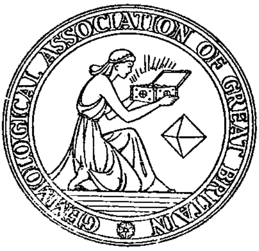
Vol. VIII No.3 July, 1961

THE JOURNAL OF GEMMOLOGY

and

PROCEEDINGS OF THE GEMMOLOGICAL ASSOCIATION OF GREAT BRITAIN



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

Vol. VIII No. 3 JULY 1961

COMMERCIAL COLORIMETRY OF GEMS

By SOBIESLAW BUZALEWICZ

The light, by which a stone is illuminated during observation, is a major factor in determining the colour of the stone.

The best illumination of a stone for the purpose of the determination of its colour is the natural daylight of the north sky covered with white clouds in the fore- and after-noon hours, i.e., sunlight reflected from the atmosphere and falling on the stone in a perfectly scattered form. An artificial light corresponding with the natural north-sky light is produced by the daylight lamp (pattern C CIE), which must be shapeless, exactly scattered and of the same strength as the natural light. The use of other light during the observation causes a change in the colour of the observed stone. A change in the colour of the stone is caused also by any change in the manner of the stone's illumination by the scattered light—for instance, by observation in directional light, whether parallel or convergent.

Any increasing or diminishing of the natural size of an observed stone image affects its colour. The colour of a stone, and especially of a transparent one, is a dimensional appearance, and therefore differs when observed in an image of a stone in the natural size, in an increased or in a diminished image. An increasing of the natural size of the stone image causes an apparent rarefaction of the colour-substance of the stone, diminishes intensity of the colour, and increases its brightness until there is nearly complete disappearance of the colour. Diminishing the natural size of the examined image has the opposite effect: it apparently condenses the colour-substance of the stone, increases the intensity of the colour and diminishes its brightness. For this reason, observation of the colour should be made on the natural size of a stone image.

The manner of the holding of a stone on a white background also affects the observed colour of the stone. A stone lying immediately on a white surface is not lighted equally from all sides; the part of the surface, on which the stone lies, and which is darkened by the stone itself, is not a source of white light, and does not illuminate that side of the stone on which it makes contact with the surface. This side of the stone remains darker, consequently causing a change of the colour of the stone. To be illuminated equally from all sides, a stone must not lie immediately on the white background, but should be held a short distance away from the white surface by means of tongs in such a way that the background could be lighted over the entire surface and thus could be a source of the daylight illuminating the stone from every side. The tongs holding the stone must be thin and sufficiently long, so as not to disturb the illumination of the stone.

The colour of the environment affects the colour of the observed stone. A white background causes an apparent darkening of the observed colour of a stone. To avoid the influence of the colour induced by the white background on the colour of a stone, it is useful to make the colour-observation by means of a " contrast colorimeter ", which consists of an open conical tube, black inside and white outside.

The contrast colorimeter acts through its black inside neutralizing the influence of the white background on the colour of the observed stone; comparing the colour of an observed stone with the black and white environment, thus enabling expression of the brightness of the observed colour in the theoretical units of measurement; limiting the field of sight and eliminating disturbing optical impressions from without; concentrating attention exclusively on the observed object, thus emphasizing the details of the image. It does not increase the natural size of the observed object and does not change its colour.

The gem trade needs precise assessments of colour. General descriptions of colour which do not specify the conditions under which it is observed are ambiguous and imprecise and can cause misunderstandings and difficulties in the gem trade. The solution can be attained by an agreement on the conditions to be observed when measuring the stone's colour, which, if generally accepted, should be a uniform and precise measure. The proposed conditions could be " normal trade colour " observed in evenly scattered north sky light, illuminating a stone held above a white background, seen through the contrast colorimeter by an observer with normal colour vision.

DENSITY BY MENSURATION AND WEIGHING

Some of the most accurate density determinations ever made on solids were carried out by exact mensuration of cubes of pure quartz, followed by accurate weighing. This was done in Paris more than fifty years ago—and the resultant figure of 2·6506 at 0°C. is unlikely to be bettered.

But in ordinary gem-testing this method would be so time-consuming and of such doubtful accuracy that it hardly merits consideration in practical gemmology. Recently, however, a " turquoise " bead was submitted for test, and the fact that the diameter of the bead in millimeters was quoted accurately on the packet decided me to attempt the calculation on the weight/volume basis. The resulting density figure (2·30) was (more by luck than skill) surprisingly close to the value of 2·295 obtained later by hydrostatic weighing in ethylene dibromide.

The specimen showed a turquoise absorption spectrum; but the low density pointed to an admixture with some lighter material. Careful micro-chemical tests showed the presence of synthetic resin and the bead was thus proved to consist of a resin-bonded turquoise of the type described by R. Webster and H. Lee in their article in THE JOURNAL OF GEMMOLOGY, July 1960.

B.W.A.

THE "COLENSO" DIAMOND

by JESSIE M. SWEET, M.B.E., B.Sc., and A. G. COUPER

The " Colenso " (B.M.63153) is the largest diamond crystal in the Mineral Collection of the British Museum (Natural History). It is a pale-yellow octahedron with rounded edges (longest edge 2.5 cm., major axis 3.2 cm.) and triangular markings on its faces. It weights 133.1450 carats. Apart from the fact that it was presented by John Ruskin in 1887 in honour of his friend Bishop John William Colenso (1814-1883) of Natal, South Africa, very little was known of its history. Much poring over the works of Ruskin and the recent publications of his diaries gave very little more information although it was discovered that there are still at least two Ruskin Museums in the country in which quite a number of minerals are preserved. It was quite by chance that contact was made with Mr. R. G. Young and through him with an article in the *Strand* magazine for April, 1896[1] in which there are some notes on the history of the diamond. According to the story told there a storekeeper at the Cape in South Africa left his shop and went up country prospecting for diamonds. He invested £2,000 in a claim in which he had two partners. After some time, when the claim appeared to be valueless, two of the partners decided to give up and the third went on alone. The workings fell in on this unfortunate man and the other two, who were afraid of being accused of murder, went home. After some months the ex-storekeeper returned to give the body decent burial and found interred with it several loose diamonds of which the largest was the one now known as the " Colenso ".[2] He brought this to England and sold it to R. C. Nockold of Soho—a well-known dealer in precious stones.[3]

John Ruskin, whose appreciation of natural crystals was great, was a constant visitor to Nockold's shop and was instantly apprised of the arrival of this specimen. He apparently received it on approval and sent the following letter to the Nockolds:

Brantwood, Coniston, Lancashire

" MY DEAR COUPLE,—I had nearly congealed into a diamond myself with fright when I opened the box. I thought in your first letter that 130 (it was written like that) meant 13½ carats, or I never should have asked for the loan ! I'm most thankful to have it, for it is safe here and is invaluable to me just now; but what on earth is the value of it ? I don't tell *anybody* I've got such a thing in the house.

