THE JOURNAL OF GEMMOLOGY
AND PROCEEDINGS OF THE GEMMOLOGICAL ASSOCIATION OF GREAT BRITAIN

Vol. III No. 8 OCTOBER 1952

SINHALITE

— another new gemstone

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

AT a meeting of the Mineralogical Society held on 24th January, 1952, for the second time within a year a new gem mineral was described.

On the former occasion only two small cut specimens of the mineral (taaffeite) were on view, these representing the whole of the world's known supply ; whereas in describing sinhalite Dr. G. F. Claringbull was able to produce a score of cut examples, some of them of considerable size. There was also one small pebble of rough, recovered by Dr. E. H. Rutland from samples of illam held by the lapidaries, Charles Mathews & Son.

Sinhalite, in actual fact, is new only in the sense that its true nature has only just been discovered. Several specimens of the species (all cut as gemstones) were already in the collections of the British Museum (Natural History) and of the Geological Survey Museum, and there is little doubt that there are examples waiting to be re-labelled in most considerable museums of the kind throughout the world.

Private collectors, too, will hold a number of these stones. In the Laboratory we have a fair number of specimens obtained by gift and by purchase during the past 20 years, and several sinhalites have recently been found in mixed parcels of Ceylon stones (mostly labelled " zircons ") submitted for testing in the ordinary course of business. One of these was a giant of nearly 75 carats—the largest so far recorded.

The aliases of sinhalite have been many and various. When appearance has been the only guide the faceted stones have been plausibly represented as chrysoberyl (which it closely resembles in colour), tourmaline, zircon, or beryl.

When tested by the usual methods, the refractive indices, birefringence, and density agreed sufficiently well with the values to be expected from an iron-rich olivine of the forsterite-fayalite series for the stones to be classified as " brown olivine " or " brown peridot." Brown peridot does indeed exist, but the few so far examined have properties near those of the ordinary green variety, and appear to be a good deal rarer than sinhalite itself.

The chief anomaly with sinhalite when considered in relation to the olivine group is the value of the β refractive index which is quite close to the maximum (γ) index—revealing that the mineral is strongly negative in its optical character with an optic axial angle of about 55°, whereas in olivines the angle is near 90°, resulting in a value for β almost exactly mid-way between the maximum and minimum indices. My colleague C. J. Payne, who had made many accurate determinations both on these brown stones and on green peridots from different localities, had noted this anomaly, and we were both also worried by the very pale colour of some of these " brown peridots " which was hardly to be expected in an iron-rich olivine. However, both axial angles and depth of colour are apt to be variable factors, so suspicions were allowed to slumber. In this connection it is interesting to note that as long ago as 1912 Dr. A. F. Hallimond examined a sinhalite in the Geological Survey collection and altered its description from chrysoberyl to chrysolite, adding the significant words " This stone is to be further examined."

In June, 1950, Dr. George Switzer of the Smithsonian Institution in Washington blew the accepted olivine hypothesis sky-high; the powder used for this explosive act being scraped from the stone itself and the detonator being an X-ray beam.

In more prosaic language, Switzer took an X-ray powder photograph of scrapings from the girdle of a so-called " brown olivine " gemstone in the collection of the United States National Museum and obtained spacings which clearly differed from those of a true olivine. In March 1951, having learned from Mr. Kenneth Parkinson that I had forestalled him in purchasing a large cut specimen of " brown peridot " which the latter had brought back from Ceylon, Dr. Switzer wrote to me for particulars of this stone and any others of the kind which we had measured. In sending him the required data I tentatively offered him one of my smaller specimens for analysis should it seem necessary.

Some time later Dr. W. F. Foshag, Switzer's chief in the National Museum, paid a visit to this country. While being shown round the Mineral Gallery in the British Museum (Natural History) he suggested to Dr. Claringbull that a brown cut gemstone exhibited as olivine had perhaps been incorrectly determined. This was a challenge to which Dr. Claringbull reacted energetically. He took powder photographs of five stones in the Museum collection and in each case obtained a diagram which, though bearing a certain similarity to that of olivine, clearly belonged to a different mineral.

A pale, broken specimen was presented by Mr. Robert Webster to the Museum to assist this research (a typically generous gift of his only specimen) and part of this was crushed and used both for more thorough X-ray analysis and for the chemical analysis which was later carried out by Dr. Claringbull's colleague, Dr. M. H. Hey who, it may be remembered, had earlier analysed taaffeite.

Preliminary spectrographic tests showed the presence of aluminium, magnesium and boron, and the surprising *absence* of silica. The presence of boron always complicates things for the analyst, but, after an unsatisfactory trial, good results were obtained on a sample of only 6.4 mg. Sinhalite, unlike peridot, is practically insoluble in all acids except hydrofluoric. The crushed sample accordingly fused with caustic soda and the fusion dissolved in dilute hydrochloric acid. Aluminium and magnesium were precipitated together by 8—hydroxy quinoline and ammonia and later dissolved and separated by reprecipitation in acetic acid. The boron was determined by titration and iron estimated colorimetrically.

The results of Dr. Hey's analysis were as follow, the figures calculated for pure $MgAlBO_4$ being given alongside :—

		Found	*Calculated*
B_2O_3	...	24.2	27.60
Al_2O_3	...	41.0	40.44
MgO	...	32.3	31.96
Fe_2O_3	...	2.0	—
H_2O	...	0.3	—
		99.8	100.00

Sinhalite is thus a magnesium aluminium borate containing inessential traces of iron. The analyst assumes this iron to be in the ferric state, but from the close similarity of the absorption spectrum with that of peridot (discussed below) in which the iron is undoubtedly ferrous, the writer would beg leave to doubt the correctness of this assumption.

As may be said of most gemstones, sinhalite is allochromatic and would be colourless if a specimen could be found which conformed exactly with the " ideal " formula. Many of the stones are, indeed, very pale in colour, having only a tinge of brownish yellow. At the other end of the range are brown stones as dark and lacking in charm as brown tourmalines—these undoubtedly contain more iron than the 2 per cent. found by Dr. Hey in the pale sample analysed. Between these extremes are sinhalites of golden brown, or greenish brown, closely resembling chrysoberyl in appearance, and these are decidedly attractive gems.

Once its properties are understood sinhalite is not a difficult stone to identify. The birefringence is strong enough to cause very distinct doubling of the back facet edges when these are viewed through the crown of the stone with a 10X or 8X lens. The strength of the birefringence is nearly the same as with peridot—that is, half-way between that for tourmaline and for zircon. It is more dichroic than zircon and less so than brown tourmaline. The pleochroic colours in a typical specimen are pale brown, greenish and dark brown.

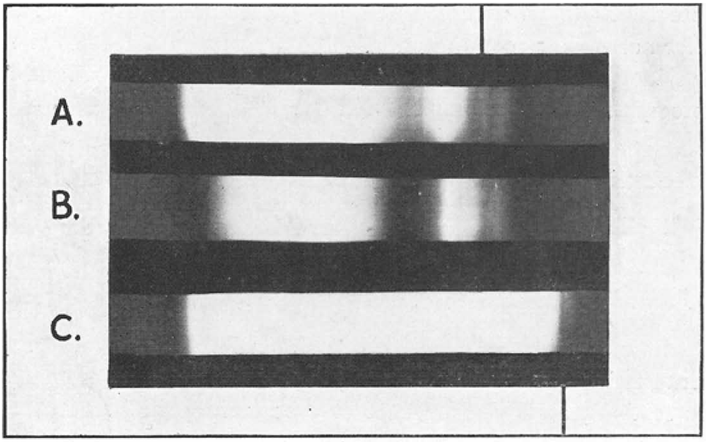
On the refractometer, the readings are nearly two units in the second place higher than for olivine, while the birefringence is higher than for diopside. With loose stones, the speed at which it sinks in methylene iodide at once separates it from peridot.

Sinhalite is usually remarkably "clean" and transparent : though isolated mineral inclusions have been observed none seem particularly characteristic, and it lacks the "feathers" seen in so many peridots, chrysoberyls and tourmalines.

As for the absorption spectrum, this bears a remarkable resemblance to that of peridot, but is sufficiently characteristic, when one is familiar with it, to serve as a useful diagnostic feature. The similarity in position between the sinhalite and olivine bands is strong evidence both of the cause for each being the same (ferrous iron) and for the atomic structure surrounding the absorbing atoms being very closely related despite the very different-seeming chemical formula.

With pale sinhalites practically no bands can be seen, while (in common with other brown stones) there is strong general absorption of the blue and violet in the darker specimens, so that it is difficult to see some of the discrete bands in the gloom.

Wavelengths of the main absorption bands in the mineral are given below, alongside those for peridot. In each case there are



Absorption spectra of sinhalite and peridot taken with a diffraction grating spectrograph, using Ilford "long range spectrum" plates. a. *Sinhalite ;* b. & c. *Peridot. In* a. *the "extra" band at* 4630A *is marked ; it will be seen that this is missing in the peridot spectrum below. In* c., *a deliberate over-exposure of the plate enables the strongest of the ultra-violet absorption bands in peridot* (3970A) *to be observed. The apparent broad absorption bands in the green region seen in* a. & b. *are chiefly due to the insensitivity of the panchromatic emulsion in this region—one reason why photographs of absorption spectra are seldom really satisfactory.*

differences in detail for each of the three pleochroic rays, but in general all the bands mentioned can be seen under good lighting conditions.

	Sinhalite.		*Peridot.*
5260A	weak, vague.	5290	weak, vague.
4930	mod. strong, narrower.	4930	strong, complex.
4750	mod. strong, narrow	4730	moderate, narrow.
4630	mod. strong, broader.	——	
4520	moderate, similar.	4530	moderate.

