pastes, doublets, soude emeralds) retain a green appearance. In rare cases certain emeralds, notably those from South Africa, may not show any pinkish reaction. Synthetic emeralds (at present only produced in Germany (pre-1939) and in the U.S.A.) react in the same way as genuine stones, though the residual red colour is more brilliant. Generally, green synthetic spinels display green under the filter, though some stones, probably coloured by chromium, show red.

A reliable indication of ruby (both natural and synthetic) is given by a characteristic brilliant red seen through the filter, synthetic rubies being on the whole more brilliant than the genuine.

Synthetic blue spinels, which are intended to imitate aquamarine and sapphire, appear yellowish-orange or red when examined, while the stones they are intended to represent appear green or greenish-grey.

Cobalt-glass imitations of sapphire show a deep red, though some other blue glass imitations, coloured by iron, etc., do not display any red reaction. Green pastes show green.

The lens, microscope, refractometer and spectroscope are the principal instruments upon which the gemmologist relies for gemstone identification, but the " Chelsea " Filter, though it has some limitations, when used intelligently, is a most valuable aid.

Some Notes on

JAPANESE CORAL & JET

by E. R. LEVETT, F.G.A.

AT the recent Gemmological Association's Exhibition, a case of Netsukes attracted attention as illustrating certain varieties of ivory not commonly used in art or commerce.

The Netsuke carver, although principally attracted to varieties of wood or ivory as the most suitable and pleasing media for his work, developed a taste for, what was to him, the unusual and used examples of jadeite, malachite, turquoise, the quartz and chalcedony groups, coral, jet, and tortoiseshell, but only some of these materials are found in or around Japan.

Both the pink and black corals are found along the coastline of Southern Japan, and, apart from the obvious one of colour, are quite distinct from each other.

The black or " horny " coral is found principally along the coast of the Iwami Province and is known as " sea pine " (Japanese Umimatsu).

Although one of the coral polyp class known as *Coelenterata*, it is of another order, namely, *Antipatharia*. It differs from the white and pink coral in that the polyp skeleton is horny and does not contain a spicule of $CaCO_3$.

It forms a similar tree-like or dentritic structure, but the size varies with the temperature of the water, and only in warm waters are the stems large enough to serve when dried as objects for carvings, the largest stems being about 1½ in. in diameter.

The refractive index is approximately 1.55 and the specific gravity I find is low, between 1.30 and 1.33, which is very similar to the figure of 1.34 suggested by R. Webster for Indian Ocean black coral (see " Practical Gemmology," page 148). The material usually has concentric drying cracks

FIG. 1.—*Umiregi. Copy of a stele with a side inscription which reads "preserved at Kofukuji."*

FIG. 2.—*Umimatsu. Cicada on branch carved by Kwanman Iwami No Kuni (of Iwami Province).*

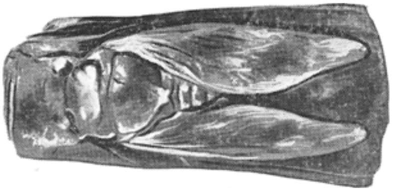


FIG. 3. - *Umimatsu. Cicada, in which the golden patches have been used by the carver to imitate the markings found on the insect's wings and head.*

FIG. 4.—*Umimatsu. Two Gomane carved by Hokkyo Setsusai.*

and it is difficult to avoid all air bubbles in hydrostatic weighing.

It takes a higher polish than the pink, and when the dark body is interspersed with patches or veins of a golden colour, the effect is very pleasing. Also found in reddish black colour which is translucent at the edges.

The best pink is found in Tosa Bay, off the Island of Shikoku, but the beds are practically extinct.

It is found in larger masses than usual, but is rarely uniform in colour, having whitish patches and a broken texture. The S.G. is lower than that for pink coral, being approximately 2.50.

The usual acid tests for coral apply to the pink type, and though the pink will be easily distinguished, Umimatsu may be more difficult to identify ; but I have only found examples amongst Netsukes, Ojimes and as one of the materials used in " Shibayama " and similar inlay work.

" Buried pine " (Japanese Umiregi) is a variety of jet found only, it would seem, in the Sendai district near Tokyo and in seams of not more than 3 in. in thickness.

It has a S.G. of 1.33, which is similar to the European jet figure, but the R.I. is distinctive, being 1.61 approximately, as against the usual figures of approximately 1.65 to 1.70.

It is not such a dense black as Whitby jet, and when the surface is broken up by carving it has been erroneously labelled as ebony ; but its lower S.G. and sectility would distinguish the latter.

The Gemmologist and The Public

by T. H. BEVIS-SMITH, F.G.A.

UNDER " To-day's Arrangements," " The Times " of the 8th and 9th January, 1947, reported that the Gemmological Association were holding an Exhibition at the Goldsmiths' Hall. The more sensational press confined itself mainly to giving misleading reports about the value of the Exhibition: the lowest was under £1,000, the highest over £100,000.

What was the reaction of the public to these reports? Did they gather, as perhaps many readers of " The Times " did, that it was possibly a Scientific Society? Did the readers of the sensational press understand that the members of the Association were also in the main members of the jewellery trade?

The dictionary would be of little help if an enquiring public tried to find out about the habits of the gemmologist.

However, the Exhibition did arouse a certain amount of public interest. A friend of mine, a member of the Association, told me that on the Wednesday, while travelling on the Underground, he heard two girls discussing the Exhibition. He listened with great interest, but was rather stunned when one of the girls announced with authority that she knew what Opal was. On being asked what it was by her friend, she said proudly, " Hydrated Silicosis."

The public can hardly be blamed, least of all the girl in the Tube train, for being ignorant if so many members of the trade maintain their present attitude towards gemmology, believing it to be entirely a waste of time. I have been told, many times in various ways, that gemmology is purely an academic study of no practical use. This attitude is defensive in its nature and is in some people the reaction to Applied Science Why not tell the public that gemmologists have undertaken this specialized training in order to serve it?

Perhaps Members and Fellows of the Association can eventually overcome this deplorable attitude. Practical demonstrations do help, but it must be pointed out that although the gemmologist is scientific by training, he is not too academically minded to realize that he has three important functions:—

1. To protect the public.
2. To protect his firm.
3. To protect himself.

The public now demands—mainly through the efforts of the examining bodies—that everyone who tests eyes is properly qualified. I hope the time will come when every jeweller will employ on his staff at least one gemmologist who can be consulted by the public in his laboratory when the occasion arises.

Many jewellers believe that there is no point in carrying a large stock of coloured stones because there is only a small demand for them. The mainstay of the jewellery trade is alleged to be diamond rings—usually engagement rings—but why must the jeweller sell diamonds and bits of glass which are trying ever so hard to be diamond? I feel that jewellers, and particularly gemmologists, should sell only real stones. No watchmaker worthy of his name would sell a pin pallet watch. I don't see how the jeweller can compete with the chain stores, and particularly the large departmental store, when cheap costume jewellery is the article being sold. Costume jewellery is most effectively sold as accessories to clothes.

The gemmologist's answer should be the less expensive stones mounted in gold, silver and silver gilt, but let attention be given to design. Each stone, no matter how cheap, is capable of being mounted to the best advantage. Nearly everybody prefers something that is real to something which is imitation.

The public to-day, as a result of the war, is at the mercy of the retailer, and many unscrupulous persons are taking full advantage of the situation. This state of affairs cannot last for ever. The history of retailing has proved two things: that the prosperity of all successful businesses has been built on fair trading and service. Why not tell the public about gemmology? Why not point out that not only are stones guaranteed as genuine, but they have been tested scientifically by specialists?