" Ever gratefully and affectionately yours,

J. Ruskin."

and later he asks:

" And now, please, will Mr. Nockold and you *advise* me whether to buy this diamond for Sheffield Museum or not ? "
He eventually bought it for £1,000 and he and his secretary, W. G. Collingwood, spent many weeks studying the diamond and many sketches and water-colours were made of it but unfortunately their present whereabouts is unknown.

Ruskin was the founder of the Guild of St. George which was largely financed by him and it was his original intention to present the diamond to its museum. It was at this stage called the " Guild " or " St. George's " diamond. However, he was on very friendly terms with Mr. (later Sir Lazarus) Fletcher, Keeper of Minerals in the British Museum (Natural History) and suggested that the Museum might like to have the diamond on loan. He was asked if he would like it to be called the " Ruskin " diamond but he replied:

" The Diamond is not to be called the Ruskin, nor the Catskin, nor the Yellowskin, diamond. (It is not worth a name at all, for it may be beaten any minute by a lucky Cape digger.)."[4]

In February, 1884, it was deposited in the Museum and exhibited at Professor Ruskin's own risk. In January, 1887, he decided to present it to the Museum on condition that it should always be exhibited with the following description:

" The Colenso Diamond, presented in 1887 by John Ruskin, in Honour of his Friend, the loyal and patiently adamantine First Bishop of Natal ". And that is how it became known as the " Colenso " diamond.

REFERENCES

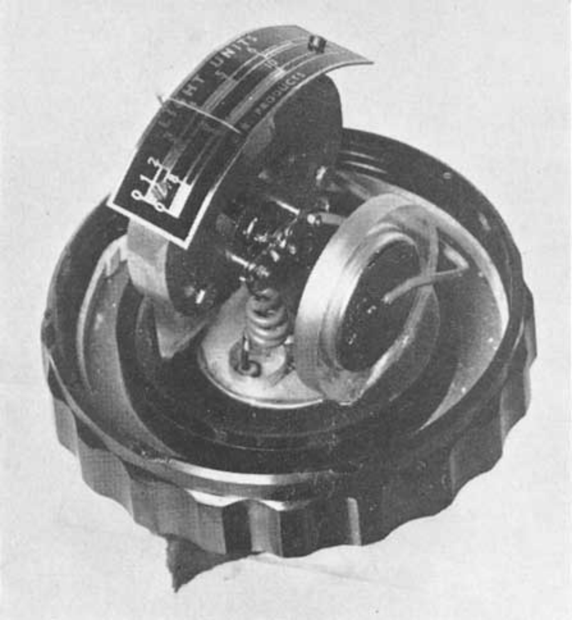
1. W. G. FitzGerald. *The Romance of the Museums*, Strand Magazine, 1896, Vol. 11, p. 429.
2. According to A. Brink (25th June, 1912), chief valuer to the De Beers Consolidated Mines Co., Ltd., this stone, to judge from its characters came from one of the upper levels of the De Beers mine.
3. Mr. R. G. Young is a great-nephew of R. C. Nockold and was trained in his workshop.
4. Sandgate, 14th December, 1887. *The Works of John Ruskin* (Library edition) edited by E. T. Cook and Alexander Wedderburn, 1906, Vol. XXVI, p. lv.

A NEW PHOTOMETER

By E. J. BURBAGE and T. G. JONES

MESSRS. RAYNER'S excellent and comprehensive list of instruments might, to an outsider, seem to provide all that a gemmologist could possibly require, no matter how extensive his interests or unembarrassed his bank balance might be. Nevertheless, a sort of gemmological " do-it-yourself " virus seems endemic among the fraternity, or, to be completely fair to them, a situation frequently arises where an enquiry can only be satisfied by the construction of a device specially tailored for the occasion. An assemblage of such gadgets would, we conjecture, make a major display.

Our own latest effort at gadgetry has been suggested by the appearance on the market of a constructional kit for a photometer of a new sort. In photographic circles one had heard in recent years of new exposure meters of vastly increased sensitivity, utilizing a cadmium sulphide cell, and at the last Photokina such instruments aroused great interest. Like most Photokina innovations, the time-lag between first showing and availability on the English market



has been considerable, and so far only one quite expensive model has reached the English photographic dealers. However, an enterprising Bristol firm, G.R. Products, has recently had the sound idea of offering for sale the components for the amateur construction of such an instrument at a very reasonable figure, and, unlike most kits of this sort, one is not pinned down to a narrow predetermined constructional pattern, as no doubt the suppliers rightly foresaw that the instrument could find applications other than as a conventional exposure meter. Consequently, we were able to construct a housing to meet our own requirements with a cell at the base, the point being that one could conveniently read light values corresponding to a beam traversing an optical system or transmitted through a mineral, e.g., through a microscope or a gemstone in an immersion cell.

In photography it seems probable that meters of this sort will compete with others of the S.E.I. type in colour-printing laboratories, or in what one might loosely call " endoscopy " as for instance in photomicrography. In fact, a cadmium sulphide cell was used in an exposure meter designed for this purpose and shown at a Physical Society exhibition of a year or so back. In straightforward photography in poor lighting conditions it will probably be preferred to a visual meter, such as the Practos, by those who consider instruments of the latter type too " subjective ".

As a photometer, one would guess that the mineralogist could employ it in the comparitively new and somewhat esoteric business of " reflectance determinations ". Certainly it is of value to the gemmologist in the parallel situation where a comparison of transmitted beams needs to be made, as for instance in quantitative work on pleochroism. As assembled by ourselves, it is a simple matter to transmit a polarized beam through a dichroic gemstone to the cell at the base, and, on rotating the polar, observe the shift in needle position. An indication of the sensitivity of the instrument is given by the considerable swing of the needle for a gemstone of such moderate dichroism as peridot, and one has scope for further refinement in the use of the instrument in that a modification can be introduced for yet greater sensitivity.

After a preliminary try-out we are satisfied that the photometer holds possibilities for further work, and we consider that the instrument is sufficiently versatile to bring to the attention of fellow gemmologists who may find other uses for it.

HERBERT SMITH MEMORIAL LECTURE

THE 1961 Herbert Smith Memorial lecture was held at Goldsmiths' Hall, Foster Lane, London, E.C.2. Mr. F. H. Knowles-Brown introduced Professor W. Eppler, of Munich, who had come specially to give the lecture. He also welcomed Dr. E. Gübelin of Lucerne, who, at the end of the lecture, thanked Professor Eppler for his interesting talk.

After surveying the types of synthetics that had been made Professor Eppler said:

The so-called " Igmerald " was produced by the former I. G. Farbenindustrie at Bitterfeld. The mystery of its production was revealed last year by Dr. H. Espig in his paper " The Synthesis of Emerald ". In principle, the method is the same as mentioned by Hautefeuille and Perrey in 1888.