It will be seen from the above table how most of the absorption bands in the two spectra correspond closely in position, though there are subtle differences in their character that description cannot easily convey. The main difference consists in the presence of a band at 4630A in sinhalite which is missing in peridot. Even without measurement this gives a sufficiently altered pattern to the practised eye to enable one species to be distinguished from the other by this means. Another difference, revealed only on the photographs taken of the spectra, is the presence of two strong, rather narrow absorption bands in the near ultra-violet in the case of peridot (at 3970 and 3850A approx.) which are not found in photographs of the sinhalite spectrum.

For the convenience of readers, I will conclude this article by giving a complete summary of the characters of sinhalite, so far as they are known. The only known locality so far is Ceylon, and the name chosen for the stone indicates this fact. But, just as brazilianite is not confined to Brazil nor andalusite to Andalusia, so sinhalite will almost certainly be found in other countries before long, now that its existence and its properties are known. It will be interesting to see whether petrologists can trace its presence in rock sections, and give us some clue as to its genesis.

Properties of Sinhalite

Composition. Magnesium aluminium borate ($MgAlBO_4$).
Crystal System. Orthorhombic. (Class not yet determined).
Hardness. 6½. (Not yet accurately determined).
Colour. Pale yellow, shades of brown and greenish brown.
Pleochroism. Distinct : Pale brown, greenish brown, darker brown.

Refractive indices, birefringence and density (typical values)

Colour	α	β	γ	$\gamma - \alpha$	*Density*
Pale yellow ...	1.6667	1.6966	1.7048	.0381	3.47
Brown ...	1.6691	1.6988	1.7069	.0378	3.48
Dark brown...	1.6708	1.7000	1.7081	.0373	3.49

Dispersion. B—G .018.

Absorption spectrum. Main bands are in blue, at 4930, 4750, 4630, and 4520A, with general absorption of violet.

The refractive indices given above were measured by C. J. Payne in sodium light on an Abbe-Pulfrich refractometer. The corresponding densities were determined by the writer by hydrostatic weighing in ethylene dibromide, and reduced to two places of decimals. The properties of the more than 20 sinhalites measured in the Laboratory are remarkably consistent, showing merely a slight increase in refractive indices and density with increasing depth of colour. There is a slight but definite tendency for the birefringence to be lower in the stones with the highest indices.

Fuller details of individual specimens, and of the X-ray investigation, will be found in the original paper by Claringbull and Hey, published in the Mineralogical Magazine for June, 1952.

One last note should perhaps be added, though for most readers of this journal the warning should not be necessary. The terms " olivine " and " peridot " in this paper must be taken as broadly equivalent terms for the same mineral, though to mineralogists the name olivine has a wider significance than has the term peridot to the jeweller. If this is not understood, much of what has been written above will prove confusing to the reader.

LETTER TO EDITOR

Dear Sir,

The article on using a ' live box ' for holding stones (Journal of Gemmology, Vol. 3, No. 7, 1952, p. 279) made me wonder if the idea I have used for years is of interest. It is an ordinary insect holder which fits in place of one of the microscope stage clips. The cork inset is removed and replaced with plasticine on which the stone to be examined is lightly pressed. It can be turned and examined in nearly all directions.

Yours faithfully,
E. W. MATON.

Queen Street, Cardiff.
10*th September,* 1952.

Feature of
AMETHYST AND CITRINE INCLUSIONS

by Norman H. Day, F.G.A.

AMETHYSTS and citrines often contain flaws which are usually known as " feathers." These may be discussed under the term Inclusions, though a true inclusion is foreign to the host crystal. Many gemmologists must be attracted by the beautiful and bold effect of these " feathers," often reminiscent of a mackerel sky of light Cirro-cumulus clouds.

Stones containing large " feathers " are rejected from use in high-class jewellery, but the presence of small and inconspicuous ones give an important diagnostic feature. The so-called "feather" inclusions found in topaz, sapphire and tourmaline do not show the same striped pattern that is seen in many amethysts and citrines.

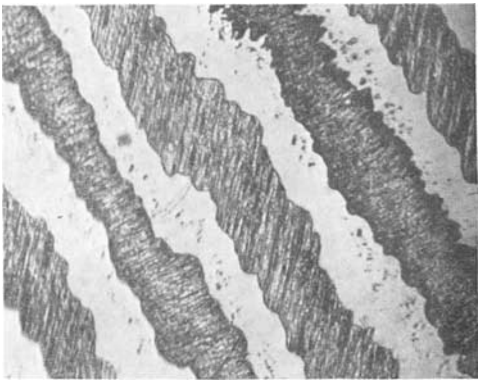
My interest in these inclusions was aroused some months ago, when Mr. K. Parkinson of Hull sent me a collection of stones that would provide good subjects for photomicrography. Among these was a square cut pale amethyst of about three carats and just under and parallel to the table facet was a " feather " which gave the whole stone what may be described as a " tiger skin " effect. (Fig. 1.)

The stone was immersed in Clove Oil ; an Ilford ordinary plate was used, with a single polaroid filter orientated to cut out any double refraction effect and an Ilford micro-filter No. 2 to cut out ultra-violet and deep violet light to which these plates are very sensitive. The result can be seen in Figs. 2 and 2A, which show part of this " feather " magnified 80 × and 130 × .

These photomicrographs show that the units in one band of the " feather " are parallel to the units in alternate bands, while the units in the intervening bands are parallel but orientated at 60° to the direction of the other units.

Fig. 1. *The "Feather" parallel to the table facet in Amethyst.* 12 ×.

Fig. 2. *Enlargement of part of the "Feather" of fig.* 1. 80 ×.



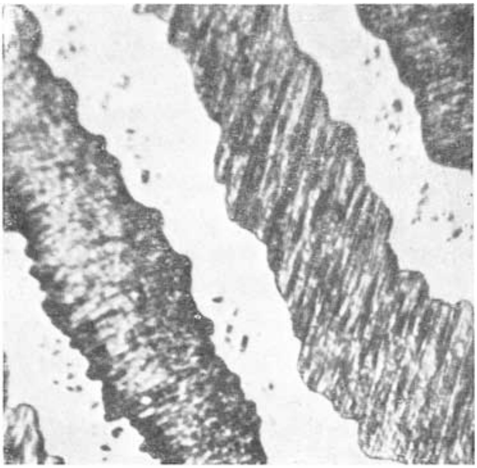


Fig. 2*a*. *Enlargement of part of the "Feather" in fig.* 1. 130× .

Having noted this phenomenon, I proceeded to examine " feathers " in a large number of amethysts and citrines (usually pale stones), with a low-powered microscope. There appear to be two main types :—

(i) A type in which the bands are evenly spaced and the whole " feather " is in a flat plane ; there may be other flat " feathers " in the stone while they all appear parallel to possible faces of the crystal ;

(ii) Those that do not form a flat plane but are the shape of a conchoidal fracture of the type that shows interference colours in some quartz. The bands of these " feathers " are uneven and do not show the orderly form of type (i).

Using a higher magnification to observe the structure of the bands, it is found that only a few " feathers " have the orderly arrangement seen in Fig. 2, often the units are arranged parallel in every band and only an odd one or two have the alternate arrangement. Fig. 3 shows this, and Fig. 4, which is the same plate enlarged, shows a grain structure which might at first be taken for double refraction ; this remains however the polaroid filter may be adjusted, so that it must be part of the " feathers " structure. " Feathers " of type (ii), showing a grain structure without parallel form, can be seen in Figs. 5 and 6.

Many bands appear opaque because of internal reflection, as do some in Fig. 5. It is usually difficult to obtain quickly a good view of a " feather " for naturally the lapidary does not cut the stone so that it is parallel to the table facet, as in the case of Mr. Parkinson's stone, but he cuts it so that there is an angle of 45° to 90° between the " feather " and the table facet.

After showing Mr. L. C. Trumper the photomicrograph (Fig. 2) he drew my attention to F. J. Sperisen's book[1] " The Art of the Lapidary " in which, among the numerous illustrations, are two photomicrographs of " feathers " within Brazilian amethyst, one 30 × and another 70 ×, the second showing the alternate orientation of the units in the bands very clearly.

In a private communication Dr. E. Gübelin comments on Sperisen's photos and my photomicrograph (Fig. 2) : " They are very much alike indeed and somehow I have the feeling that they

Fig. 3. *A typical evenly spaced "Feather" of group ii.* 36 ×.

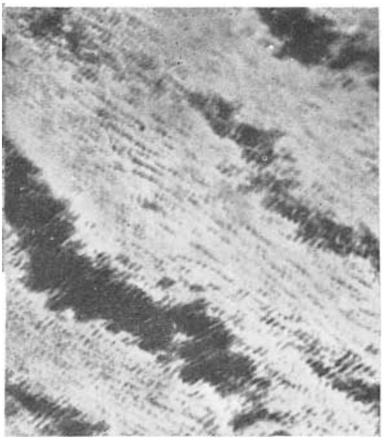


Fig. 4. *Part of plate fig.* 3 *with further enlargement.* 96 ×.

Fig. 5. *Typical "Feather" of group ii.* 36 ×.

Fig. 6. *"Feather" of group ii with complex arrangement.* 55 ×.

are ‘ scrape ’ marks of a crack which partly healed with time, or then they might be marks caused by the shifting of the atomic planes which happened under mechanical strain (what is generally known as ‘ translation ’).”

It is interesting to note that Church[2], Spencer[3], and Herbert Smith[4] all state that they consider these feathery inclusions and ripple fracture characteristic of amethyst to be due to twinning.

Spencer refers to “ feathers ” as “ thumb prints,” a name which might easily be adopted for these inclusions in amethysts and citrines, because of the wide application of the term “ feathers ” for so many types of inclusions.