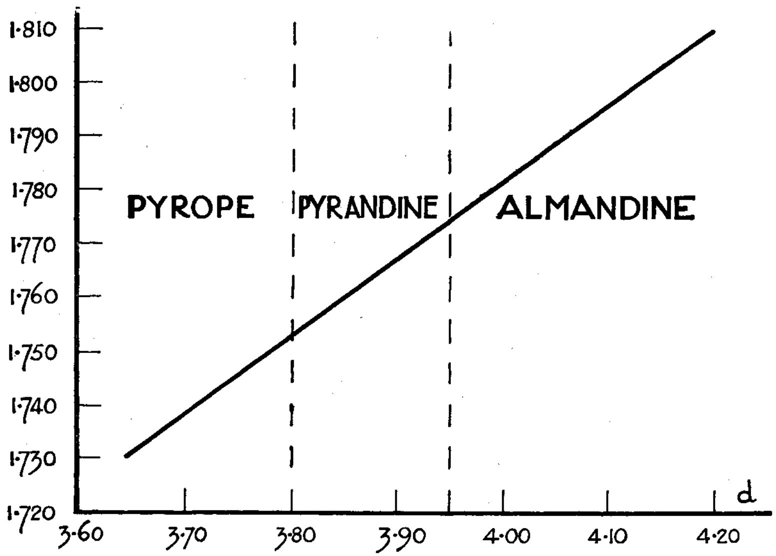
PYRANDINE—

a New Name for an Old Garnet

by B. W. Anderson, B.Sc., F.G.A.

NOMENCLATURE in gemmology, as in other sciences, has always been a thorny and controversial matter, and who approaches the subject must tread with care, lest he cause more harm than good. Particularly is this so when, as here, a new name is suggested. The stone in question is not a new mineral nor even a new variety. On the contrary, it is a very old and common gem—a red garnet having a refractive index between 1.75 and 1.78 and density between 3.80 and 3.95, and which is thus neither an almandine or a pyrope. Admittedly there is *no* pure pyrope found in nature and *no* pure almandine, but the terms serve very well for those specimens which are predominantly the one or the other. For a large number of the red garnets used in jewellery there is no compelling reason why they should be called either of these names since they contain almost equivalent quantities of iron and magnesium, and in an attempt to give an accurate description one either has to use the circumlocution " a red garnet of the almandine-pyrope series " or shorten that to " an almandine-pyrope." Having got so far as the hyphenated term it seems a reasonable step to coin a portmanteau word, and of various possibilities in this direction *pyrandine* seems the neatest, and the derivation should be obvious even though, for the sake of euphony, the first syllable must be pronounced short, as in Pyrenees.

The name " rhodolite " has been used for a garnet of intermediate type, having R.I. 1.76 and density 3.84, but was intended only to apply to a peculiar rhododendron-red variety found in North Carolina. The term is thus not of universal application and has the additional drawback of being easily confused with the manganese silicate rhodonite, the two names being as prone to misinterpretation as are lazurite and lazulite. There is no other mineral name with which pyrandine is likely to be confounded. The organic chemical pyridine has a closely similar sound, but the context should preclude any possible trouble on this account.



It is hoped that this short article will serve to " put up the banns " for the proposed name, so that any who know of any just cause or impediment may declare against it forthwith before " pyrandine " is on its way to become common currency.

The limits chosen are admittedly quite arbitrary, but are intended to exclude from the pyrandine region those well-established pyropes from Bohemia, Kimberley and Arizona, and at the other end of the scale almandines of the distinctive colour associated with the name so often cut as " carbuncles " in hollow cabochon form. The graph (kindly drawn by Mr. Robert Webster) gives an approximate idea of the proposed division. The R.I./S.G. slope must not be taken as exact for all red garnets, since in addition to the pyrope and almandine molecules grossular and uvarovite are often present and modify the constants.

It is worth recalling that the theoretical values for the " pure " garnets, as calculated by W. E. Ford, are as follow:—

	Density	Ref. Index		Density	Ref. Index
Pyrope ...	3.51	1.705	Spessartite ...	4.18	1.800
Almandine ...	4.25	1.830	Andradite ...	3.75	1,895
Grossular ...	3.53	1.735	Uvarovite ...	3.7?	1.870

These figures are often quoted out of their context, which is dangerous, as they do not represent values found for any actual specimen.

The New RAYNER REFRACTOMETER

Reviewed by B. W. ANDERSON, B.Sc., F.G.A.

FOR the gemmologist, two instruments beyond all others are essential: the microscope and the refractometer. Since microscopes are used by practically all the Sciences, many thousands are in circulation, so that second-hand instruments of a sort (and at a price!) have been procurable throughout the war ; but for five or six grim years jewellers' refractometers have been virtually unobtainable, and a waiting list of eager would-be purchasers has been steadily growing on the files of the manufacturers.

" Hope deferred maketh the heart sick " expressed the feelings of many keen gemmologists as delay after unavoidable delay prevented the promised arrival of the first post-war refractometers, but now at last they really are here, and in very fair quantity.

Though in essentials the new " Rayner " remains the same as the popular pre-war model, there are some significant improvements.

The shape is more squat than formerly, the instrument standing firmly on its base. The shield for protecting the stone from overhead light is larger and is domed, so that it will not foul the culet of even a large stone while it is being tested. In the previous model the corresponding shield, even when tilted back, prevented a reading being obtained where the polished base of a carving was concerned or a stone set in a bulky ornament. This disadvantage no longer obtains with the new " Rayner," since the whole superstructure can be removed in a second, leaving the upper surface of the refractometer free to receive the largest conceivable article of jewellery.

As for the readings obtainable, they are a sheer delight, especially where one of the dense yellow filters (provided as an extra by the makers) is used. This filter transmits a narrow band of light of effective wavelength about 5875A with only a faint red transmission centred near 6800A ; shadow edges are thus practic-

ally as sharp as with sodium light and barely .001 lower—a difference which will not in the least affect identifications.

The particular instrument examined was splendidly calibrated, being correct to three places of decimals with standard specimens of known index. To eyes accustomed for years to expect only faintly discernible shadow-edges on battle-scarred instruments the density and clarity of the effects seen on the brand new refractometer are intensely satisfying and make one vow never to spoil the surface of the glass by careless handling of the stone or by leaving any surplus liquid to crystallize thereon!

In addition to the filter, another useful accessory is a polaroid cap which enables each of the two edges in a birefringent stone to be studied separately. Polaroid is quite as effective as a nicol prism for this purpose, and far less cumbersome. A supply of liquid of refractive index 1.81 is provided with each instrument. There is an acute shortage of dropping bottles of suitable type for containing this liquid, but these will doubtless be available eventually.

There has inevitably been an increase in price compared with the pre-war " Rayner," but the cost of £13 for the instrument is very reasonable and there may well be many occasions when it will save or benefit the user to an extent many times its cost price. The cost of the yellow filter is 16s. extra, and the polaroid cap £1.

By SIR JAMES WALTON, K.C.V.O., F.R.C.S., F.G.A.