In the production a crucible of platinum has been used, its diameter 7½ inches, and its height approximately 2 inches. In this the so-called oxide mixture of berylliumoxide and alumina were placed. Above the mixture a melt consisting of acid lithium molybdate, in the composition of $Li_2MoO_4 . 1{\cdot}66\ MoO_3$, was added. On the top were placed some pieces of silica-glass, which furnish the SiO_2. Now, it has been found that at the optimum temperature of 800°C (equal to 1470° Fahrenheit), the oxides on the bottom of the bowl are dissolved by the melt and, by diffusion, brought upwards to the surface. Here, they act with dissolved silica particles and form clusters of synthetic emerald.

It is a crystal growth at random. To avoid this, seed crystals of synthetic emerald are placed below the surface of the melt and held in position by a platinum sieve. Thus, the seeds are situated in the region of preferred crystallization, where the three components of the emerald are joined and react with each other. Besides the formation of emerald crystals, the seeds enlarge at a certain rate.

The process described depends upon a well defined concentration of the oxides in the melt. As the concentration diminishes in the same rate as emerald is grown and the seed crystals enlarged, it is necessary to add from time to time new material to the amount of the oxide-mixture—in practice every second day. This is carried out by a vertical tube of platinum in the centre of the crucible which, by the way, also bears the sieve. A removable funnel of platinum easily allows the additional feeding material to be brought down the tube to the bottom of the crucible, even if the apparatus is in action. Each run of crystallizing or synthesizing lasts between two and three weeks. Then, the enlarged emeralds are removed from the melt, cleaned from smaller and undesired crystals by polishing the crystal faces and, according to their size, they are prepared for another run or given to the cutter.

The economic side of this process is very interesting. The time it takes to synthesize an emerald crystal, big enough to be cut into a one-carat-stone, is calculated by Espig to be one year. Most probably, this long time has been the reason why the Igmerald has never entered the regular market.

My own experiments to synthesize emerald have been done to find an answer to two questions. Firstly: what is the reason for the healing fissures in synthetic emerald ? Secondly: are the crystal inclusions in synthetic emerald really phenacite ?

The experiments carried out by me followed the paper of Hautefeuille and Perrey, which was published in the Comptes Rendues in 1888. Small crucibles were used, three of which could be placed simultaneously in an electric heated furnace with automatic control of temperature. For most of the time, three such furnaces were working.

The melt consisted of acid lithium molybdate, and the time of each run was between two and ten weeks. The size of the largest

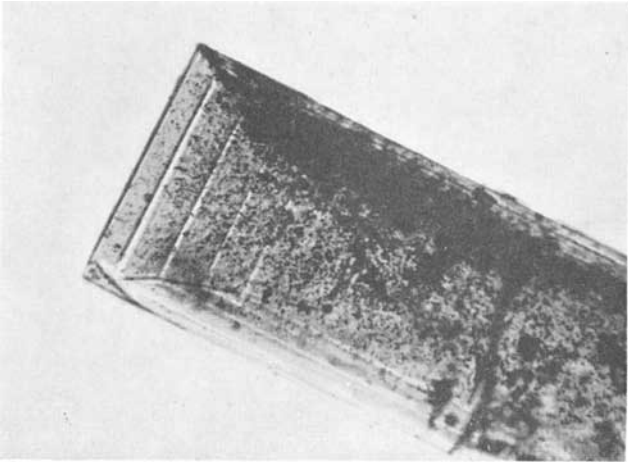


FIG. 1 *Zonal structure in synthetic emeralds; 65x*

emeralds thus produced was up to two millimeters or nearly one tenth of an inch. This was found to be large enough for further investigation.

To the first question a ready answer was found: it depends on the rate of growth, if healing fissures are produced or not.

The regulation of the growing rate is easily done by increasing or lowering the temperature, or by altering the concentration of the melt, or by adding crystallizers.

During the experiments it was found that a regular adding of the feeding material caused zonal growth (Fig. 1). Some emeralds preferred the direction of the c-axis, as in this direction, on the basal plane respectively, more material is deposited by crystallization than on the faces of the prism zone. The relation between the length and the width with these crystals is equal to 2·64 : 1 (Fig. 2). Such growth with one preferred direction can often be seen in natural emeralds. Here, an intermittent crystallization is marked by different colouring in different zones (Fig. 3). The growth of this natural emerald occurred by " surges " of the feeding material which, additionally, contained more or less of the colouring agent.

The second and still unanswered question was: are the crystal inclusions in synthetic emerald really phenacite ?

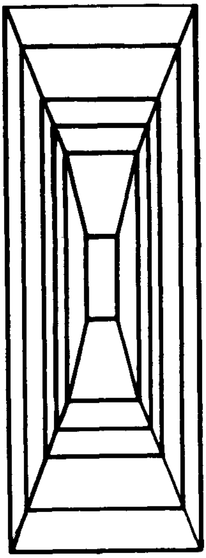


FIG. 2 *Growth zones in synthetic emerald are in a length to width ratio of* 2·64 : 1

To find an answer, it seemed useful also to synthesize the phenacite. This was done in the melt under the known conditions. One of the results is shown in Fig. 4. Besides these, elongated prims of phenacite and rounded groups of very small phenacite crystals are obtained with the same habit as they occur in the Igmerald and in the synthetic emeralds made by Chatham. It may be assumed that the different habits of phenacite are due to a difference in the growing rate, whereas the clusters have most probably been crystalized quickly.

In each case the synthetic phenacite has been tested by conventional means, including an X-ray analysis. And now, the second question can be answered with the confirmation, that the inclusions of phenacite in synthetic emerald are synthetic phenacite.

Some observations when synthesizing emerald from the melt may be of general interest. First is the easy crystallization at the beginning. After twenty-four hours, the greatest part of the oxides has been crystallized into emerald. A week or ten days later, the crystals have a mean size of approximately 250 microns. Then,

FIG. 3 *Growth lines in natural emerald parallel to basal plane; 22x*

the growing rate drops drastically, and to obtain crystals with a length of 0·5 mm and up to two millimeters, the melt must be heated for one month or more.

Another feature of synthetic emeralds obtained from the melt was a regular intergrowth or twinning (Fig. 5). It is known that twins of natural beryl are very rare and when they occur the face (1101) is the twinning plane. The twins of the synthetic emerald are not yet determined, but most probably they follow the planes of steep hexagonal bipyramids. Finally, two-phase inclusions can be observed in this particular kind of synthetic emerald (Fig. 6).

After having acquired some experience with experiments, a starting material of natural beryl instead of the oxides was tried. Crushed natural beryl was used, together with a little chromium oxide. After three days, it was dissolved entirely by the melt, and a multitude of six-sided plates of *tridymite* were grown. By maintaining the melt on the working temperature for a fortnight's time, little crystals of emerald appeared which grow very slowly. The experiment reveals that it is possible to recrystallize natural beryl into synthetic emerald by using a melt. But it is not possible to have a seed crystal of natural beryl enlarged in a melt with added oxides, as the natural beryl is disintegrated at a temperature of 800°C and dissolved by the melt. This has been proved many times. Therefore, no " cultivated emeralds ", to use the incorrect name for Chatham's synthetic stone, can be crystallized from a natural emerald with the diffusion melt method.