REFERENCES

1. F. J. Sperisen. “ The Art of the Lapidary.” 1950. (The Bruce Publishing Co., Milwaukee), Figs. 60 and 61.
2. Sir A. H. Church. “ Precious Stones, A Guide to the Townshend Collection.” 1924. Victoria and Albert Museum. p. 130.
3. L. J. Spencer. Encyclopædia Britannica. 1929. Vol. XVIII, p. 831.
4. G. F. Herbert Smith. “ Gemstones.” 1949. (Methuen & Co. Ltd.), p. 346.

The temporary building which houses the Headquarters of the National Association of Goldsmiths, British Jewellers' Association, the National Jewellers' Association and the Gemmological Association of Great Britain. Behind is the facade of Goldsmiths' Hall.

NOTAE — UT INFRA

by D. S. M. Field, A.G.A.

THE writer has just received an interesting parcel of greenish-yellow scapolite from a new deposit opened up in the Township of Grenville, Argenteuil, Quebec. This material is quite compact and should cut good cabochons, although it is not sufficiently transparent for faceting.

Chief interest in the newly discovered variety of scapolite rests in its remarkable reaction to ultra-violet radiations. It fluoresces a slightly paler colour than the better-known type from that locality ; but is phosphorescent as well as fluorescent.

An authority in the United States who has studied the duration of phosphorescence in a large number of minerals reported that this particular scapolite has the longest phosphorescence of any—approximately *fourteen-hundred hours.* That is to say, a specimen exposed to ultra-violet light for a given time would affect a photographic film for a period of about three months thereafter.

Specimens are, in general, all rock, containing on the average from 40 to 60 per cent. scapolite in single individual crystals up to one-half to one-inch in size.

* * *

A considerable upswing in the price of moonstone above five carats in weight has resulted from the almost complete exhaustion of the Ceylon moonstone mines.

Gems that a year or two ago sold for a few shillings per carat are now being quoted in some circles in pounds sterling. Small gems, material for which is still relatively abundant in the gem gravels of certain districts of the island, are still available at the old prices ; but large stones of flawless quality are fast becoming collectors' items, and are practically unobtainable from Singhalese dealers in precious stones.

An advance in price is also expected in quotations for tiger-eye crocidolite. The South African deposits located near Griquatown, north of the Orange River, are now reportedly almost worked out. Fine specimens of this attractive mineral may, therefore, become unavailable when dealers' present stocks are exhausted.

* * *

The mad rush of manufacturers, cutters and dealers to unload synthetic rutile in Canada and the United States has apparently somewhat subsided. Fewer and fewer advertisements extolling the virtues of the brilliant gem have been appearing in trade papers, and in journals designed for the reading public.

* * *

Something new in interference figure slides is now being manufactured in North America. The slides are designed for the aid of teachers and students of optical mineralogy, and might therefore be of interest to the gemmologist.

Each slide provides oriented plates of six different minerals—permitting study of the interference figures without change of focus.

The following orientations are contained in a given slide : Quartz (uniaxial positive) perpendicular to C ; Topaz (bi-axial positive) perpendicular to Bxa ; Muscovite (Biaxial negative) perpendicular to Bxa ; Epidote, optic axis ; Barite, perpendicular to Bxo ; and Topaz, cut half-way between optic axis and Bxa, so that one axial emergence point and the centre of Bxa are in the field simultaneously.

Other slides of interest to the scholar are also available. These include multiple-orientation grain-thin sections of the following gem minerals : albite, andalusite, apatite, beryl, calcite, chalcedony, diopside, enstatite, epidote, idocrase, kyanite, labradorite, opal, orthoclase, peridot, prehnite, rock crystal, rutile, sphene, topaz, tourmaline, and zircon.

A relief slide is also of interest. This slide contains grains of six separate gem species mounted in the form of a star. They are : fluor, orthoclase, quartz, beryl, apatite, and garnet. The grains are arranged close enough together to allow the centre of the star and all six of the minerals to be viewed at one time in the field of a 10x (16 mm) microscope objective.

* * *

An American gem company has sold more than ten million carats of a new imitation turquoise material for use in the manufacture of novelty jewellery. Misnamed " synthetic turquoise," much of the output is utilized for facsimile American-Indian jewellery, and sold to tourists, principally in the southern and south-western sections of the United States.

* * *

A few black cultured pearls—probably stained by silver compounds—are occasionally reported ; and the writer has identified an exceptionally clever imitation bloodstone intaglio. The latter is of dark green opaque or sub-translucent glass with very realistic specks of opaque red " jasper." Considering the low cost of bloodstone, a clever imitation of this nature (with hand engraved figure) is most unusual, and hardly worth the effort its manufacture must have entailed.

* * *

Ugly Victorian-type cameos, wrist-watch bands and other tasteless jewellery items patterned after the styles popular during the latter half of the 19th century, seem to be the current vogue in North America—particularly with regard to the so-called " popular " items. The emphasis—perhaps mirroring the current international diplomatic situation—is definitely on the synthetic and the loud. Huge, heavy appearing (hollow-shoulder) rings with atrocious scissor-cut, patently synthetic " octagon " stones, for men ; and hanging drop trash jewellery for women. It is therefore to be hoped that the trend will eventually develop toward the quiet designs and standard cuts that were so popular during the first quarter of the present century ; and that, with a renewed sense of the worth of genuine things, the public will abandon its mad chase after the gaudy, and begin to share with the gemmologist his love for and appreciation of the quiet beauty of genuine, natural coloured stones.

Unusual Two and Three Phase

INCLUSIONS IN CEYLON SAPPHIRE

by L. P. Hoagland

OF increasing importance in the study of gemmology is the determination or verification of variety or species of gemstones on the basis of internal inclusions. In addition to being informative, the study of gemstone inclusions will occasionally bring the student into contact with an unusual or fascinating deviation from the expected.

Such a deviation is the occurrence of two- and three-phase inclusions in sapphire which alter to single- and two-phase inclusions of different character under the influence of heat. In the Summer and Fall, 1943, issues of Gems and Gemology, and in the Journal of Gemmology for July 1948, Dr. E. J. Gübelin presented findings on two-phase inclusions in a variety of gemstones. His researches established that those inclusions in which the liquid component altered to gas at a critical temperature usually contained carbonic acid, or carbon dioxide in liquid and gaseous forms.

In the inclusions studied by Dr. Gübelin, the application of heat resulted in the gradual expansion of the gas bubble, with a straightening of the meniscus or curved line of demarcation between the gas and the liquid. At the critical temperature of 31.1 degrees centigrade, when the meniscus formed a nearly straight line, the liquid component of the inclusion was vaporized and the cavity was occupied by gas only.

The inclusions herein reported on are similar in some respects to those noted by Dr. Gübelin, and were discovered in a single cabochon Ceylon sapphire during microscopic examination in the laboratory of Tiffany & Co., New York. Almost by chance, an active but short-lived turbulence within the stone was noted and it was set aside for further examination.

Figure 1 shows the effect of gradual heat applied to an inclusion of the type described by Dr. Gübelin. At room temperature the gas bubble is enclosed by the concave surface of the liquid, and a cluster of small black crystals is lodged in the corner of the cavity which forms an oblique angle. As heat is gradually applied the successive stages of enlargement of the bubble and loss of curvature

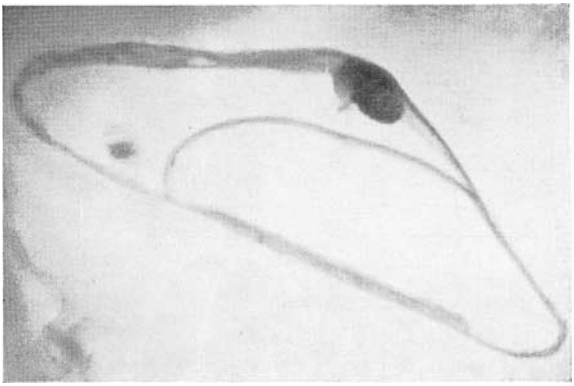


Fig. I

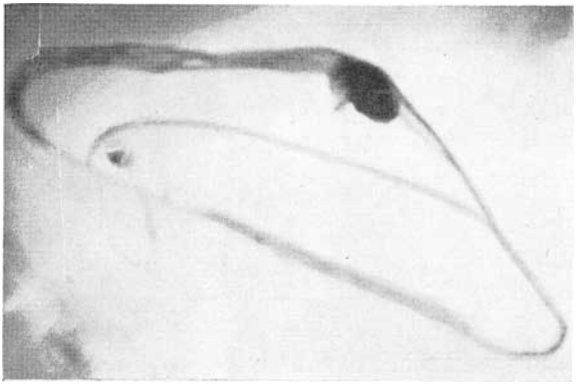


Fig. I a

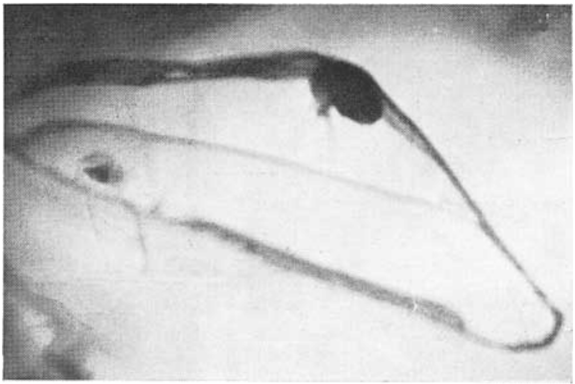


Fig. I b

of the meniscus are shown. Just prior to the sudden and complete alteration of liquid into gas, the meniscus is a thin, faint, nearly straight line of demarcation. In the final stage the liquid is vaporized and the cavity is occupied only by gas and the crystal cluster.