Refraction of Light in Gem Minerals

HAVING commenced the study of Gemmology many years after my training in physics and mathematics, I found that an understanding of the optical characters of minerals was beset with considerable perplexity. This was, I think, in part due to the fact that most of the text-books tended to assume that their readers possessed a knowledge of general physics which but few had obtained. I am therefore emboldened to write this article in the hope that, although it contains nothing new or original, I may be enabled, by logical development, the use of the simplest, non-technical language and by the employment of simple line diagrams, to make the subject of interest and easy understanding even to those who have no previous knowledge whatever of physics or mathematics.

Light travels in waves through the surrounding medium, the ether, vibrating in all possible directions at right angles to the path of travel. If travelling with equal velocities in all directions, the wave surface is a sphere.

The *wave length* is the nearest distance between two particles on the wave surface in the same position and travelling in the same direction. The *wave amplitude* is the distance between the crest and trough of the wave. (Fig. 1.)

White light is a mixture of red, orange, yellow, green, blue, indigo and violet rays, each having different wave lengths, red having the longest, around 7,000 Angstrom units (each unit $=10^{-7}$ m.m.), and violet the shortest, around 4,000 Angstrom units.

The velocity of light in air is approximately 186,000 miles per second, but in a denser medium it is slower. It is also slower with a short wave (violet) than with a long wave (red), i.e., in a diamond the velocity of the red light approximates to 77,000 miles a second, and that of blue light to 75,000 m.p.s. Therefore the *velocity varies directly with the wave length.*

If a ray of light passing through the air enters a sheet of glass at right angles to its surface, that is, along the normal, its velocity through the glass will be diminished, but it will emerge on the opposite side with its path and characters unaltered. If, however, it enters the glass obliquely, that is, at an angle to the normal, it will be bent towards the normal and is said to be *refracted.* On emerging on the opposite side it will again be bent away from the normal to an equal degree so that its new path will be parallel to the old but laterally displaced. (Fig. 2.)

The path of the refracted ray obeys definite laws. If *SOS'* represent the surface between two media air and glass and *N,N'* represent the normal with the incident ray *IO* and the refracted ray *OR*, then if equal distances be measured off on *IO* and *OR* and perpendiculars be dropped on to the normal, then in the two triangles i will be the angle of incidence, and r the angle of refraction. The two laws of refraction (Snell's laws) are:—

(a) The incident ray, the refracted ray and the normal all lie in the same plane.

(b) The angle i which the incident ray makes with the normal is related to the angle r which the refracted ray makes with the normal by the equation $n \ x \ IN - = n' \ x \ RN'$ where n and n' = the refractive indices of the two media.

Snell's Law actually states that $n \sin i = n' \sin r$, but the sine of an angle in a right angled triangle = the side opposite the angle divided by the hypotenuse, and since in our figure the two hypotenuses are equal, it becomes $n \ x \ IN = n' \ x \ RN'$.

This is true whatever be the nature of the two media in contact. The refractive index of air is taken as unity and hence in our diagram the refractive index of glass will be $n' \ x \ \frac{IN}{RN'}$ and RN' being less than IN it will be greater than unity. (Fig. 3.)

The refractive index is a constant for each medium and is an expression of the optical density of the medium.

The refractive index is different for each coloured ray, but when the rays emerge from a plate with paralleled sides they again combine to form white light. If, however, the ray of light passes through a prism the rays will be further refracted on emerging (Fig. 4), so that the emergent ray forms a spectrum of all the colours. In this spectrum the red ray with the longest wave length

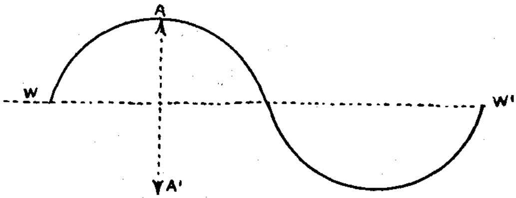


FIG. 1.—*Length and amplitude of lightwave. A—N = Amplitude. W—Wl = Wavelength.*

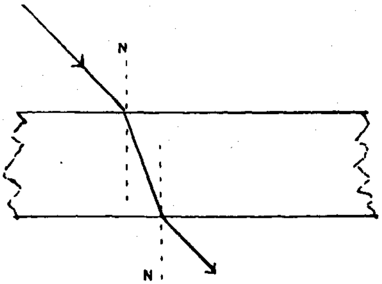


FIG. 2.—*Refraction of light through a parallel sided sheet of glass.*

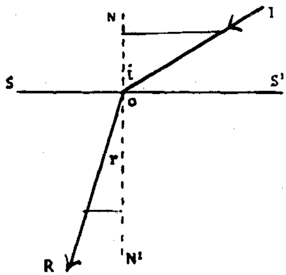


FIG. 3.—*Snells laws of refraction.*

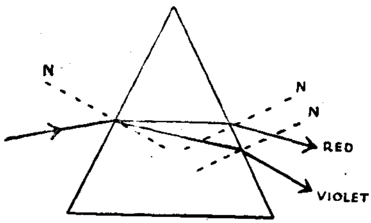


FIG. 4.—*Path of ray of light through prism.*

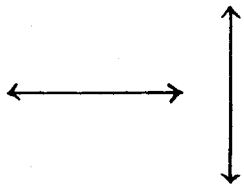


FIG. 5.—*The wave vibrations in two rays of polarised light*

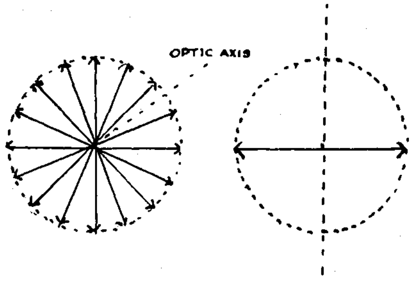


FIG 6.—*Wave fronts of an ordinary ray.*

Left : Travelling along optic axis.

Right: Travelling across the optic axis.

and the greatest velocity is refracted to a lesser degree than the violet with the shortest wave length, and the slowest velocity. The refractive index therefore varies inversely with the velocity and the wave length.

The width of the spectrum varies, but as a rule increases as the refractive index of the medium increases. It is known as the colour dispersion, which is expressed by the difference between the refractive indices of the red and blue rays, the distance being usually taken between the B (6807Å) and the G (4308Å) Fraunhofer lines of the solar spectrum or between the C (6563Å) and F (4861Å) lines which are used for optical glasses. The difference in the refractive indices of the rays increases more rapidly as the violet end of the spectrum is reached.

It is the amount of colour dispersion which determines the fire of the stone, and since in general the dispersion increases with the refractive index, the stones in which it is most marked—Blende, Cassiterite, Demantoid, Sphene and Diamond—all have high refractive indices.

Varieties of Refraction. Light traversing transparent substances may pass as one ray or be split up into two rays. The substances which transmit the light as one ray are known as *singly refracting* or isotropic. Those which split the incident ray into two rays having different paths are known as *doubly refracting* or *anistropic*, and they again are of two varieties, *uniaxial* and *biaxial*.

Isotropic Substances

These consist of the amorphous substances, glasses, resine and all liquids and all crystals of the cubic system, i.e.:

Diamond	Garnet	Fluorspar	Cobaltite
Spinel	Hauynite	Blende	Rhodizite
Pollucite	Sodalite	Pyrites	

The wave vibrations travelling through them are in all directions at right angles to the path of the ray and the light travels with the same velocity in every direction through the substance. Therefore the wave surface is a sphere. The optical properties show no variation with the direction of the ray within the substance or crystal.