In his paper on the synthesis of emerald, Espig suggests the use of a lithium-molybdate melt as a solvent, by which other crystals can be obtained. He reports to have grown by this method the following synthetic crystals—phenacite, willemite, zircon, garnet, magnetite, sphene, rutile (brookite).

While the Igmerald and the synthetic emerald of Chatham are true synthetics, it is not quite so with the " coated beryl " made by J. Lechleitner. I imagine that you are familiar with the paper of Holmes and Crowningshield about the so-called " Emerita" which paper an abstract appeared in THE JOURNAL OF GEMMOLOGY. It contains worthwhile detail about this material.

The method which is used is a hydrothermal one. An autoclave is used, in which the coating takes place. The conditions of the process are not known in detail, but they can be guessed easily.

After the filling of the bomb with the three oxides BeO, Al_2O_3 and SiO_2 in the required proportions and after adding chromium-oxide for the green colour, the completely cut beryls—mostly of poor colour—are placed in it. Then water is added in such a quantity that at the chosen temperature a pressure of approximately 700 to 1,000 atmospheres (or 10,000 to 14,000 pounds per square inch) is realized. The temperature will be, most probably, about 450 to 500°C. or 840 to 930° Fahrenheit.

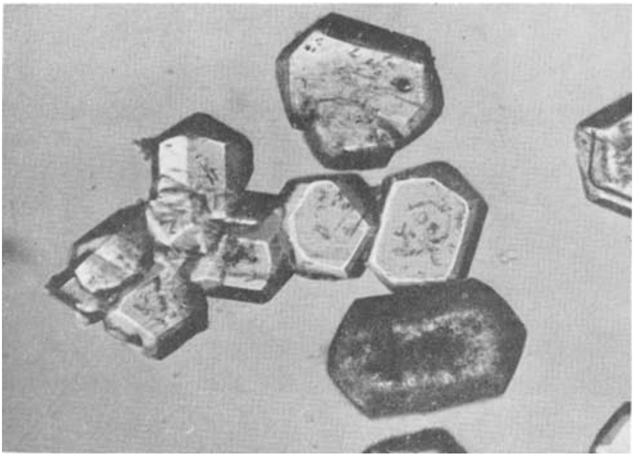


FIG. 4 *Phenacite crystals from a lithium-molybdenum melt; 120x.*

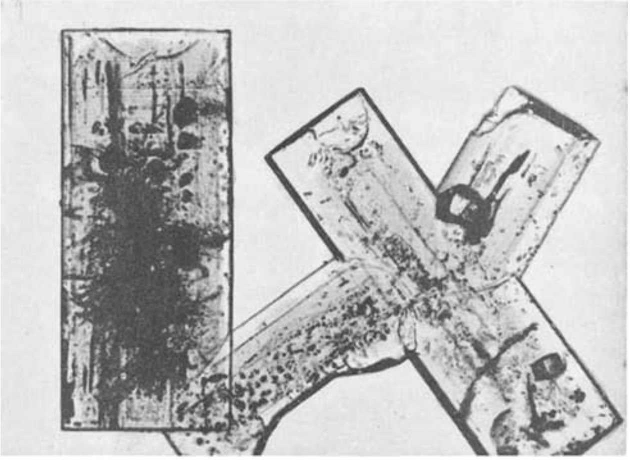


FIG. 5 *Twins af synthetic emerald with inclusions of phenacite; 65x.*

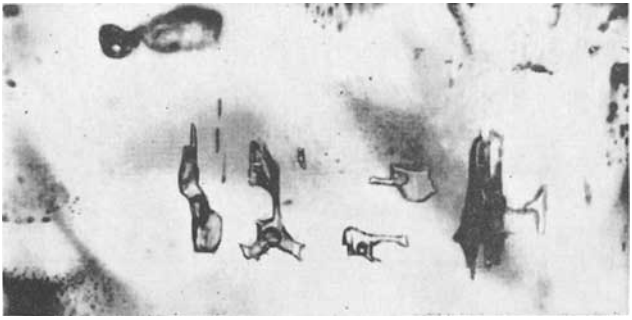


FIG. 6 *Two-phase inclusions, along the prism zone, in synthetic emerald; 220x.*

The conditions are super-critical with respect to water. The coating is a crystallization of new material, and it has to be regarded as a continued growth of the beryl. Only the emerald-green colour of the deposited material and its synthetic nature makes it different from the natural core. The thickness of the coating is different according to the crystallographic directions. On the average it is less than half a millimeter on the repolished stones.

A particular feature of the new material are fine lines which can be observed with a pocket lens and, better still, under the microscope. They have been mentioned by Holmes and Crowningshield and by Dr. E. Gübelin in *Gems and Gemology* and in THE JOURNAL OF GEMMOLOGY. The lines are parallel to the basal plane of the coated beryl, and they offer a reliable means of easily identifying such stones.

The lines represent healing fissures, which are broad enough to be present after the stone has been repolished. In most of the cases, they are crossed by another system of healing fissures, which are parallel to the prism zone of the beryl. A second type of inclusion consists of little tubes parallel to the c-axis. Mostly they start from a solid inclusion, like hematite or ilmenite. They are always pointed at one end. They contain a liquid and a they start from a solid inclusion, like hematite or ilmenite. Also they are always pointed at one end. They contain a liquid and a gas bubble and by this they represent typical three-phase inclusions.

Similar inclusions, which remind one of " tie-pins ", are present in the synthetic emerald made by Nacken. Here, a tiny crystal of synthetic emerald has been the cause of the formation of the tubes, which, by the way, indicate the direction of growth of the host crystal. Such primary inclusions of synthetic emerald can also be present in the coating of the Lechleitner stones, but in most of the cases they are not.

The boundary between the beryl and the coating of synthetic emerald is well defined by the green colour. Finally, it is easy to understand, that the big core may have inclusions which are typical for beryl.

One difficulty remains: how should the product, to be sold as " Emerita ", be described ? It is a beryl or an aquamarine, with a thin layer of synthetic emerald. For the moment, the expression " synthetic-coated beryl " seems to be the best, even if it does not satisfy every aspect.

EKANITE

Ceylon Gemmologist Discovers New Mineral

By R. KEITH MITCHELL

INEVITABLY the course of years and the spread of gemmological knowledge has widened the field of rare minerals which may be used as gems. In many cases these are already known to mineralogists but have suddenly been found in cuttable well-crystalized gem quality previously unknown.