Heat from a microscope lamp is sufficient to cause this change which may also be accomplished merely by placing a finger on the stone for a few moments. To reverse the reaction, removal of the finger or turning off the lamp is sufficient. Dr. Gübelin mentions that on removal of heat and reversal of the reaction, the insides of the inclusions studied by him were momentarily filled with a cloud or mist which obscured the view of the interior. The inclusions discussed herein showed instead a sudden partial liquification of the gas, followed by a relatively violent separating out of additional small gas bubbles from this liquid. This separation continued for a brief period of time until a state of equilibrium seeming to correspond to the temperature of the stone was reached. It was found that a drop of alcohol placed on the stone and allowed to evaporate hastened the reversal of the reaction and reappearance of the gas bubble.

Further examination of this stone reveals that there is an entirely different type of reaction to heat to be found in inclusions of this type. On the basis of appearance, the nature of the reaction and the critical temperature involved, it seems certain that the constituents of the inclusions are the same or closely similar even though the two types of reaction are complete opposites.

Figure II shows a roughly triangular cavity containing liquid, a small black crystal, and a gas bubble. The stages of reaction to heat are shown by the gradual decrease in size of the gas bubble and a greater degree of curvature of the meniscus. When heated above room temperature, small gas bubbles form on the surfaces of the crystal and float upward through the liquid to join the original bubble. At first, this bubble increases in size with the addition of new bubbles but thereafter contracts as more small bubbles are added. This contraction continues until the large bubble has entirely disappeared, at which point no more small bubbles are formed on the faces of the crystal and action within the inclusion ceases. What had been a three-phase inclusion has altered to two-phase and contains not the crystal and gas which might be expected, but rather the crystal and a liquid.

Fig. II

Fig. II a

Fig. II b

Fig. II c

Figure III shows a larger inclusion of the same type which proved much more active and versatile than the one just discussed, although considerably more difficult to photograph. By moving the stone, it was possible to position the gas bubble in a remote corner of the cavity where the stream of bubbles forming about and rising from the cluster of included black crystals could not reach it. These small bubbles were then seen to form a single new bubble which gradually increased in size. As the new bubble grew, the original decreased and was eventually completely absorbed in the liquid. On its disappearance, the second bubble ceased growing, and as more small bubbles reached it, gradually grew smaller and

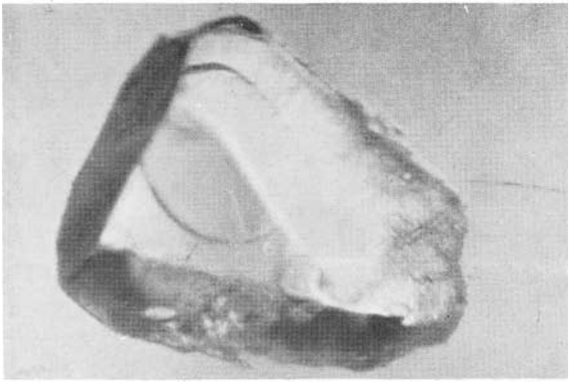


Fig. III

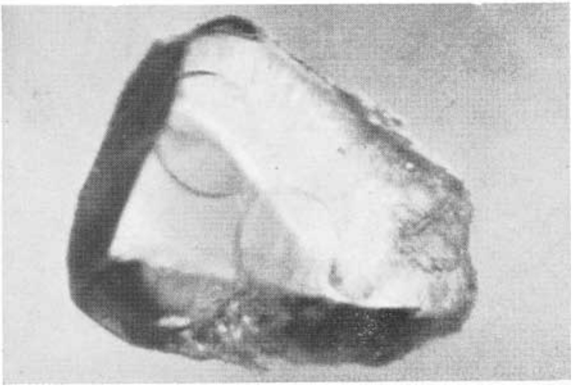


Fig. III a

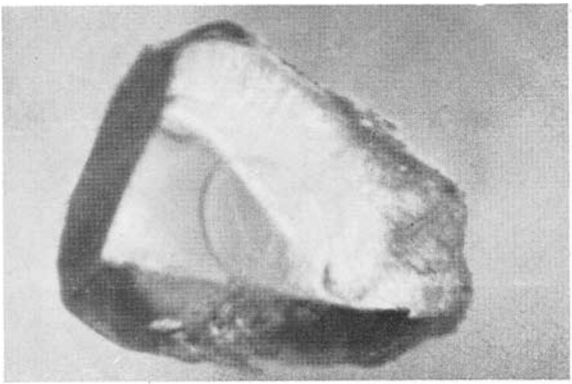


Fig. III b

disappeared. At this point, the generation of small bubbles on the faces of the black crystals came to an end and activity within the inclusion ceased.

An interesting sidelight to this type of reaction lies in the behaviour of the cluster of crystals in this latter inclusion. With the formation and release of gas bubbles on the sides of the crystals (possibly due to a more rapid absorption of heat by them than by the other constituents of the inclusion) these crystals were agitated, danced erratically about the interior of the inclusion, and on occasion floated to the surface of the liquid.

Also interesting to note with respect to the function of these crystals is a two-phase inclusion (gas and liquid) in the same stone which became single-phase (liquid) on the application of heat. (Fig. IV). The absence of a crystal component was paralleled by the absence of a stream of released gas bubbles as a feature of the reaction. The end result, liquification of the included gas, was the same as previously noted.

In each of these inclusions where the gas was liquified, the reversal of the reaction followed the same pattern. At a lowered temperature, a mass of small gas bubbles was seen to separate out from the liquid, rise to the surface, and form the gas bubble characteristic of the inclusion at room temperature. This reaction was particularly apparent in the violent movement within the larger inclusions. Depending on the position of the stone the resulting gas bubble might be seen as one, two, or three separate bubbles.

Fig. IV

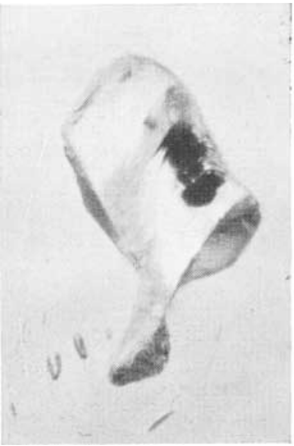


Fig. V

Figure V represents what on examination seemed to be a two-phase inclusion within the same stone and containing only liquid and the familiar black crystals. Since a reduction in heat had been seen to cause gas to separate out from the liquid in the previous inclusions, it seemed worthwhile to find out if a greater reduction below room temperature would have the same effect on this inclusion. The reasoning involved was that perhaps unusual pressures within the cavity were affecting the critical temperature of the solution.

To effect cooling, the stone was packed in dry ice with only the portion above the inclusion open for observation. To prevent frosting and preserve visibility, this portion of the stone was kept wet with alcohol. The effect of freezing was found to be similar for all of the inclusions discussed above. In those containing gas bubbles, the bubble showed an initial increase in size. At another critical temperature which it was not possible to measure, the gas and liquid components went through a rather spectacular change. With a violence resembling a small explosion, the remaining liquid became gas and almost simultaneously froze in a layer of ice crystals on the inner surfaces of the cavity.

On removing the stone from the dry ice, no gradual melting of the ice crystals of any significance was noted. As the critical temperature was again reached, a sudden violent reaction returned the gas and liquid components to the interior of the cavity.

In the case of the inclusion which had prompted the freezing, a gas bubble was formed in the liquid, but with inconclusive results. On warming the stone to room temperature, this bubble was found to be still present and thereafter reacted as had those previously discussed. It seems likely that the bubble may have been present, although not visible, in the small extension of the inclusion which was not susceptible of thorough examination. The freezing and melting just referred to may then have relocated the bubble in an area where it could be more easily seen.

It is realized that the pictures accompanying this report may not be as clear or detailed as might be wished. However, the rapidity of the reaction when coupled with the time required for exposure makes it extremely difficult to reproduce on film all of the interesting aspects of this phenomenon. In closing, the writer wishes to acknowledge the valuable assistance and advice furnished him by Dr. A. E. Alexander.

Gemmological Abstracts

Benson (L. B.). *Many "reconstructed rubies" found to be synthetic corundum.* Gems and Gemology. Vol. VII, No. 5, pp. 139-144. Spring, 1952.

It is the author's opinion that many stones identified as reconstructed rubies are either cut from early Verneuil boules or from the bottom tip (stems) of boules. What is known of the processes of reconstruction is discussed. Considerable work has been carried out on the examination of the various internal structures of boule tips and the summing-up is mainly based upon these examinations. 12 illustrations. R.W.

Cahn (A. R.). *Pearl culture in Japan.* Report No. 122. Natural Resources Section, General Headquarters, Supreme Commander for the Allied Powers, Tokio. October 1949. *Reproduced by permission of the Civil Affairs Division, United States Department of the Army.*

Probably the most complete report on the cultured pearl industry of Japan. The early beliefs of the cause of the formation of pearl and the history of the experiments which led to the present mass production of cultured pearls. The biological aspects of the pearl oysters—the term *pinctada* is used instead of the older *margaritifera*—particularly that of *pinctada martensii* which is used to produce the cultured pearl. The rate of growth of the animal, the functions of the mantle and the structure of the shell and the origin and development of the pearl—both natural and cultured are discussed. Some information on the staining of cultured pearls to a rosée shade is given but nothing about the black coloration which is so often found in the case of cultured pearls. The collection of spat and the farming of the oysters, with the localities of the various farms (complete with maps) and the various types of rafts used in these farm processes are explained. Full information is given on the techniques of nucleus insertion and the types of instrument used in the operation. The fishing and the operative measures are carried out by girls. The nature of the biological enemies of the pearl oyster is given, special mention being made of the nature of the "red tide" which is said to be due to an abundance of members of the *dinoflagellata* and *distomacea* which colour the water red. The recovery and grading of the cultured pearls is fully explained. Information is given of the production of non-nucleated pearls by cultivation of the freshwater clam *Hyriopsis schlegeli* at Biwa-ko, Shiga prefecture, which, although experiments have been carried out for some 20 years, has resulted in pearls of good colour and lustre, but of irregular shape, only since 1945. The report is completed with a number of appendices including a summary of the patents relating to pearl culture ; the production of cultured pearls from 1926 to 1946, and other valuable statistics. 91 pages. 23 illustrations. R.W.