Anistropic Substances

In anistropic substances the vibrations of the wave front, probably owing to the nature of the atomic packing, are limited to directions at right angles to one another and are not free to move in any direction. They of course also only vibrate in directions at right angles to the path of the ray. It has been pointed out that a ray of light passing from air through a denser medium has its velocity reduced. In anistropic substances the reduction of the velocity varies with each vibration direction. Hence there is not a compound ray vibrating in two directions at right angles to one another, but two separate rays having different velocities, and therefore different refractive indices. The maximum difference between the refractive indices is known as the *birefringence*. In each ray the wave vibrations, unless the ray is travelling along the optic axis, can only take place in one direction at right angles to the path of the ray, and the vibration directions in the two rays are at right angles to one another. Such light with the vibrations in the wave front moving in only one direction is said to be *polarized* or *plane polarized*. (Fig. 5.)

There are two varieties of anistropic substances, uniaxial and biaxial.

Uniaxial Substances. These consist of crystals of the tetragonal and hexagonal systems.

Tetragonal.	Hexagonal.	
Zircon	Corundum	Apatite
Cassiterite	Quartz	Dioptase
Scapolite	Beryl	Phenakite
Idocrase	Tourmaline	Benitoite
Rutile	Calcite	Willemite
Anatase	Haematite	Smithsonite

If a ray of light is travelling along the vertical axis of the crystal its wave front can vibrate in any direction. Along this vertical axis the crystal is isotropic, and this path of single refraction in a doubly refracting stone is known as the *optic axis*. In uniaxial crystals it always corresponds to the principal crystallographic axis (c).

In all other directions through the crystal one ray is vibrating at right angles to the principal crystallographic axis, that is, the optic axis. This ray, whatever its direction, has the same velocity for light of one colour in the same kind of crystal, and therefore its refractive index, which is denoted by *o* or *w*, is constant. It obeys the ordinary laws of refraction and it is therefore known as the *ordinary ray*. (Fig. 6 a and b.)

(To be continued)

STANLEY F. BONES, F.G.A., makes

A Confession

I HASTEN to explain that this " confession " has not been extracted from me by " coaxing " or even suggestion, but is quite a voluntary effort made in the hope it may prove an incentive to others.

There are doubtless many who have entered for the highly esteemed Diploma of the Gemmological Association and have failed to earn the standard of marking that carries the award of " F.G.A.," and many more who, on account of age, might be " hovering on the brink " of attending a Course in Gemmology at the various classes or through the Correspondence Courses.

Based on my own experience, to the former I would say " Try and try again," and to the latter " Do not hesitate another minute."

It is unfair to keep the reader in further suspense after giving such a title to this article . . . therefore my confession is that, having attended gemmological classes at Chelsea Polytechnic during the years 1943-4-5-6, I entered three times for the Diploma examination and did not succeed until the third attempt.

In pre-war years one often heard the phrase " too old at 40," which has always stimulated me to the possession of greater knowledge and to a fuller life, and to endeavour to prove (at least to myself) that there is practically no age limit to the acquisition of knowledge of a variety of subjects.

Amongst other interests, just prior to the War, one evening I found myself signing up as a student at evening classes in one of the London Schools of Art—in the delightful company of students who in the main were 30 years my junior. I had no previous experience of drawing or painting.

A chance meeting with a friend who turned out to be a mineralogist gave me my first interest in gemmology. He suggested I might find a course at Chelsea Polytechnic a means of acquiring greater knowledge of the subject. I first called at Audrey

House, where it was my pleasure to meet Mr. G. F. Andrews, who quickly put me at ease and assured me of a welcome in the classes. I commenced at Chelsea Polytechnic in 1943.

The War years were anything but conducive to study and I well remember with very mixed feelings those regular wailing sirens and the disturbing influence of the sound of falling bombs and gunfire. The times when we left the lecture room for a point of more comparative safety were many and instruction was carried on under the greatest difficulty.

One evening the plan might be for practical work with refractometers, microscopes, spectroscopes, etc., but one perhaps drifted to the examination of Mr. Webster's new Sten gun.

Uniforms were much in evidence, and naval ratings, privates and airmen shared their heavy liquids with Admirals, Generals and Air Marshals in the pursuit of gemmological knowledge! I recall an American G.I. who stayed a short while with us and who used to sit directly in front of me. This was rather disturbing, as evidently one of his colleagues had drawn in crayon on his waterproof jacket a most attractive figure of a girl, and other members of the class were inclined to look at the back of the G.I. instead of the blackboard!

Mr. B. W. Anderson, I recollect, had National Fire Service duties heavily carried on top of his normally extremely busy day. Just how Mr. Anderson retained his characteristic charm, patience, and great ability to impart his profound knowledge under such trying conditions will ever remain a matter of wonderment to me.

Mr. R. Webster, radiant with enthusiasm and with a positive appetite for work, also did much to keep the classes going.

Mr. Andrews, as Director of Examinations and Secretary of the Gemmological Association, also put in frequent visits to Chelsea and did valiant work in the interests of the students, but he was called to the R.A.F. just after I joined the classes.

I admit frankly I should not have entered for the Diploma examination in 1944 as I had not had the opportunity to acquire the necessary knowledge, but it was good " fun " to try.

The following year I made another attempt and in failing learned my lesson.

I have been told I possess a vivid imagination ; this prompted me to write pages on the aspect of a subject which did not carry marks! I was " carried away " by the intriguing properties of the colour change in alexandrite when alternatively exposed to daylight and artificial light, to the profound beauty of colour of the emerald and ruby, or by the human side of the fishers of pearl!

1946 brought the return of Mr. T. G. Jones, F.G.A., to Chelsea, and in his person an added stimulant to effort on my part. Refractometers were re-polished, heavy liquids duly strained and brought up to a high standard of S.G. accuracy. What an excellent team of instructors were now available to us.

The classes in 1945-46 were able to be run on two nights a week and greater concentration was possible. In this period I realized that there were so many actual facts to record that there was no time to elaborate on one's own personal reactions to the aspect of a particular problem, and that brief and concise definitions would bring the fullest reward.

The many books of Dr. Herbert Smith, M.A., D.Sc., Mr. Basil Anderson, B.Sc., F.G.A., and Mr. Robert Webster, F.G.A., all provide many examples on which to base a full yet brief answer to most questions likely to be set by the examiners, and Mr. Anderson's lectures provided the final key to the solution of being the holder of the high award of a Fellowship Diploma.

The return of Mr. T. G. Jones gave me an opportunity to " invent " another " Mr. Jones." I gave him the name of " L. S. Jones," which enabled me to memorize some of the Monoclinic gemstones, which in order are as follows:—

Lapis **S**phene **J**ade **O**rthoclase **N**ephrite **E**uclase **S**podumeme

I also found " TAK " most useful to recollect some of the Triclinic gemstones, Turquoise-Axinite-Kyanite, whilst " ZIC " did good service to bring to mind some of the Tetragonal gemstones, Zircon-Idocrase-Cassiterite.

In conclusion, based on my own experience, I would recommend everyone in the jewellery and allied trades (whatever his or her age or previous training) to attend a course at Chelsea, Birmingham or Edinburgh, or where this is impossible to take the Correspondence Courses, and gain that Fellowship Diploma at any cost of time involved. It was a great experience and worth every minute and effort expended.

The Gemmological Association's FEBRUARY MEETING

Speakers :
Mr. H. Rayner
Dr. W. F. P. McLintock, D.Sc., F.R.S.E.
Mr. P. Grodzinski, A.I.M.Mech.E.