In other and far rarer cases they are entirely new minerals, unknown until they are found in gem quality crystals. Brazilianite was an example of this; an unusual one in that comparatively large crystals were found in quantity. Taaffeite is another example which springs to mind, a gem which exists in three known specimens totalling less than 2·5 carats in weight. A rough crystal of this mineral has yet to be recognized. The gem was discovered as a cut stone by the Dublin gemmologist Count Taaffe after whom it was named. Another mineral, which exists in only two known specimens, is cuttable but is preserved in its crystal form. This is Painite, named after A. C. D. Paine, a mining geologist, who discovered it.

So it can readily be seen that in the world of minerals new ones which may be used as gems are of extremely rare occurrence and it is always an event when one is found and is recognized as hitherto unknown by the finder. When this discovery is made by a gemmologist rather than a mineralogist the occasion is very remarkable.

In 1953 I received from my friend, F. L. D. Ekanayake of Colombo, Ceylon, a round cabochon-cut gem of dark green colour, which exhibited a faint four-ray asterism. Mr. Ekanayake is a good and painstaking gemmologist with a flair for the unusual and an almost inspired ability to find and identify the rarer stones in the gem gravels of Ceylon. His letter accompanying the stone on this occasion stated quite simply " I am sure that this is a new mineral ".

The stone was a dark zircon-green in appearance and a straightforward examination quickly established that it was amorphous, with S.G. 3·28 and R.I. 1·60, and that the asterism was due to reflection from large numbers of short acicular inclusions oriented at right-angles in two directions.

The colour and the amorphous structure suggested that the stone was some kind of natural glass and, at my request, Mr. B. W. Anderson, seeking confirmation of this, submitted the gem first to the British Museum (Natural History) and then to Dr. D. K. Hill, of the Sheffield University Department of Glass Technology.

An early spectrum analysis at the Chamber of Commerce Laboratory had revealed silica, calcium and traces of lead, which according to Anderson made it virtually certain that the material was an artificial glass. And at this stage we had more or less accepted it as such and I reported it as a glass in a short paper in this journal at that time.* But at the back of everyone's mind the fact of the oriented inclusions still lingered as an incongruous feature, which was as yet unexplained. Ekanayake, informed of this, stuck to his original contention with admirable tenacity and still said that the substance was mineral and a new one.

D. K. Hill, in correspondence with B. W. Anderson, at first confirmed the glass idea and then, during a spectrographic analysis found the radio-active element thorium present in large quantity. It is a matter of comment that he *estimated* at this stage that the thorium oxide content was about 26 to 27% of the total. Subsequent chemical analysis of another specimen at a much later date gave a figure of 27·6%, a tribute to the accuracy of this estimate.

Anderson at once realized that the material could not be either artificial or a glass and that the lead, which was present in a very much smaller quantity than had at first been thought to be the case, was in fact the result of the disintegration of the thorium to its end product. It was now obvious that the stone was a metamict mineral analogous to low-type zircon, which it resembled in colour.

At this point in the investigation an attempt was made to return the slice, which had been taken from the stone for experimental purposes, to its original crystal form. To this end the fragment was heated to an increasing series of temperatures, which at first lowered the density but did little else. Unfortunately a final heating to 1000°C failed to produce the desired result and altered the material to an opaque putty-coloured mass on which little further work could be done. The remains were sent to the British Museum but apparently were not investigated any more at that time.

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*Journal of Gemmology. Vol. IV No. 5, 1954

There the matter rested for some years with my friend in Ceylon still hoping somewhat sorrowfully that his " new gem " would obtain some recognition. Meantime one other specimen of the material was received from a West of England jeweller by the laboratory, but was not used for the chemical analysis which was now lacking from the investigation.

Early in 1959 I received three further specimens of the mineral from Ekanayake. These included a large water-worn piece of rough and were all from the same gem pit at Eheliyagoda, Ratnapura, as the original specimen. These were passed to the Laboratory but, for a variety of reasons, it was not possible to get a final analysis done until early this year, when I handed these three pieces of the material to Dr. G. F. Claringbull, Keeper of Minerals at the British Museum (Natural History), for the difficult matter of micro-analysis and the elimination of known minerals.

The results of this investigation were finally published in *Nature* (June 10th, 1961) and the mineral at last established beyond doubt as a new one. Details are given below. The name Ekanite has been given to the gem in recognition of the gemmologist who found it more than seven years ago and who never lost faith in his discovery.

The results of the long investigation, as published in *Nature* show the chemical composition to be $(Th, U)\ (Ca, Fe, Pb)_2Si_8O_{20}$. The uranium, which is about 2% of the total, was a puzzling constituent, which was resolved only in the last stages of analysis.

Density and refractive index are quoted as 3·280 and 1·5969 respectively. Heating and recrystallizing produces an ordered atomic lattice with tetragonal symmetry. Because of the directions of the oriented inclusions it had already been assumed that the mineral was originally tetragonal.

Finally, it should be realized that ekanite is extremely rare and, even with all the rough so far found, converted to cut stones, not more than about a dozen specimens are known.

Gemmological Abstracts

GÜBELIN (E.). *Farbe und künstliche Farbveränderung von Diamant.* Colour and artificial coloration of diamond. Deutsche Goldschmiede-Zeitung, Vol. 59, No. 2, February 1961, and No. 4, April 1961.

Really colourless diamonds are chemically pure and very rare and expensive. The cause of colour in diamonds is not known, but is presumed to come from the presence of foreign atoms or from local irregularities in the atomic lattice. At first it was believed that all colour in diamonds must come from some trace element, but this was doubted by the Indian scientist Raman who made his experiments mainly with yellow and brown stones and found the colour to be mainly caused by irregularities in the lattice. New methods using very sensitive spectrographs have shown a millionth of a trace element to be sufficient to give diamond some colour. Most diamonds were shown to contain about 14 different elements. Correlation in the case of a pink diamond is shown by the absorption spectra. From reports about synthetic diamonds it is assumed that the colour is determined by pressure and temperature. In order to improve the colour of a diamond many experiments with X-rays, cathode-rays and radium have been made. It has now been shown that it is possible to colour a white or pale diamond blue, green, yellow, brown or even red by bombarding it with deuterons, protons, neutrons, alpha-particles or gamma rays. Various experiments are described.

The most important method of colouring diamonds is by means of neutron bombardment. The method is described in detail. If a diamond thus artificially coloured is heated later on, the green colour is reduced either to a pale green or yellow-brown depending on the length of bombardment. Natural green and black diamonds do not loose their colour by thermal treatment. It has been shown that the original colour of the diamond cannot be reconstituted, white diamonds keeping a slight yellow tinge, however high the temperature of the thermal treatment. The importance is stressed of finding methods of differentiating between naturally coloured and artificially coloured diamonds. It has been seen in many cases that the artificial colour is very thin and is removed when the surface is polished. Those green stones artificially coloured by bombardments and whose surface colour is very thin, have a peculiar colour reflex, in the form of a dark edge inside the girdle when the stone is put with the table onto a white piece of paper. If the stone has been bombarded from the other side, this colour reflex can be observed as an umbrella-like formation in the culet. For newer types of artificial bombardments, the differences in the absorption spectrum are of help. Details of the differences in this absorption spectrum are given.