HUNT (G. C.). *Greenstones of the Maoris.* Gemmologist, Vol. XXI, No. 251, pp. 102–104. June, 1952.

A short article on the New Zealand nephrite (reprinted from the New Zealand Watchmaker and Jeweller). It commences with a short introduction to the history and legend of Maori jade. Native cutting is discussed. The material is found as boulders in the rivers of Westland (misspelt Westerland). The native names for seven varieties of New Zealand jade are given. Tangiwai from Milford Sound is not nephrite but bowenite (a variety of serpentine). It is stated that nephrite from China (presumably material carved there) and sold as New Zealand jade for the export market commands a better price than the true New Zealand material. Scheerer's analysis showing the New Zealand material to have more iron and less magnesia than the material from China is mentioned. It is suggested that the New Zealand greenstone should be given its true name — jade. *This article called forth a letter from Prof. C. Osborn Hutton (Gemmologist, No.* 253, *p.* 139. *Aug.*, '52) *who pointed out that the one analysis of each jade made by Scheerer was not acceptable in view of later work and could have little value. He also criticised the spelling of the name Teremakau for the river in Westland where much New Zealand jade is found. Prof. Hutton says the correct spelling should be Taramakau. It appears that most English gazetteers use the " e."* R.W.

WEBSTER (R.). *Secrets of synthetic emerald.* Gemmologist, Vol. XXI, Nos. 252–3, pp. 117–121 and 140–145. 1952.

A resumé of the history of emerald synthesis. It is suggested that the synthesis may be analogous to the growth of quartz crystals by hydrothermal method. The characters of the natural and the synthetic emeralds are given and compared. The value of the Chelsea colour filter and ultra-violet light fluorescence discussed. The typical inclusions of natural and synthetic emerald illustrated by photomicrographs. P.B.

HARRISON (A. R.). *Occurrence—mining and recovery of diamonds.* Gems and Gemology, Vol. VII, No. 5, pp. 154–161. Spring, 1952. Also *Diamond mining and recovery.* Gemmologist, Vol. XXI, Nos. 252/3, pp. 123–126 and 155–157, and 254, pp. 164-166, 1952.

The author commences with a historical survey of diamonds mining and gives notes on the occurrences. The Indian diamond fields and the methods of working them are told. The pipe mines of Kimberley area ; the alluvial deposits of Belgian Congo, Angola, Tanganyika Territory and Sierra Leone deposits are reported on. The methods used in the recovery of diamond being given for each locality. R.W.

WEATHERBY (E. W.). *Diamond sorting and valuation.* Gemmologist, Vol. XXI, No. 253, pp. 146–148, and Nos 254, pp. 173-176, 1952. Reprinted from *Optima.*

An informative article written by a man who has spent his lifetime in the diamond trade as sorter and valuer. The basic idea of sorting is discussed with relation to the buyers' requirements. Smaller and lower priced stones, even if slightly flawed, are more economical for the production of small brilliants than larger stones. Value of the sawing technique for well-shaped octahedral crystals in order to save weight is explained. The Central Office of the Diamond Producers Association in Kimberley deals with the classification and the basic value of the mined diamonds. The Diamond Trading Company breaks up the valued stones into suitable " parcels " to sell to the cutters. R.W.

GARRELS (R. M.). *The synthesis of quartz.* Gems and Gemology, Vol. VII, No. 5, pp. 151–153. Spring, 1952.

A general note on the growing of quartz single crystals. The theoretical consideration of the problems of quartz synthesis due to changes in crystal structure at different temperatures. A discussion of the constant temperature and the temperature gradient methods for the production of quartz crystals. Crystallographic orientation of the quartz seed plate is of much importance. Resultant crystals are untwinned and unstrained and inclusions (two-phase) are minute. Author states that it appears possible to grow coloured material quite readily. R.W.

BARBER (R. J.). *Jade in Mexico.* Gems and Gemology, Vol. VII, No. 5, pp. 147–150, and 166. Spring, 1952.

The origin of the material used for the archæological jades of Mexico is discussed. The theory that the jadeite, for most of these pieces are made of jadeite, was not indigenous to Mexico and came, and was possibly carved, in China, is discredited. Analysis showed that the ancient jadeite pieces had replacement of parts of the soda and silica by lime and magnesia and was therefore a diopside-jadeite. The history of Mexico from these ancient times is given as an explanation why sources of jade minerals in Mexico have not so far been found. Ancient pieces representing all Mexican cultures are found in many parts of the country during excavations of tombs and temples and by being washed out by rain action. The true artifacts are sold to dealers but much of this "archæological" carved work and also carved pieces for feminine adornment are merely modern imitations of green glass. R.W.

ANON. *Gem industry of the Jura Mountains.* Gemmologist, Vol. XXI, No. 253, p. 149. August, 1952.

The industry is said to have originated in Geneva during the XVth century. Gives a short history of the Jura lapidaries from those times. Topazes, amethysts, rubies, sapphires and emeralds were cut during the 19th century. A diamond cutting centre was established at Saint Genis in 1874, and later spread to other villages around the Gex district. Before 1929 there were some 200 diamond cutters in the Jura, but the industry has fallen and now only about 10 diamond cutters are in Saint Claude the main centre of the Jura lapidary workers. R.W.

FIRSOFF (V. A.). *Gems of Arran.* Gemmologist. Vol. XXI, No. 251, pp. 97-101. June, 1952.

A general geological outline of the rocks of the island of Arran off the Firth of Clyde. Gem materials found in the island are red jasper, agate, rock crystal, citrine, smoky quartz and some amethyst—most quartz crystals marred by inclusions and carbon-dioxide gas bubbles. Aquamarine, white to deep honey yellow topaz, black (and green) tourmaline and garnet are also found. There is an occurrence of sapphire but the blue crystals are usually thin hexagonal plates containing inclusions of foreign material and unsuitable for jewellery. R.W.

MEASUREMENT OF COLOUR

by

M. D. S. Lewis, A.R.C.S., B.Sc., F.G.A.

IN the previous article it was explained how the " dominant wavelength " and " excitation purity " of a colour can be found on the C.I.E. Chromaticity chart. These two measurable quantities correspond adequately, though perhaps not precisely, with the mental sensations of hue and saturation respectively. It is first necessary to plot the position of the illuminant on the chart by means of its trichromatic coefficients, which normally are accurately known. Those of the colour will have been ascertained by use of a colorimeter and the position also marked on the chart. A straight line is drawn from the illuminant point to the colour point and produced to meet the Spectral Locus, on which the point of intersection gives the wavelength of the hue.

No difficulty will be experienced if the colour point lies anywhere above the dotted lines BS and RS in Fig. 1. If, however, the colour " C " is located within the triangle BSR which represents the purple area, the line SC produced cannot meet the Spectral Locus, as purple is not a spectral colour. To cope with this situation an artificial device is employed and the line joining the colour point to the illuminant point is extended backwards to meet the Spectral Locus in the green region. Thus in Fig. 1 if CS produced cuts the Spectral Locus at " d " (say 5150A) the dominant wavelength is given as " complementary to 5150A " and is sometimes expressed as C5150 or minus 5150A. The " excitation purity " is still defined as the ratio CS/DS.

By joining any colour point not in the purple area to the illuminant point and producing this line until it meets the Spectral Locus on the *opposite* side, the complementary hue is quickly found. This information may be useful for " killing off " an unwanted colour since admixture with its complementary results in desaturation. A knowledge of complementary colour is useful in questions concerned with colour contrasts and display generally.

By defining the colour of a gemstone in terms of C.I.E. co-ordinates and thereby plotting its position on the C.I.E. chromaticity chart the whole aspect of gemmological colour assumes a precise meaning, particularly as regards nomenclature. There could be internationally agreed areas on the chart within which any particular gemstone could be designated as " fine " (as regards colour). Precise and even legal meaning could be given to terms such as " pigeon-blood " rubies, ordinary " rubies," pink sapphires, etc., whilst the grading of diamonds might merely resolve itself into a statement of trichromatic coefficients. The C.I.E. system embraces the whites and " off-whites " as well as the more saturated colours. If colour grading is to be applied to diamonds or any other stone there can be no better way of doing it than to delineate some specific area or areas on the C.I.E. chromaticity chart and so give objective meaning to what we are trying to say.

The simplicity and success of the C.I.E. system derive largely from its separation of " quality " from " quantity " of light, thereby presenting the problem in two dimensions, which can be dealt with by elementary arithmetic and simple co-ordinate geometry. Unfortunately, however, colour is dependent on quantity, and nothing illustrates this better than the new fluorescent paints which stand out so vividly from others. Some may do this through an unusual hue—different from those surrounding and perhaps unexpected. Possibly some show enhanced saturation, but the principal cause is usually increased " luminosity." They send *more* light to the eye than non-fluorescent paints and therefore have a different colour.

For some purposes—particularly in gemmology—these difficult concepts of Brightness, Luminosity and Lightness may be disregarded, for provided two colours have the same chromaticity (hue and saturation) they can be brought to equality by adjusting the intensity of illumination on one of them. Brightness, like Hue and Saturation, is a subjective phenomenon greatly influenced by the state of adaptation of our eyes. The motor car headlamp, so blindingly brilliant by night, seems quite feeble in daylight in spite of its physical intensity remaining unchanged. When we apply the concept of " brightness " to a primary source—such as a lamp—we refer to it as " luminosity " but when dealing with secondary sources such as surfaces or transparent objects we speak of

" lightness." Fortunately in gemmology we are mainly concerned with secondary sources and our immediate problem is to find some measurable entity which is correlated with " lightness " in the same way as dominant wavelength and purity are related to hue and saturation. Actually the eye (within limits) perceives a surface or transparent object to be light or dark according to the fraction of total light which it reflects or transmits. This is called the " luminance " factor.