THE presentation of Rayner refractometers, won by students in the Gemmological Association's preliminary examinations held during the war, took place at Burlington House, London, W.1, on Thursday, 27th February. The instruments have not been available during the war years.

Dr. Herbert Smith, the President, referred to the fact that the Association would soon, he hoped, become Incorporated and thus acquire higher status. He was glad that Mr. H. Rayner had been able to attend to present the refractometers.

Mr. Rayner confessed his small knowledge of gemmology, but pointed out that as a member of the optical industry he was concerned with providing instruments that were of aid to mankind. Every trade and profession needed magnifying instruments of differing powers. The refractometer was a means of measuring the physical characteristics of a substance. It was just as informative when applied to oil, fats, butter or any sugar solution as it was to the crystal substances in which the members of the Association were most interested.

Difficult to define or trace were the colourings of, say, a diamond. Whether it was, for instance, yellow or blue, and by how much. Various printed charts of colours or glasses have been used by industry, but they are essentially arbitrary standards. None can be exactly reproduced and it is doubtful whether they are sufficiently finely divided to serve in this industry. However elaborate the charts, the precise hue you seek to match is not always there ; but now, given an electric lamp bulb, filters and apertures, it becomes possible to mix the colours to match any colour, and this process can be repeated—that is, you can repeat the colour.

At present the colourometer is in its infancy, but he had hopes that it may be available to gemmologists in the future.

Mr. Rayner referred to the friendship which had existed between his late father and Mr. B. J. Tully, whose work and that of his contemporaries had been so fruitful.

To come out top in the Association's examinations was an honour marked by the award of the Tully medal. Mr. Rayner said he proposed at the next examination to present a Tully refractometer to the Tully medallist and he hoped that could be repeated in future years. In addition, he looked forward to giving a Rayner refractometer to the best students in the preliminary examinations. The refractometers were then presented to:—

MR. S. G. MOULD (1941).
MR. LIONEL WALFORD (1943).
MR. E. R. LEVETT (1945).

Mr. R. W. Hester (1942), Mr. R. R. Cox (1940) and Mr. D. P. Guest (1944) were unable to be present.

During the evening Mr. P. Grodzinski gave a talk on his recent visit to the diamond mines of South Africa, in which he gave interesting facts concerning their present-day operations.

In the questions that followed this talk, Mr. Anderson expressed qualms at the highly mechanized state of the industry. Might not this mechanical pounding seal the fate of another Cullinan? The crusher would destroy it. Mr. Grodzinski thought, however, that such a large stone would probably reveal itself after blasting.

Mr. Braunfeld asked for more information concerning the coloured stones found with diamonds, to which the lecturer replied that they were often used on pathways and tennis courts. Occasionally a large garnet or zircon was found, but it seldom showed good crystallization.

In closing the meeting, Mr. F. H. Knowles Brown, Chairman of the Association, thanked Mr. Rayner for his long interest in the Association and the encouragement given to the students, Mr. Grodzinski for his talk, and expressed appreciation of the delightful and interesting manner in which Dr. McLintock had spoken. A vote of thanks to the Geological Society for the loan of their hall was proposed by the President.

A summary of Dr. McLintock's talk appears on page 29.

40 YEARS OF GEMMOLOGY

by DR. W. F. P. McLINTOCK, D.Sc., F.R.S.E.

FOR some forty years Dr. W. F. P. McLintock, D.Sc., F.R.S.E., Director of H.M. Geological Survey and Museum, has been a gemmologist, yet it was only last February that he actively participated as a speaker at the meeting of the Gemmological Association of Great Britain in the Rooms of the Geological Society, Burlington House, London, W.1.

His talk revealed that in his years of work, both out in the field and in the museum, gemmology has provided romance and humour as well as much interest in the daily round.

Dr. McLintock was able to stake his claim to being a gemmologist a year before the Association was founded, when he joined the staff of the Geological Survey and entered on his duties at the Geological Museum, then in Jermyn Street, S.W.1. There he found a collection of precious stones and the scientific instruments left by his predecessor. These included a balance that swung horizontally and a laboratory that was a dark and dirty cupboard.

At that time mineralogy took a new turn with the discovery of the fact that recognition of transparent stones could be made by their refractive index ; this was made practicable for gemstones by the use of the Herbert Smith refractometer, which had just made its appearance. Armed with this new instrument, he re-examined the collection and found only two wrong attributions. One of his first tasks was to prepare a Guide to the collection at the Museum.

He soon found that visitors upon his predecessor had included Duchesses and other ladies of title, and even less respected ladies. They came for advice about their gems. He recalled one attractive lady who asked him about a fine and large blue stone in a pendant. In those days the synthetic sapphire was just coming on to the market and he had not the slightest difficulty in detecting the striae and air bubbles.

" Rather to my surprise when I told her this," said Dr. McLintock, " she replied, ' You are quite right. That is exactly what I bought it as.' "

She then wanted an estimate of its value, and after pointing out that as a Government representative he was disinclined to value it, Dr. McLintock suggested 15s. a carat, the stone weighing 4½ cts.

" ' The rascal, the rascal,' was the lady's exclamation," said Dr. McLintock. " ' He told me it was an extremely fine synthetic sapphire and I paid £35.' "

These synthetic stones, added Dr. McLintock, were at the beginning of their introduction being sold at considerably beyond their market value.

A year or so later, Dr. McLintock recalled seeing in a Piccadilly jeweller's window a notice: " The dream of the alchemist realised. Synthetic diamond is now a reality. The stones exhibited in this window are superior to the natural diamond in hardness and brilliance and fire." Below was a tray full of beautifully cut white stones.

As an enthusiastic gemmologist, Dr. McLintock went in the shop, only to have the salesman look at him and say: " You are from the Museum in Jermyn Street, aren't you? "

The salesman, however, continued to claim that the stones were harder than diamonds.

" I picked up a 6-7 ct. stone and pulled a diamond point out of my pocket, saying, ' If it is harder this point will not scratch it.' But the salesman quickly replied, ' Give me the stone back.' "

This was not the end of the Doctor's " synthetic diamond " experience, for he told his audience how, a few days later, Mr. Doyle Heaton, a gemmology lecturer, came into the Museum and told him that the jeweller was now claiming that his artificial diamonds had been vouched for by him. " Eventually I put a stop to the swindle by threatening to publish a statement in ' The Times,' " said Dr. McLintock, adding that there was a similar ramp in 1935 with synthetic white spinel.

Pointing out the greater difficulties of the gemmologist, the speaker said that the mineralogist could always turn for identification in the last resort to the chemist or crush his specimen and examine it under a microscope. The precious nature of the gemmologist's material limited his method of attack.

For a short time Dr. McLintock went to Edinburgh, and on returning to Jermyn Street in 1921 he had to organize the move to South Kensington. This took about 14 years, partially owing to difficulties with the Treasury.

There he planned to do something for gemmology, though he found that the claims of other sections of palaeontology and petrology were strongly put by their various adherents. Though he had travelled in Europe and seen most of the collections, he had not seen one in which the gemstones were separate from the minerals. He had set his heart on doing this and succeeded, and claimed that the curved glass used in the showcase gave almost no reflection from the overhead skylight.

Mentioning that he had never yet found a dealer selling a real stone as a synthetic, though in his long experience he had sometimes known the reverse, he said he had known dealers make a mistake to their disadvantage. He cited the case of a friend who was left some jewellery, including an antique ring in which was mounted a flawless emerald of 2 carats. It was believed to be genuine, but on probate the valuer said it was worth £5. Despite being told that the ring had been in the family 100 years, the valuer insisted it was worth only that. A jeweller dismissed it as paste. Then it was unmounted and found genuine, but so fine and flawless that it " deceived " the other experts.