E.S.

SCHLOSSMACHER (K.). *Beryll mit Auflage von synthetischem Smaragd.* Beryl with synthetic emerald surface. Zeitschr. d. deutsch. Gesellschaft f. Edelsteinkunde, No. 33, pp. 5-7. 1960.

Article about the method by J. Lechleitner (Journ. Gemmology, Vol. VIII, No. 2. 1961) of crystallizing synthetic emerald onto a pale beryl. Various methods of detection are discussed.

E.S.

JAKOB (E.). *Die Saeurebestaendigkeit von synthetischem Rubin.* Acid resistance of synthetic ruby. Zeitschr. d. deutsch. Gesellschaft f. Edelsteinkunde, No. 33, pp. 7-8. 1960.

In the bearing industry the stones were fixed in position during their working by means of shellac, etc., which afterwards had to be removed by acids. These acids were shown to attack the surface of the synthetic rubies. A microphotograph of such surface is shown. It has been found that the synthetic ruby bearings are not attacked by concentrated nitric acid, but mainly by concentrated sulphuric acid.

E.S.

HOLMES (R. J.): CROWNINGSHIELD (G. R.). *New emerald substitute.* Gemmologist, Vol. XXIX, No. 353, pp. 224-233. December 1960.

The article on the Lechleitner emerald coated beryls reprinted from the original in Gems and Gemology. (Abstracted Journ. Gemmology, Vol. VII, No. 8, p. 309. October 1960).

R.W.

SCHLOSSMACHER (K.). *Die Entstehung der Achate.* Formation of agates. Zeitschr. d. deutsch. Gesellaschaft f. Edelsteinkunde, No. 33, pp. 11-16. 1960.

E.S.

SWITZER (G.). *35th Annual report of the diamond industry 1959.* Jewellers' Circular-Keystone, 1960.

Although world production was less than in 1958, the year reviewed was a prosperous one for the diamond industry. The survey follows the pattern of previous years.

S.P.

ANGUS (J.). *Cultured pearl problems.* Gemmologist, Vol. XXX, No. 354, pp. 1-2. January 1961.

The report of an unusual pair of cultured pearls which had apparently been formed of two halves of, maybe, blister pearls. They weighed 66·56 and 65·20 grains respectively and that the core was mother-of-pearl was proved by Laue diffraction pattern. 1 illus. R.W.

DOWDING (R. R.). *Opal in the Eulo district.* Australian Gemmologist, No. 1, pp. 12-15. November/December 1960.

An interesting and informative article on the types of opal found in the Eulo district. A number of unlisted fields are mentioned, particularly the Blackgate field and others on the Toomooroo holdings. The many different types of opal found in the Yowah field are discussed. Some notes are given on the seeking of opal and the article closes with a poem written by the authoress.

R.W.

FISCHER (W.). *Die Technik der Jade-Bearbeitung in China.* The technique of working jade in China. Deutsche Goldschmiede Zeitung, Vol. 59, No. 2, pp. 69-72. February 1961.

Jades were already worked in China from 1122-246 B.C. while in Turkestan during the Han-dynasty (202-220 B.C.) nephrite was worked. Details of the production methods are not well known, although illustrated descriptions were published in 1176 and again in 1341. Originally the centre of jade working was Soochow, and since 1644 in Peking. The illustrations now published are taken from a work published in 1906 and notes taken in 1954. The illustrations show (1) crushing, washing and sieving of the polishing powder, which consists of emery, almandine, quartz sand and ruby dust; (2) sawing of the rough jade; (3) sawing of the smaller pieces; (4) forming of the jade object; (5) first polishing of the jade. The surface is then even enough to draw on it the ornamentation; (6) hollowing the material. This is done by means of a round cylindrical steel drill; (7) engraving of the ornaments. This is done by means of small steel wheels which can be either round with sharp edges (ting-tzu or nails) or with thick edges (yat'o); (8) If the ornaments consist of lace work, a diamond drill is now used; (9) In this case a diamond with bow is used; (10) the drilling of holes into small objects, say mouth-pieces for pipes or small boxes is done underwater by a diamond drill; (11) shows the wooden polishing lap, which is impregnated with diamond dust or paste. For very fine work a small lap is made out of the skin of a pumpkin; (12) shows a leather lap for the finest polish. This consists of four or five layers of leather sewn together with a linen thread. The diameter can vary from 2-3 inches to a foot.

E.S.

EPPLER (W. F.). *Ungewöehnliche Kristall-Einschluesse in Aquamarin.* Unusual crystal inclusions in aquamarine. Deutsche Goldschmiede-Zeitung, Vol. 58, No. 12, pp. 736-738, 1960, and Vol. 59, 1, pp. 13-15, 1961.

Inclusions of apatite in aquamarine are recognizable by their hexagonal crystallization, by their R.I., which is about 1·63-1·64, i.e. higher than that of aquamarine, and by their basal cleavage. There are five photomicrographs illustrating apatite in aquamarine and four showing mica inclusions in aquamarine. Mica is found as an inclusion in the emeralds of the Urals, Transvaal and from the Austrian Habachtal. In aquamarine they seem to be rare.

Two photomicrographs show petalite inclusions. These are small, doubly refractive crystals, which have a tumbled look. These inclusions are probably formed by an excess of Li_2O in the mother liquid. Usually these petalite inclusions in aquamarines are rare and very small, so that their determination is difficult. One of the photomicrographs shows a fairly large inclusion of this type. Inclusions of haematite are a great rarity. A few photomicrographs are shown. The author mentions the existence of various other undetermined inclusions in aquamarines, and hopes that soon they will all be known and recognized.

E.S.

BURKART (W.). *Das Trommeln von Bernstein.* Tumbling of amber Deutsche Goldschmiede-Zeitung, Vol. 59, No. 1, pp. 21-22. January 1961.

The article describes the production of tumbled amber beads. The diameter of the tumbling drum is about 60-70 cm. These drums are filled to nearly half their capacity with a mixture consisting of two-thirds tumbling balls and about one-third amber. The process takes about 10 hours.

E.S.

ANON. *Neues vom Tuerkis.* News about turquoise. Zeitschr. d. deutsch. Gesellschaft f. Edelsteinkunde, No. 33, p. 16. 1960.

The surface of pale turquoise is treated with acid and a layer of blue resin poured over the stones, thus impregnating the attacked surface. When polished the treated stones are very difficult to discern with the naked eye.

E.S.

HASCHMI (MD Y.). *Der orientalische Tuerkis.* Oriental turquoise. Zeitsche. d. deutschen Gesellschaft f. Edelsteinkunde, No. 33, pp. 16-24. 1960.

Detailed list of occurrences in the East with bibliography of 34 items.

E.S.