It will be recalled that the tristimulus values usually obtained in colorimetry are merely proportions. If no adjustment had been made the specification of a colour might equally be written as

$$20X + 30Y + 40Z \text{ or } 40X + 60Y + 80Z.$$

In other words we can give any value we choose to the coefficient of Y (or, indeed, to those of X or Z) provided the other two are altered in the same proportion. When the C.I.E. system was inaugurated the clever suggestion was made that the final co-efficient of Y should equal the " luminance factor." The exact specification of the X, Y, Z stimuli was made in such a way that the total luminosity of all three was to be regarded as concentrated in the Y stimulus. Thus if the final Tristimulus Equation of the colour of a light transmitted by a glass filter were given as

$$C = 24X + 36Y + 20Z$$

it could be immediately inferred that this glass filter transmitted 36% of the total incident light. If we convert this equation to unit form by dividing throughout by 80 (the sum of the coefficients) we get $c = .30X + .45Y + .25Z$. The complete colour specification of this filter would then usually be given as $x = .30$, $y = .45$, $Y = 36$, in which the values of x and y are the trichromatic coordinates and the value of Y the transmittance (luminance) factor. It goes without saying that the precise illuminant used must also be stated in any specification. By these means a colour is satisfactorily specified in its three dimensions of Hue, Saturation and Brightness through the measurement of the corresponding entities of Dominant Wavelength, Excitation Purity and Luminance Factor.

We are now in a position to consider the relative colours of the turquoise mentioned in part 1 of this article. It was supposed that the original stone had been examined in a colorimeter, the final Tristimulus Equation having been found to be

$$C_1 = 15.51X + 21.33Y + 38.64Z.$$

After " treatment " in some way it was remeasured for colour which was then found to be given by

$$C_2 = 25.85X + 35.55Y + 64.00Z$$

In which way had the colour changed ? Comparing Y coefficients we can immediately say that the " treated " stone was very much brighter. In fact it reflects 35.55% of the total light incident upon it whilst in its original state the percentage was only 21.33. To determine chromaticity or quality we must divide by the sum of the coefficients in each case, i.e. by

$$75.48 \text{ in } C_1 \text{ and } 125.40 \text{ in } C_2$$

yielding the unit equations

$$c_1 = .21x + .28y + .51z$$
$$c_2 = .21x + .28y + .51z$$

which are identical, showing that the hue and saturation had not changed. Probably the stone had just been re-polished. To assess the actual hue and saturation we should find the point on the C.I.E. chromaticity chart with the co-ordinates .21, .28 and then by the simple graphical methods already described proceed to make our evaluation. Alternatively and perhaps preferably, the two colours could be specified as .21x, .28y, 21.33Y and .21x, .28y, 35.55Y respectively.

Mathematically the luminance factor is conceived as the ratio of the Y value of the reflected or transmitted light to the Y value of the incident light. Graphically it is represented by the ratio of the areas under the " Light Flux—Wavelength " curves representing the reflected or transmitted light and the unchanged illuminant. The actual determination of luminance factor, where necessary, is often a problem of photometry rather than colorimetry but in view of its importance in colour calculations most colorimeters employ devices for its direct measurement.

To a first approximation it may be said that the X, Y and Z values roughly represent the relative proportions of red, green and blue respectively present. A perfectly white or colourless substance would therefore have the trichromatic coefficients,

$$x = .333,\ y = .333,\ z = .333.$$

A perfectly colourless diamond might be expected to have these co-ordinates. A yellow diamond would show some deficiency in blue and hence a lowering of the z value compensated for of course, by an increase in z and y values. If a " blue-white " were really more blue than a colourless stone the measurements would show a z value greater than .333, with x and y values correspondingly less. A perfectly reflecting surface (never attained in practice but approached by white magnesium oxide) would have a Y value of 100 whilst increasing greyness would be accompanied by a fall in Y value reaching zero when black was attained.

Among the best known English colorimeters are the " Donaldson " and the " Tintometer " both in general use in a wide variety of industries. The former is probably more suited for fundamental research, employing three coloured lights of standard quality which can be mixed in any desired proportions. One half of the field is filled with light, say from a coloured gemstone and the other with a mixture of the three radiations, the quantities of which are varied until a complete match is obtained. To ensure thorough mixing they are first directed into an integrating sphere, the interior of which is lined with white magnesium oxide. After multiple reflections at this surface they emerge through another hole as one homogenous beam. From the amounts of the three radiations used and reference to tables issued by the manufacturers the chromaticity of any colour and, if necessary, the luminance factor, are quickly found.

In the " Lovibond-Schofield " Tintometer a series of coloured glass slides are available for placing in the path of the incident light, bringing it to equality as regards chromaticity with the colour under test, whilst an ingenious " obturator vane " enables " luminance factor " to be determined at the same time. Theoretically the accuracy of measurement is limited by the fact that colours can only be varied in discrete steps but for all practical purposes the sensitivity is more than adequate. It also has the advantage of being extremely simple in operation and robust in

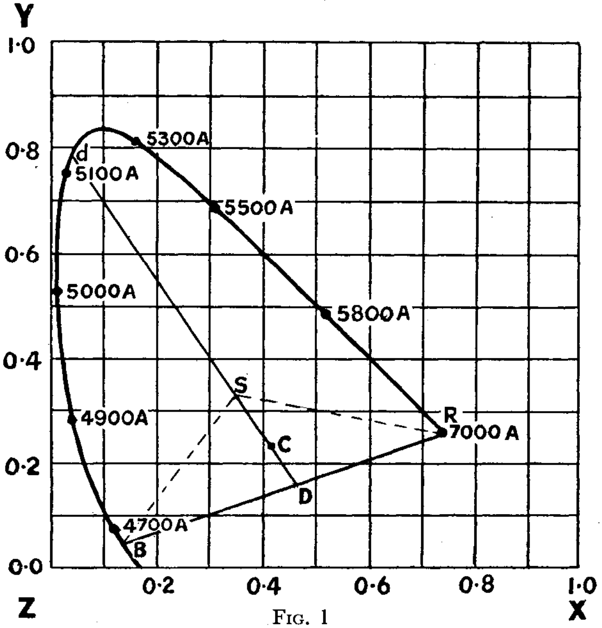

Y
1·0
0·8
0·6
0·4
0·2
0·0
Z
0·2
0·4
0·6
0·8
1·0
X
5300A
d
5100A
5500A
5000A
5800A
S
R
4900A
7000A
C
D
4700A
B

Fig. 1

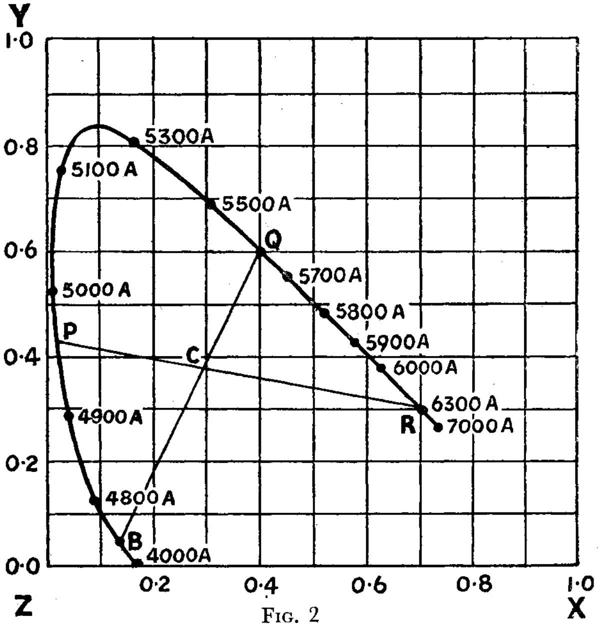

Y
1·0
0·8
0·6
0·4
0·2
0·0
Z
0·2
0·4
0·6
0·8
1·0
X
5300A
5100A
5500A
Q
5700A
5000A
5800A
P
5900A
C
6000A
6300A
R
7000A
4900A
4800A
B
4000A

Fig. 2

structure, yielding direct results in C.I.E. terms through an easy graphical procedure.

Before leaving the subject of colorimeters mention may be made of an attractive technique suggested by J. Guild (Trans. Opt. Soc., 27, 139, 1925) and summarised by Dr. W. D. Wright in his book " Measurement of Colour." Known as Guild's Vector Method it would enable chromaticity to be measured with no computation whatever, although no colorimeter has yet been particularly designed to operate the technique. The requirements would be a primary red radiation, a primary blue radiation and an apparatus for filtering off a narrow band of light from any part of the spectrum. The wavelengths of the two primary radiations would, of course, be known whilst the spectrum would be provided with a scale from which the wavelength of the selected beam could be read. The C.I.E. chromaticity chart is again reproduced in Fig. 2 and the positions of the two primaries are indicated by the points R and B. First the colour is matched by a mixture of the primary red and light from the opposite end of the spectrum the wavelength of which is noted—say P. The colour under test will be on the line RP. Next the operation is repeated, using the primary blue and light from the other end of the spectrum—say Q, the wavelength of which is also noted. The colour then is fixed by the intersection at C of the lines RP and BQ. The co-ordinates of " C " are, of course, the trichromatic coefficients.