Dr. McLintock pointed out that it was right and proper that in London, one of the principal gemstone markets of the world, there should also be a good collection of gemstones for study and an active Gemmological Association. The greatness of the market depended very largely upon confidence, which was founded on scientific knowledge. The Gemmological Association were the " vigilants " of the gem market. If there was not constant watchfulness, the undermining of confidence was bound to happen.

The market had withstood the synthetic stone and the cultured pearl, thanks largely to the efforts of their members, and so there should be no need to worry about the synthetic emerald. Dr. McLintock paid a tribute to Dr. Herbert Smith for his leadership and his pioneer work for gemmology.

From the Association's

LIBRARY

THE illustration here is taken from the oldest book in the library of the Gemmological Association. The title of the book is as follows:—

> The HISTORY OF JEWELS, and of the Principal Riches of the East and West, Taken from The Relation of Divers of the Most Famous Travellers of Our Age. Attended with Fair Discoveries, conducting to the knowledge of the Universe and Trade.
>
> London. Printed by T.N. for Hobart Kemp, at the Sign of the Ship in the Upper Walk of the New Exchange. 1671.

The style of the book, which is a delight to read, is indicated by the following passage:—

> " First of all then they have discovered four Fishing Places for the Pearl in the East, the most considerable is performed in the Isle of Behren in the Persian Golph ; the which appertains to the Sophy of Persia, who receives whence a great revenue. While the Portugals were Masters of Ormus and Mascati, every Vessel which went to fish was obliged to take a Passport from them at a dear rate ; and they maintained five or six small Galleys in the Gulph, to sink those Barks which took no Passports ; but at present they have no farther power upon those Coasts, and each Fisher payeth to the King of Persia not above one third of what they gave to the Portugals."

It will be interesting to know whether any member has an older book in his or her collection. Other interesting books in the Gemmological Association's library will be featured in future editions of the Journal.

monds of great value fifteen dayes together, without comeing to ſee them, and by that means affording them all the leaſure they can wiſh to conſider well their marchandiſe, ſo that it is their own fault if they be cheated in it.

The ſecond Mine is called *Coullour* in the Perſian Language, and the Idolaters of the Countrey call it *Gany.* This is a large Town, near a great River, and they dig from the River to a Mountain about two Leagues from thence, and in the Mountain it ſelf. This Mine hath been

been diſcovered but within 50 or 60 years, and is the place where they find the moſt part of the great Stones, whereas before that time they rarely met with any above twelve Carrats; but that at this day ſome are to be ſeen of threeſcore, an hundred, and of two hundred Carrats, *Mirgimola* Chief Miniſter of State, and General of the Armies of the King of *Golconda*, a man of great parts, much believed of his Maſter, who gave him the Title of Prince of Princes, though at length he proved a Traitor, preſented the *Great*

C 2 *Mogol*,

By GEORGE SWITZER, Ph.D., Director of Research, Gemmological Institute of America, and RAPLH J. HOLMES, Ph.D., Instructor in Mineralogy, Columbia University, New York City

The Identification of Gems by X-Rays

THE present known methods of gem testing in certain unusual cases make it impossible for one to positively identify an unknown stone without powdering a portion of it for chemical or X-ray analysis. This is especially true of opaque substances, where the only property that can be determined without the possibility of damaging the gem is that of specific gravity, and if the gem is mounted, even this test cannot be made without first removing it from the setting.

To a lesser extent non-opaque materials can prove to be very troublesome, especially if they are cut with all curved surfaces, so that their index of refraction cannot be determined with accuracy. With curved surface gems, even the property of single or double refraction cannot be determined by either the polariscope or the polarizing microscope if the gem is in a solid-backed mounting, or if it is semi-translucent.

There has been a definite need, therefore, for a method of gem identification which will yield positive results on all gems, and especially on opaque or semi-translucent materials, mounted or unmounted. Hence at the suggestion of Robert M. Shipley, such a method of gem identification by means of X-rays has been developed in the laboratory of the Gemological Institute of America which fulfils this need.

The design of the instrument to be described is based upon a suggestion made by Dr. Samuel G. Gordon, Associate Curator, Academy of Natural Sciences of Philadelphia. Work was begun in the Los Angeles laboratory in April, 1946, to develop and construct an X-ray camera of a special type that would make it possible to identify gemstones by a method of X-ray diffraction. After preliminary work by Switzer the problem became the joint effort of Switzer and Holmes in the summer of 1946.

REQUIREMENTS TO BE MET

Before describing the actual camera design it will be advantageous to review briefly the requirements that must be met by an instrument which will make it possible to identify an unknown gem by means of X-rays.

Crystalline substances, and all gem materials except opal, jet, amber, obsidian, moldavite, glass and some plastics, are made up of atoms having an orderly arrangement. This orderly atomic arrangement causes a crystalline substance to act as a three dimensional diffraction grating, with the result that when an X-ray beam strikes it, secondary beams of X-rays are generated. This diffraction effect, for simplicity, may be thought of as reflection of the X-ray beam by planes of atoms within the crystal.

Any crystalline substance will produce a diffraction pattern if placed before a narrow X-ray beam and a sheet of film is put in proper position to record the secondary X-ray beams generated by the orderly atomic arrangement of the specimen. In the general case, when the specimen is stationary and having a random orientation, a pattern is obtained consisting of an unsymmetrical network of spots. A pattern of this type is known as a Laue pattern.

In general a Laue pattern is taken of a *single crystal.* A single crystal is a homogeneous crystalline body and may be one having natural crystal faces, or a cut gem where the natural crystal faces have been removed by the lapidary. In any case, to be most useful a Laue pattern must be taken with the X-ray beam parallel to an axis of the crystal. Then a symmetrical pattern is obtained which indicates the crystal system to which the material belongs. In other words, to obtain a usable diffraction pattern from a stationary cut gem (single crystal) such as corundum, topaz, or beryl, it must be set before the X-ray beam with one of its crystal axes parallel to the X-ray beam. Since in cut gems the naturally occurring crystal faces (which lie parallel to the crystal axes) have been removed, to locate the direction of a crystal axis is extremely difficult, or in some cases impossible, and therefore impractical.

A more useful type of diffraction pattern is obtained if the specimen is rotated or oscillated about an axis of the crystal. Here again, however, unless the position of a crystal axis is known, and the crystal carefully placed before the X-ray beam in a particular position, the resultant pattern is useless for purposes of identification.

The most useful type of X-ray diffraction pattern for the identification of minerals is the so-called powder pattern, first developed by Debye and Sherrer in 1916. A pattern of this type is ordinarily obtained by finely powdering the material under investigation and cementing the powder into a small rod-shaped specimen. The sample thus prepared is made up of a large number of randomly oriented crystals, so that the position of the sample in the X-ray camera is now of no consequence. Powder patterns consist of a group of concentric circles recorded on the film, and are in a sense a " fingerprint " since every crystalline material gives its own characteristic grouping of circles or lines.

It is evident from the foregoing discussion that the ideal condition for identification work is to have available a powdered sample. However, this cannot be done without damaging the specimen, and cannot be considered as a practicable method of identification of a cut and polished gem. The new X-ray camera was therefore developed, so that a *powder-type* diffraction pattern may be obtained from a cut gem, whether it be cut from a single crystal, or from an aggregate of many crystals.