SCHLOSSMACHER (K.). *Falschbezeichnung von Zuchtperlen.* Wrong nomenclature of cultured pearls. Zeitschr. d. deutsch. Gesellschaft f. Edelsteinkunde, No. 34, pp. 5-6. 1961.

Cultured pearls are often named " real cultured pearls ". The author draws attention to this wrong nomenclature.

E.S.

BANK (H.). *Smaragdvorkommen in Kolumbien.* Emerald occurrences in Colombia. Zeitschr. d. deutsch. Gesellschaft f. Edelsteinforschung, No. 34, pp. 7-23. 1961.

Occurrences of emerald outside Colombia in Africa (Egypt, Transvaal, Rhodesia), in Asia (Urals and India), in Europe (Austria and Norway), unimportant finds in Australia and North America and in South America (Brazil) are mentioned. A detailed description and map of the mines in Columbia are given, as well as historical data of the mining in the Colombian emerald mines, mainly in Chivor, Muzo and Coscuez, which are near to Muzo and also belong to the Colombian nation. Two small new mines are mentioned, Buenavista and the Mine de Vega de San Juan. The mines are described from a geological point of view, and the production and importance discussed. The article ends with a short survey of the chemical and physical properties of emerald.

E.S.

TISDALL (F. S. H.). *Spessartite garnet from California.* Gemmologist, Vol. XXX, No. 357, pp. 61-62. April 1961.

Reports the examination of some spessartite garnets from the " Little Three Mine ", Ramona, California. The stones were a yellowish orange in colour and the density was found to be 4·17. The refractive index was greater than 1·81 (above the limit of the refractometer), and the absorption spectrum is discussed. Comment is made on the peculiar inclusions.

2 illus. R.W.

JOHNSON (P. W.). *All about emeralds.* Lapidary Journ., XV, 1. 1961.

A general survey covering both natural and synthetic gems.

S.P.

JAHNS (R. H.). *Gem stones and allied materials.* Chapter 18 in Industrial minerals and rocks. Amer. Inst. Mining, Metall., and Petrol. Engrs., pp. 383-441. 1960.

Following the introductory remarks on terminology and classification the properties of 103 gem minerals and other gem materials are tabulated and the influence of these properties on preparation and on both decorative and industrial uses are discussed. The origin and geologic occurrences of gem minerals are outlined and the geographic distribution of gem materials is tabulated (though one might express surprise at the listing of the British Isles as having appreciable commercial output of gem varieties of apatite and axinite): the problems of prospecting, mining and concentrating are briefly noted. Following a statement on synthetic and imitation gem materials, the production, cutting, consumption and marketing of natural gemstones are reported and the comparative retail values of cut but unset gemstones, exclusive of diamonds, correlated with colour, size and other features, are listed.

20 Figs. R.A.H.

TWINING (LORD). *A history of the crown jewels of Europe.* London (Batsford), 1960, 230 pls. Price £16 16s.

R.A.H.

BENSON (L. B.). *Developments and highlights at the Gem Trade Laboratory in Los Angeles.* Gems and Gemology, Vol. X, Nos. 3-4, pp. 75-80 and 92. Fall 1960 and Winter 1960/61.

A very full discussion on colour-dyed and colour-treated pearls and upon the correct terminology to use in reporting them. The results of many experiments are given. In the case of treated pearls the effect was inferred to be due to the darkening of the conchiolin content by chemical means. The recutting of a flat diamond which had been damaged, yet maintained its value, is mentioned. The results of the examination of a number of pieces of jewellery which had suffered fire damage are reported. Plastic-bonded and paraffin-treated turquoise is discussed. Exceptional stones examined by this laboratory were a ¾ carat cat's-eye demantoid garnet and a 2·78 carat benitoite.

4 illus. R.W.

GÜBELIN (E. J.). *More light on beryls and rubies with synthetic overgrowth.* Gems and Gemology, Vol. X, No. 4, pp. 105-113. Winter, 1960/61.

A survey of the hydrothermal rubies made by the Bell Telephone Laboratories, and those produced by Carroll Chatham. The method and the apparatus used to grow the Bell crystals are described. The physical and optical characteristics of Chatham rubies, which use a " seed " of Burma ruby, are similar to those of natural rubies. Distinction lies in the inclusions of the overcoat of synthetic ruby. The writer admits that it is not easy to observe these features. The article continues with comments on the Lechleitner emerald-coated beryl called " Emerita ". The characters of such stones are similar to those of natural beryl and do not have the lower density and refractive index as do the Chatham synthetic emerald. Again it is the inclusions seen in the overgrowth which are the dominant features indicating the nature of the stone. These are more easily observed than in the case of the above-mentioned ruby. One of the safest tests may be by lateral examination in a liquid having an index of refraction about 1·57, when the coating will betray itself by the dark green relief.

18 illus. R.W.

WEBSTER (R.). *A new ultra-violet lamp.* Gemmologist, Vol. XXX, No. 357, pp. 67-69. April 1961.

Describes the characteristics of a British twin fluorescent tube lamp (the Allen lamp) for long-wave ultra-violet light. Comparison is made with the American " Burton " lamp, which is similar in major characters. Reports are given on experiments designed to show the efficiency of the Allen lamp for various tasks.

2 illus. P.B.

RAAL (F. A.). *Artificial colouration of diamond.* Gemmologist, Vol. XXX, No. 357, pp. 63-66. April 1961.

Electrons with energy of about one million volts will give a bluish colour provided the stone is kept cool during irradiation. Higher energies give a blue-green colour. Colouration is only skin-deep. Heating such blue-coloured stones at 300°C results in a limited reduction of colour and at 600°C the colour changes to green and finally to a permanent yellow. An explanation of " radiation damage " is given. The article concludes by giving some tests for artificial colouration and the writer comments on the " coating " of diamonds by a film of dyestuff in order to whiten off-coloured diamonds.

1 graph. R.W.

ANON. *The Maori Heitiki.* Australian Gemmologist, No. 3, pp. 5-6. March 1961.

This article, reprinted from an illustrated booklet issued by Whitcombe & Tombs Ltd., discusses the legends of the Heitiki, the neck pendant of grotesque human form used by the Maori people for adornment.

R.W.

TUFFLEY (J. R.). *The relationship between refractive index and specific gravity.* Australian Gemmologist, No. 3, pp. 7-9. March 1961.

An investigation of the relation between refractive index and specific gravity of gemstones. Resort is made to a statistical method —the " method of mean squares "—to produce a straight-line graph. The part the atomic lattice plays in determining the refractive index and the density of a solid substance is explained. The gemstones which form exceptions to the straight-line graph are discussed.

1 graph. R.W.

CROWNINGSHIELD (G. R.). *Developments and highlights at the Gem Trade Laboratory in New York.* Gems and Gemology, Vol. X, Nos. 3-4, pp. 67-74 and 92; 114-123. Fall, 1960, and Winter, 1960/61.