So far two broad principles of colour measurement have been mentioned. There is the fundamental analytical procedure of the expert colour physicist who uses spectrophotometers, relative energy curves, luminosity curves, etc., to make calculations of C.I.E. co-ordinates. Then there is the synthetic method, described at some length, using colorimeters and more suitable for those with little knowledge of colour theory. There remains a third method—that of comparison—using colour atlases, deceptively alluring through the fact that virtually no intellectual demands on an observer appear to be made. Every paint manufacturer issuing a chart showing half a dozen of his colours makes use of this principle. There are, however, three fundamental requirements which must be met before a colour atlas can be considered as a suitable vehicle for measuring colour. The design must be in three dimensions corresponding with the properties of Hue, Saturation and Brightness. The samples must be spaced in such a way to show regular and consistent gradations of these properties and their " specification " should be capable of expression in C.I.E. terms. Furthermore they must be absolutely permanent in colour. This last condition is exceedingly difficult to ensure as most coloured surfaces change through age, dirt, corrosion, etc. Bearing in mind that some millions of different colours can be experienced it is also obvious that a colour atlas should contain a very large number of specimens—if it is to be reasonably discriminatory—a requirement which tends to make it bulky and expensive. Yet another complication lies in the fact that it is almost impossible to compare coloured surfaces if they are of widely different texture. Thus a colour atlas used, say, in the silk industry would be unsuitable for gemmology.

In spite of these limitations two well-known Colour Atlas systems—those of Munsell and Ostwald—have been widely used for some years. Of these the Munsell system is better known and extensively employed in America. In theory Munsell conceived a solid frame of reference roughly in the shape of a cylinder. The vertical axis represents the scale of brightness at the base of which is black and at the top white. Considering any horizontal circular section, the hues of the spectrum joined by purple are disposed round the circumference—Blue, Green, Yellow, Red and Purple. The distance of any colour point from the centre is a measure of saturation. The Munsell system has its own notation to define the position of a colour within this imaginary solid, a number of selected points being specified by appropriately coloured " chips," the C.I.E. co-ordinates of which have been calculated. Whilst at first the number of colours which can be measured by means of a Munsell Atlas would seem to be severely restricted by the necessarily few specimens it could contain, a considerable extension of usefulness is achieved by a process known as " disc colorimetry " which enables intermediate colours to be interpolated. If two differently coloured chips are placed on a neutral disc which is rapidly rotated an intermediate effect is obtained. By adding white or black segments to a certain coloured segment on this circle and again rotating rapidly, further assessments of saturation and brightness may be obtained. Estimates of brightness might also be made by controlled changes in illumination.

Throughout these articles certain assumptions are implicit. It is, of course, obvious that no person suffering from any form of colour blindness can be expected to make accurate colour measurements, but in view of the subjective nature of colour perception it might be doubted whether any two persons—however normal their sight—could be relied on to reach identical conclusions in colour matching. Fortunately experience has shown that remarkable unanimity is achieved by about 80–90% of the population ; their judgment approximates very closely to that of the " standard observer " of the C.I.E. system. It has been further assumed that the three attributes of colour perception—hue, saturation and brightness—are independent variables. Strictly speaking this is not so. In theory the addition of black to a colour should produce no change in hue yet this does not apply to some greens and yellows. Nevertheless the interdependence of Hue, Saturation and Brightness is not sufficient to vitiate the usefulness of the C.I.E. system.

It must be confessed, however, that there seem formidable difficulties in the general application of colorimetry to gemmology. There is the average small size of gemstones, making observation difficult in some colorimeters which require an area of at least one square centimeter for observation. In general, colorimetry does not deal with specularly reflecting surfaces but concerns itself primarily with diffuse reflectors or transparencies. Anisotropic gemstones display different colours according to the direction of view and the greatest disquiet must always exist whether the colour actually measured in a colorimeter is " the " colour seen under normal conditions. In the article on colour perception[1] it was pointed out that a gemstone in use is always viewed by a mixture of transmitted and reflected light. If we attempt to exclude one of these beams we obtain an unnatural colour effect.

Nevertheless it would not be unreasonable to suppose that the colour measured in a colorimeter under some standard procedure would bear a definite relationship to the colour normally seen. What form this standard procedure would take could only be decided on after extensive experiment. Possibly the stone might be illuminated by a beam of light passing from culet to table, or alternatively it might be illuminated from above and the scattered light collected by a system of lenses to give an out of focus image. Observance of the form or texture of the surface would preclude proper colour observations. In addition, the specimen might be spun on a rapidly rotating holder to " integrate " varying colour effects from different angles and to obliterate surface structure. This is quite a usual procedure in colorimetry. The reflection from the surface of a normally cut gemstone and the transmission of light within are such complex processes it is doubtful whether the term " luminance factor " can have much meaning in gemmology. The concept is of great importance, as the relative transmission of a stone is often a vital factor in its colour, but the difficulties in the way of measuring it by conventional methods seem colossal.

Very recently the writer's attention has been drawn to a remarkable article which appeared in " The Gemmologist " of September, 1933 (Vol. 3, No. 26), on the " Measurement of the Colours of Precious Stones." A description is given of the Guild Trichromatic Colorimeter (now superseded by the Donaldson instrument) and of the calculations determining the colour quality of a stone. A fascinating and ingenious technique of measuring the light path in a gemstone is also described. It is astonishing to find that even 20 years ago—within two years of the inauguration of the C.I.E. system—a London firm of scientific instrument makers was ready with an apparatus for the measurement of gemmological colour. Unfortunately the ground was not sufficiently fertile for the idea to take root.

1. Colour perception in gemmology, Vol. III, No. 6.

ASSOCIATION NOTICES

COUNCIL MEETING

The Council of the Association met at 19/25 Gutter Lane, London, E.C.2, on Tuesday, 26th August, 1952. Sir James Walton (Vice-Chairman) presided.

The report of the examiners in respect of the 1952 examinations in gemmology was received and the award of prizes approved.

The presentation of awards was arranged to be held at Goldsmiths' Hall (by kind permission of the Wardens) on Wednesday, 22nd October, 1952, at 7.15 p.m., the presentation to be preceded by a reunion of Members at 6 p.m.

It was agreed that Sinhalite be added to the syllabus of examinations.

The Council approved rules for the use of Branches of the Association that were being established. It was announced that the inaugural meeting of the Midland Branch would be held in Birmingham on 30th September.

The following were elected as members of the Association :

Fellow

Winnert, George M., Edinburgh. D.1949.

Ordinary

Kumi, Emmanuel A., Accra, Gold Coast.
Martin, John, London.
Mason, Cyril T., Lahore, Pakistan.
Mills, Frederick W., London.
Warrender, Stanley, Redhill.
Mitchell, James J., Edinburgh.

Probationary

Donn, Leslie, Manchester.
Embleton, Joseph, Darlington.
Grahame-Armstrong, Stanley J., Singapore.
Jason, Lewis, Bulawayo, S. Rhodesia.
Jayawardana, Col. Christopher P., Colombo, Ceylon.
Mehra, Pashupatti N., Calcutta, India.
Sunde, Gunnar B., Oslo, Norway.
Aitken, Mrs. Elizabeth, Edinburgh.
Galloway, John, Edinburgh.

EXAMINATIONS IN GEMMOLOGY

The 1952 examinations in gemmology were held in May and June at centres in the United Kingdom and Overseas. In the Preliminary examination the Rayner Prize has been awarded to Mr. Trevor M. Brook, of Lincoln.

The Diploma examination was held at five centres in the United Kingdom and in Australia, Canada, Ceylon, Malay States, Netherlands, Switzerland and the United States of America. Forty-five candidates qualified, thirteen with distinction. The Tully Medal has been awarded to Mr. Louis C. Siedlé, of Messrs. Louis Siedlé, Ceylon.

The following is a list of successful candidates (arranged alphabetically) :—

DIPLOMA

Qualified with Distinction

Austin, Leslie Frank, London.
Denham, Francis John, Harrow.
Edwards, John, Manchester.
Kochel, Ann, Alpine.
Lardeur, Kenneth John, London.
Mason, Stanley, Harrogate.
Parsons, Charles Jay, El Cajon.
Payne, Leslie, Bournemouth.
Rice, Jean Mary, Birmingham.
Siedlé, Louis Cochrane, Colombo (Tully Medal)
Spence, Christopher Roy, London.
Svensson, Kurt Wilhelm, Lucerne.
Vos, Dirk, Wassemaar.

Qualified

Allen, Herbert, Newbridge
Boudreau, Guy Armand, Harrow.
Boxall, William John, Edinburgh.
Cannon, John, Gerrards Cross.
Caudell, Peter Miller, London.
Chisholm, Marie-Louise, Leverstock Green.
Crouchley, David, London.
Cuss, Francis Charles, London.
Davies, George Henry, Birmingham.
Davies, John William, Loughton.
Drury, Ernest George Henry, Birmingham.
Evans, Freda Margaret Maude, London.
Fifield, Lawrence John, St. Albans.
Flood, Frank, London.
Green, Phyllis Daphne, London.
Hval, Jens-Olav, Oslo.
Johnson, Douglas R., Toronto.
Light, Donald Ashton, Sutton Coldfield.
McKay, Jane, Glasgow.
McRae, Arthur John Hutchieson, Glasgow.
Paterson, William, Edinburgh.
Pollington, Kenneth Ian, Welling.
Pye, Davis Trann, Methil.
Roos, Leo, Lucerne.
Rudelsheim, Henri Salomon, Amsterdam.
Scott, Maxine O., San Diego.
Short, Elsie Andrina, Twickenham.
Silver, Bernard, London.
Smith, Jack Edwin, Reigate.
Velden, Johannes van der, Amsterdam.
Whelan, Kenneth James, Hainault.
Yaghobi, Hadi, London.

PRELIMINARY

Qualified

Aitken, Elizabeth, Edinburgh.
Bache, Samuel, Old Hill.
Baglee, Gordon, Monkseaton.
Baker, John Thomas, Bristol.
Banister, Halcyone Judith, London.
Barry, Joan Doreen, Birmingham.
Bowen, Walter William, Birmingham.
Brack, Alfred John, London.
Brook, Trevor Martin (Rayner Prize), Lincoln.
Brown, Justin Rowland Caney, Durban North.
Burnett-Ham, Dorothy, London.
Charles, Arthur Edmund, London.
Charles, Helen M. L., London.
Collyer, Rodney Frederick, Birmingham.
Cooper, Paul Gilbert, London.
Ekanayake, Brian Edmund Rodney, Colombo.
Endal, Sverre, Oslo.
Forsey, John Norman, Sutton Coldfield.
Fox, Robert Cecil, London.