As stated above, a large number of randomly oriented grains are required in order to obtain a powder-type pattern. In the new instrument an analogous condition is obtained *without powdering the sample* by giving to the specimen a combination rotatory and oscillatory motion.

The new instrument, or *X-ray diffraction camera,* is shown schematically in Figure 1. On the extreme right is indicated the X-ray tube. The X-ray beam passes through a pin-hole system which serves to confine it to a narrow pencil of essentially parallel X-rays. The X-ray beam then passes through a hole in the film holder and film and strikes the specimen. Secondary X-ray beams are generated by reflection of the primary beam from planes of atoms within the specimen and are reflected back to the film to produce an X-ray diffraction pattern. The primary X-ray beam

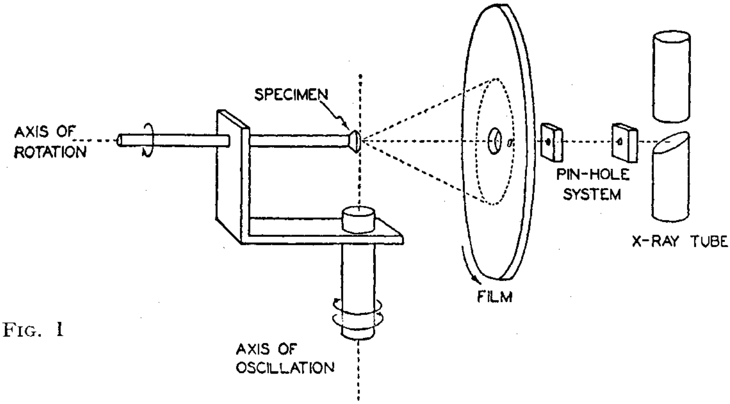


FIG. 1

in Figure 1 is shown as a dotted line passing through the pin-hole system, through the centre of the film, and striking the specimen. The secondary X-rays generated by the orderly atomic structure of the specimen are shown as dotted lines leading back to the film. The dotted circle on the film indicates the manner in which concentric circles are recorded on the film. A pattern obtained in this way is referred to as a *back-reflection* diffraction pattern, since the secondary X-rays are reflected from the specimen back to the film.

The motion imparted to the specimen is of particular importance. As has already been pointed out, diffraction patterns usable for identification work cannot in general be obtained if the specimen is motionless, or if it is given a simple rotatory or oscillatory motion. However, *powder-type* patterns are obtained when the specimen is simultaneously rotated about one axis and oscillated about another axis at 90 degrees to the first. Referring to Figure 1, the specimen is rotated continuously about the horizontal *axis of rotation*. At the same time it is oscillated to and fro through a 90-degree arc about a vertical axis, the *axis of oscillation*.

The motive power is supplied by clock motors, the horizontal rotation taking place at the rate of one revolution per minute, and the vertical oscillation at one degree per minute. As a result of this " oscillating fan " type of motion given to the specimen, a large number of atomic planes are brought into reflecting position, with diffraction patterns such as those shown in Figure 2 being the result.

A third motion may be introduced, this being a rotation of the *film* about the X-ray beam as an axis.

RESULTS AND USES

Typical results obtained with the new X-ray diffraction camera consist of a family of concentric circles. The spacings and intensities of the circles vary according to different gem materials.

The X-ray method of gem identification described is intended for use primarily in especially difficult cases, or in cases where identification by all other means has led to dispute as to the gem's true identity. Its advantages are as follows: (1) It can be *used on all specimens regardless of size,* depending on camera design. The present model can accommodate specimens up to 10 centimetres in diameter. (2) It can be used on any specimen, *regardless of shape or contour of surface.* (3) It can be *used on mounted or unmounted gems.* (4) It will give a positive identification of *opaque as well as non-opaque material.* (5) It will work equally well *on a single crystal* such as ruby, emerald, or marcasite, *or upon fine grained crystalline aggregates* such as onyx, lapis, haematite, jadeite or nephrite.

The results described herein are the first obtained with the new X-ray camera. Eventually a catalogue of standard patterns will be made, one for each gem mineral species, and routine identifications will be made by direct comparison of the standard film with those obtained from unknown specimens. Since this is a back-reflection camera, it is not possible to make a direct comparison of these patterns with those obtained in an ordinary type powder camera.

Extracted by courtesy of "Gems and Gemology"

Post-Diploma Students at Chelsea

NOW that the 1946-47 term has reached its last stage it seems opportune to become personal for once and discuss some of the personalities who help to make the classes in gemmology at the Chelsea Polytechnic so successful.

We will consider only the instructors and the enthusiastic group of Fellows who are continuing their studies, after an enforced war-time interruption, for the third, sixth—or is it twelfth year?

The teaching staff is headed by B. W. Anderson, B.Sc., F.G.A., who was appointed as Senior Lecturer in 1933. At the present time he is assisted by Thorold Jones, Junior Lecturer, who obtained his diploma in 1926, and Robert Webster. B. W. Anderson is well known as the Director of the Gem Testing Laboratory of the London Chamber of Commerce, and as author of "Gem Testing," which is now in its fourth edition. Thorold Jones is in charge of the Preliminary Class and his return to Chelsea, after doing a great deal of gemmological work in the war effort, has brought about the reunion of the quartet of Fellows which has assisted the classes for so many years. Webster, an example of a gemmologist capable of carrying out research work from start to finish (he was awarded a Research diploma recently), is also a writer, and his "Practical Gemmology" and "Compendium" are trusty companions of students.

So far we have mentioned three names; the fourth member of the quartet is G. F. Andrews, a 1931 diplomatist, who is Secretary of the Association. He is the "family" critic—reading page proofs of the works of Anderson, Webster and others, ascertaining views of students, and generally collating and disseminating views for the benefit of the students.

There are at least fourteen "inveterate" gemmologists now working at Chelsea, among them L. F. Cole, who gained his diploma in 1937, R. K. Mitchell (1934), F. Eade (1933), Ross Popley (1934), F. Ullmann (1938), V. Levett (1946 Tully Medallist), T. Bevis-Smith (1936), W. West (Tully Medallist for 1940), Sir James Walton (1945), A. Kemp (1936), Audrey Newman (1946), Vera Benson (1946, first winner of the Anderson prize in the practical examination) and Mrs. A. M. Sharpe (1945).

They are all sound gemmologists and their deep enthusiasm is a great encouragement. They come along to Chelsea to learn something new and consort with old friends. It is good to have some of these Fellows return to Chelsea after the war, and it is hoped that those now studying will be inspired to follow in the footsteps of these workers. By so doing a really efficient school of post-diploma gemmologists can be maintained. Possibly, from the hundred odd students at Chelsea and the centres in Edinburgh and Birmingham, more Fellows will have the desire to continue their studies.

Gem Testing Laboratory Achieves its Majority

PRESENTATION TO MR. B. W. ANDERSON, B.Sc., F.G.A.

AT a meeting on 6th March of the Standing Committee of the Diamond, Pearl and Precious Stone Trade Section of the London Chamber of Commerce, the occasion was taken to make a presentation of a silver waiter to Mr. B. W. Anderson, the scientist in charge of the Section's Laboratory at 55, Hatton Garden, to mark the twenty-first anniversary of its establishment and of Mr. Anderson's long and devoted service.

It may be recalled that in 1925 the Committee of the above Section representing the leading merchants, brokers and manufacturing jewellers in London, decided that the most effective way to protect the trade agaist the fraudulent use of cultured pearls would be to establish a Laboratory where pearls could be scientifically tested and certificates issued as to the nature of any goods submitted.

The work started in a small fourth-floor room in Diamond House, Hatton Garden, the pearl testing equipment consisting at first of a " Lucidoscope," which was not a very satisfactory instrument, and a diamond balance being practically the only other apparatus in use.

In the following year the endoscope appeared, pearl testing becoming a matter of scientific certainty, so that the work of the Laboratory steadily increased and extended to the testing of precious stones of all kinds and to the issue of certificates of weight in cases of dispute.

The number of pearls tested rose rapidly from 4,000 in 1926 to 49,000 in 1928, and to cope with the extra work the staff was increased and the Laboratory moved in 1929 to larger premises at 55, Hatton Garden, where special X-ray equipment was installed to enable undrilled or part-drilled pearls to be tested—the endoscope being suitable only for drilled pearls.

The world-wide trade depression of 1930-1931 and the consequent falling-off in testing work afforded an opportunity for research, which included a long series of investigations on the density of pearls from different localities and the accurate measurement of the density and refractive index of all manner of gem materials. The data thus obtained conflicted in many cases with text-book figures and the first-hand knowledge so gained has been of the greatest service.

In 1935 the value of the Laboratory to the trade was brought to the fore in connection with an alleged " synthetic diamond " discovery which obtained much publicity in the Press. Specimens of these stones were examined in the Laboratory and found to be nothing more than colourless synthetic spinels having a composition and properties entirely different from diamond. In order to reassure the market an official statement by the Section was published and broadcast, stating the true nature of the fraud.

Apart from the early years of the last war, increasing use of the Laboratory has been made by members of the trade, and at the end of 1944 a revision of the charges for testing became possible, with the result that for two years now it has not been necessary to call upon the Guarantors to the Fund set up some years ago by members of the Section to finance the work. It is very much hoped that this state of affairs will continue.

In the year 1946, when the Laboratory " came of age," all records were broken, over 62,000 pearls and over 100,000 stones being tested and nearly 1,700 reports issued.

The Laboratory staff has been greatly increased, and is now in a position to cope with a much greater volume of work, and it is intended to provide improved accommodation as soon as circumstances permit.

Letters to the Editor

The Secretary

We congratulate you on the issue of your interesting Journal, and send our best wishes for the future. At the same time we wish to draw your attention to a reference on p. 16, para. 1, regarding the quartz crystal supplied for the Stalingrad Sword. We supplied the piece of crystal for the pommel and also cut and polished the crystal in our workshops.

Afterwards the two craftsmen employed by us were invited to attend the Russian Embassy, and each was presented with a magnificent casket in appreciation of their share in producing the sword.

Yours truly,

14, Hatton Garden,
E.C.1.

C. MATHEWS & SON.

Dear Mr. Andrews,

I feel I must congratulate you on yet another outstandingly successful meeting of the Gemmological Association ; you are indeed setting yourself an alarmingly high standard which it will be difficult to maintain, let alone succeed.

The decision of Mr. Rayner to offer a Tully refractometer to the winner of the Tully medal was a very pleasant surprise. The award is splendidly appropriate, since it forms yet another commemorative link between the Gemmological Assocation and the late B. J. Tully, who did so much to further the cause of gemmology in its early beginnings. The announcement was doubly welcome in that it afforded proof that the production of an improved model of this form of refractometer will not be long delayed.

Of Dr. McLintock's talk it would be difficult to speak too highly. I think Sir James Walton expressed the feelings of us all when he said that it was one of the most delightful to which he had ever listened. It was heartening to learn that even to the Director of the Geological Survey the optics of biaxial crystals presented certain difficulties, and that he found the mathematical treatment of the subject in Dr. Herbert Smith's " Gemstones " a little hard to follow. In paying a well-deserved tribute to our President's famous text-book Dr. McLintock touched only very lightly on his own short " Guide to the Gemstones in the Museum of Practical Gemmology," which first appeared in 1912 and was revised in 1923. This most readable and accurate introduction to gemmology, costing only one shilling, was for years the recognized companion to the standard text-book amongst students at the Chelsea classes. I was glad to learn that Dr. McLintock is seriously contemplating the production of a new edition of the " Guide " which, in addition to general matter, will contain information about some of the magnificent stones to be seen in his Museum.

Mr. Grodzinski's first-hand account of the South African Diamond mines was exceedingly interesting and informative. One envies his opportunity to see for himself the processes about which one has read so much. As Mr. Braunfeld remarked, it does seem a pity that the interesting secondary minerals are apparently discarded as waste when (to judge from examples one has seen) some at least of the pyrope and enstatite could be cut into attractive gemstones.

Altogether it was a splendid meeting, and I am sure we all went home with the satisfied sense of an evening well spent.

Yours sincerely,

B. W. ANDERSON.

OFFICIAL NOTICES

AMERICAN AWARD TO MR. M. D. S. LEWIS, B.Sc., F.G.A.

The American Gem Society has awarded the title of Certified Gemmologist to Mr. Malcolm D. S. Lewis, a jeweller, 33, Conway Street, Fitzroy Square, London, W.1, England, who undertook and successfully completed the final examinations for the four-year gemmological course offered by the Gemological Institute of America in Los Angeles.

Mr. Lewis, who is an F.G.A. and the winner of the Tully Medal in 1944 for the highest grade, is now further to be credited with being the first in England to receive the C.G. title. He has also been awarded the first Research Diploma of the Gemmological Association of Great Britain for noteworthy research in the field of gemmology, an accomplishment comparable to a Research Membership in the Gemological Institute of America, an honour awarded so far to but one man, Dr. E. Gübelin, Ph.D., F.G.A.

Mr. B. W. Anderson, B.Sc., F.G.A., the noted British gemmologist, Director of the Gemmological Laboratory in London, acted as proctor for Mr. Lewis.

FIRST ANNUAL DINNER

The first annual dinner of the Association will be held on Thursday, 15th May, 1947, at the Waldorf Hotel, Aldwych, London, W.C.2.

Tickets and details of the dinner, which is being held to mark the Incorporation of the Association, are obtainable from the Secretary.

OBITUARY

It is with great regret that the Council has to record the death on 21st February of Victor William Clarke.

Mr. Clarke, who was in his 81st year, was chairman of Wilson and Gill, Ltd., and his wide knowledge of the jewellery trade enabled him to perform valuable work in Trade Association activities. He was Vice-Chairman of the National Association of Goldsmiths in 1920 and 1921, Chairman in 1922 and 1923, President in 1927, and Treasurer from 1931 to 1942.

During his term of office with the National Association Mr. Clarke took a considerable interest in the work of the National Association of Goldsmiths' Gemmological Committee, which in 1931 became the Gemmological Association. In recognition of his work he was made the first Honorary Fellow of the Gemmological Association in this country in 1943. He was Chairman of the Association from 1943-1946 and held the office of Honorary Treasurer from 1931 until his election to the Chair. He was admitted to the Livery of the Worshipful Company of Clockmakers in 1925.

By the death of Mr. Clarke the Gemmological Association has suffered a great loss. He was always prepared to place his great knowledge of the jewellery trade at the disposal of the younger members, and his kindly interest and advice will be greatly missed.

The Association was represented by Mr. F. H. Knowles-Brown, Chairman, and Mr. G. F. Andrews, Secretary, at the funeral ceremony which took place at the Golders Green Crematorium on 25th February.