Furness, Gwendoline Vivienne, Reading.
Galloway, John, Edinburgh.
Gerling, Chester William, Gloversville.
Goad, Michael J., Sutton.
Graham, Sadie Dickson, Irvine.
Grey, Elmer, London.
Harrison, David John Le Grew, Amersham.
Hessling, Frederick, Birmingham.
Jason, Lewis, Bulawayo.
Jones, Roger Ward, Cirencester.
Keay, Graham Edward, London.
Kell, Ronald George, London.
Kemp, Anthony Lionel, Bristol.
Kemp, John Brian, Bristol.
Kochel, Ann, Alpine.
Korn, Cyril David, London.
Lachowich, Vladymir A., Astoria.
Lambert, Norman Alfred, London.
Leese, Peter Francis, Northwood.
Lennie, David Gemmell, West Kilbride.
Levy, Eric, Glasgow.
Lipman, Maurice, Johannesburg.
Mokrow, William George, Birmingham.
Neerbye, Erling, Oslo.
Niemans, Hendricus Johannes, Amsterdam.
Noye, Leonard George, Ipswich.
Oliver, Richard James Neville, Eastleigh.
Parsons, Charles Jay, El Cajon.
Porter, Lawrence, Preston.
Potter, Byron Allen, Vancouver.
Pyne, Eileen Bridget, South Woodford.
Redmayne, Kenneth, Gateshead-on-Tyne.
Renton, David Alexander, Edinburgh.
Ritson, Ronald, Newcastle-on-Tyne.
Rogers, Dermot Stephen, Belmont.
Roos, Leo, Lucerne.
Roth, Raphael Isaac, London.
Rudell, Justin John, Wolverhampton.
Rudelsheim, Henri S., Amsterdam.
Sacks, Leopold, London.
Scott, Maxine O., San Diego.
Shackman, Julian, London.
Spragg, Ronald, Bristol.
Spray, William Frank, Norwich.
Summerfield, Jane, London.
Summers, William Hamilton, Burnham.
Swan, Winifred Margaret, New Barnet.
Thomson, Douglas Marshall, Dumfries.
Thomson, Roger Ian, London.
Tugwell, Ronald Frank, Thornton Heath.
Vos, Dirk, Wassenaar.
Waites, Leslie Phillip, Birmingham.
Walden, Derek, Enfield.
Watson, Peter Jervaise, London.
Watts, Sidney Frederick, Birmingham.
Wells, Leslie Nield, Chadderton.
Whitehead, Jack, Dudley.
Wickens, Colin Sidney, London.
Wijnhoven, Jos, Eindhoven.
Wilson, Malcolm Edward, Birmingham.
Wood, Beatrice Mary, London.

NOTICE

Volume I (Symmetry Groups) of the International Tables for X-ray Crystallography, published for the International Union of Crystallography, is now ready. The text and tables (in English) have been planned to be of the maximum practical usefulness in the determination of crystal structures and in allied problems, but their value for teaching purposes has also been kept in mind. The price is £5 5s. (five guineas) inclusive of postage and packing; cloth binding, 558 + x pages, 237 figures, with dictionary in English, French, German Russian and Spanish. Members of the Gemmological Association of Great Britain may obtain one copy for their personal use only at the subscription price of £3 post free by using a special order form available, with the prospectus, from the Kynoch Press, Witton, Birmingham, England.

Volumes II and III, which are in preparation and which will be sold separately, will cover Mathematical, Physical and Chemical Tables used in X-ray Crystallography.

TALKS BY FELLOWS

N. Kennedy : " Gem Minerals of the British Isles." Merseyside and District Branch of the National Association of Goldsmiths, 6th October.

C. A. Jarvis : " Gemstones." Methodist Youth Club, Cranbrook Park, Essex, 18th September.

L. Penn : " Gemstone Inclusions." Birmingham Microscopical and Naturalist Society, 23rd April.

Mrs. J. Thomas-Ferrand : " Gemstones." Bury St. Edmunds Inner Wheel, 16th July ; Bury St. Edmunds Ladies' Luncheon Club, 30th September.

F. Leak : " Science of Jewellery," Fellowship of St. Barnabas Church, Warmley, Bristol, 23rd September, 1952.

FIRST ASSOCIATION BRANCH

The President of the Association, Dr. G. F. Herbert Smith, gave the inaugural address when the Midlands Branch of the Association was constituted in Birmingham on Tuesday, 30th September, 1952. Mr. F. H. Knowles-Brown and the Secretary were also present. The first Chairman of the Branch is Mr. Trevor P. Solomon and Mr. J. Best is Honorary Secretary. A full report of the inauguration of the Branch will be given in the next issue of the Journal.

A NEW PUBLICATION

The Vice-Chairman of the Association, Sir James Walton, has recently had published " Physical Gemmology." It is dedicated to Her Majesty Queen Mary.

Without technical language or mathematical formulæ, this new book achieves a notable success in explaining the scientific facts behind the physical phenomena of gem minerals. It begins with an up-to-date account of atomic theory and atomic structures, and goes on to deal with the formation of crystals, microscopic and optical characters, colour and general physical properties. There is a concluding chapter on the fashioning of gems.

A work of over 300 pages, with 400 illustrations, it should be of practical value to those with a professional interest in the subject, and of absorbing interest to those indulging a hobby.

The book has been published by Sir Isaac Pitman & Son Ltd., and copies may be obtained from the Association, 19/25, Gutter Lane, London, E.C.2., price 30/- (postage 9d.).

INDEX TO VOLUME III — Nos. 1 - 8

1951 - 1952

Names of authors are printed in small capitals, subjects in lower case and abstracts in italics

RAYNER

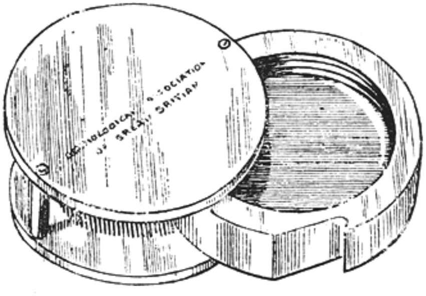
INSTRUMENTS FOR GEMMOLOGY

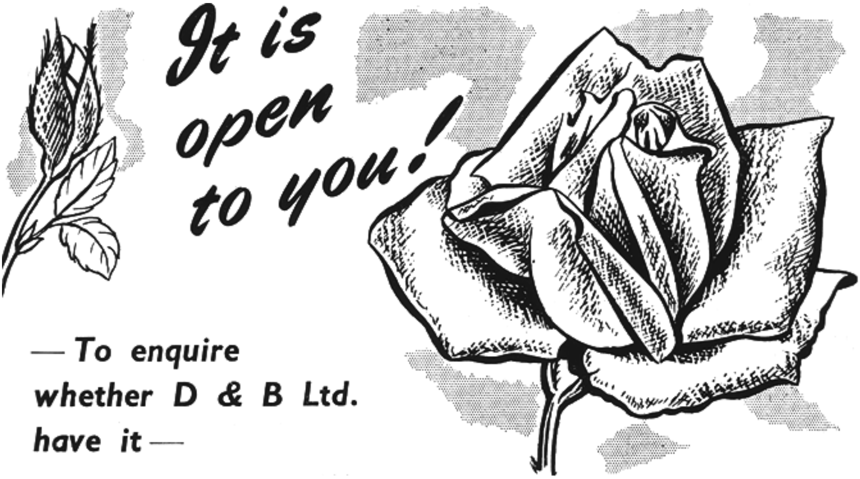
	£	s.	d.
Rayner Refractometer, complete with 1 oz. Refractometer Fluid ...	14	0	0
Polarising filter for refractometer	1	0	0
Yellow filter for refractometer	0	16	0
1.81 Refractometer fluid, per oz.	0	15	0
Rayner Dichroscope	4	4	0
Walton Polariscope	6	6	0
Specific gravity Indicators, per set	3	3	0
Specific gravity testing set	12	0	0
Methylene Iodide, S.G. 3.32, Nd 1.742	0	6	0
Monobromonaphthalene, S.G. 1.49, Nd 1.66	0	2	4
Bromoform, S.G. 2.86, Nd 1.59	0	2	0
Clerici Solution, S.G. 4.33 at 40 C.	1	4	0
(prices per ounce, bottles 8d.)			
Hardness pencils, Mohs' 6-10, per set	2	0	0
Hardness pencils, Mohs' 1-10, per set	3	0	0
Ultra Violet Lamp, complete with transformer, reflector and Test Cabinet	22	12	0
Woods glass, 2″ × 2″	0	5	0
Spectroscope, pocket, diffraction grating with fixed slit	2	5	0
Spectroscope, „ „ „ „ adjustable slit ...	5	17	6
Spectroscope, d.v. prism	8	15	0
Spectroscope, „ „ with wave length scale	17	0	0
Spectroscope stone holding attachment	0	12	6
Spectroscope cylindrical lens attachment	2	0	0
Spectroscope table stand	2	2	6
Spectrum recording stamp	0	15	0
Lamp, Sodium, complete with stand and control gear	13	5	0
Lamp, High Intensity, on stand with transformer, for microscope, spectroscope, refractometer	7	7	0
Diamond Balance, pocket	20	0	0
Stone Holder, three spring prong	0	9	0
Chelsea Filter	0	8	6
Immersion Cell	0	7	6

For magnifiers of all types — see catalogue "Magnifiers and Visual Aids" — obtainable on demand.

100 NEW BOND STREET, LONDON, W. 1

(*Telephone :* GROsvenor 5081/3)




It is open to you!