Discusses some of the specimens submitted to the laboratory in New York. These include a 48·12 grain freshwater pearl from Ilinois and a carved pink topaz in which difficulty was encountered as normal testing techniques were not able to be carried out and short-wave ultra-violet light was used as a convincing answer. A suite of cat's-eye blue topazes is referred to. Two " cave pearls " (pisolites) were examined and on being X-rayed showed a darker spot, which was considered to be a single calcite crystal. A soudé type stone of emerald-colour was found to consist of two pieces of beryl which showed the inclusions to be continuous through the two parts. There is a report of a radium-treated diamond set in an old ring and comments are made of the possibility of the danger of the legal liability of anyone who sells such a stone. Other stones which were sent in for testing were a brown scheelite, a cut azurite, a pink scapolite, a purplish star-sapphire, a translucent variscite, a 32-carat andalusite, a cut crocoite, a green idocrase cameo and a purple glass cameo. Marble cameos also had been submitted. A note is given on pearls dyed rosée, pink synthetic sapphires showing " needles " and round beryl beads artificially coloured by green plastic placed in the string canal. More and better quality non-nucleated cultured pearls are reported. A large blister pearl having a hollow centre filled with small pearls and buckshot, and the use of black coral in jewellery are mentioned. A note is given on burned diamonds and on the schiller seen on some natural emeralds. A new synthetic star-stone is reported. This consists of a cabochon of synthetic corundum or spinel on the base of which is engraved three sets of fine lines, and this cabochon is backed with a metallic film on a ceramic base.

29 illus. R.W.

BENSON (L. B.). *Planning and using your new diamond room.* Gems and Gemology, Vol. X, No. 4, pp. 99-104 and 127. Winter, 1960/61.

Describes lay-outs for a *diamond room* in a retail establishment. The types of decoration, use of mirrors, illumination and furnishings are discussed. The diamond sales room should be provided with

suitable instruments, such as a " Diamondscope " or " Gemolite " and a " Diamondlite ".
1 illus. R.W.

WEBSTER (R.). *Tanganyika tourmaline.* Gemmologist, Vol. XXX, No. 356, pp. 41-45. March 1961.

A green tourmaline, first suspected to be chromiferous owing to its red residual colour through the Chelsea colour filter, had been found by Professor Bassett, to be vanadiferous and not chromiferous. The stones emanate from the Gerevi Hills in Tanganyika. A number of such stones were examined by the writer and the data gained from this examination are set out in the paper.
3 illus., 1 map. P.B.

WEBSTER (R.). *Fluorescence in gemstone identification.* Lapidary Journal. Vol. XIV, No. 6, pp. 492-509. February 1961.

The article commences with an outline of the history and the nature of photo-luminescence. The difference between long- and short-wave ultra-violet lamps, and their respective filters, are discussed. The differential responses of substances to stimulation from different wavebands of ultra-violet light is mentioned and the " crossed-filter " technique described. The luminescent response shown by some thirty gem materials is given, and there is a short list of references. A useful article which is enhanced by a double-page coloured plate of fluorescing minerals.
8 illus. P.B.

SHREVE (R. N.). *Jade cutting to-day.* Gems and Gemology, Vol. X, No. 3, pp. 81-89. Fall, 1960.

The story of a jade carving works in Hong Kong which was instituted by a Chinese refugee from Pekin. Some history of jade carving is given, the various processes explained, and the time taken to produce jade carvings is mentioned. Notes on the origin of jade minerals are given. Minerals other than jade, such as rose-quartz, African tiger's-eye, South American green quartz, amethyst, rock crystal, agate, turquoise and lapis-lazuli are carved. There is another group of hardstone carvers at Taipei in Formosa.
11 illus. R.W.

PING-HENG (P.). *Jade carving.* Australian Gemmologist, Vol. 3, No. 3, pp. 13-17. Sept. 1960.

A general article on jade carving. It deals mainly with the historical and folklore aspect of the designs and of the blending of the colour streaks in the rough material to bring out effects in the carving. Jadeite from Yunnan, nephrite from Sinkiang, coral from Taiwan, amethyst and smoky quartz from Hopei Province, and agate from Inner Mongolia are the materials used in carving. Some notes on carving methods are given. R.W.

WIRTH (A. A.). *Alexandrite.* Australian Gemmologist, No. 2, pp. 11-12. Jan./Feb. 1961.

A popular article on the species chrysoberyl, with particular reference to alexandrite. The ethics of naming as alexandrite any green chrysoberyl with only the slightest trace of colour change is commented upon. The simulation of alexandrite by andalusite and by synthetic corundum and spinel is mentioned, and the localities where chrysoberyl are found are given. R.W.

ANDERSON (B. W.). *Nitrogen in diamond.* Gemmologist, Vol. XXX, No. 355, pp. 21-22. February 1961.

The article is based on the paper by W. Kaiser and W. L. Bond in which these workers report that they had found the element nitrogen in Type 1 diamonds, and to this they ascribe the main absorption effects of this type of diamond. Kaiser and Bond found that the strength of the 78,000Å band in the infra-red is exactly proportional to the strong band in the ultra-violet at 3060Å, and, further, that the strength of these bands is proportional to the nitrogen content, no less than 0·2% of nitrogen being found in Type 1 diamonds. A test for the ultra-violet bands in Type 1 diamonds using a short-wave mercury lamp and elementary photographic apparatus is mentioned. R.W.

HARDY (E.). *Diamond through the ages.* Gemmologist, Vol. XXX, No. 355, pp. 39-40. February 1961.

A general story of the use of diamond from early times. Some notes are given on the discovery of the method of cutting diamond by its own powder, and on the chemical nature of the stone. Notes are given on the mining areas and on the Israeli diamond cutting industry. R.W.

ANON. *The art of the Tassies.* Gemmologist, Vol. XXX, No. 355, pp. 36-37. February 1961.

James and William Tassie made, mostly in a readily fusible glass, a vast number of medallions and reproductions of intaglios. Over 20,000 Tassie gems are in the National Gallery of Scotland.

R.W.

ZWAAN (P.). *Some notes on the identification of the pyrope-almandine garnets.* Proc. Koninkl. Nederl. Akad. v. Wetenschappen, series B, 64, 2, 1961.

It is possible to differentiate between garnets of two groups (pyralsite and ugandrite) by means of X-ray powder photographs. From the gemmological point of view, the best way to determine a garnet is by the measurement of the physical properties, of which the absorption spectrum is very important.

S.P

ANON. *The peridots in the gem collection of the Museum of Geology and Mineralogy,* Leiden. Leidse Geol. Mededelingen, No. 22, 501-516, 1959.

A survey of the peridot collection in the museum. Stones from Egypt and Sibera show diagnostic inclusions.

S.P.

SINKANKAS (J.). *What do we really know about the formation of agate and chalcedony?* Lapidary Journ., XV, 2, 1961.

The problems of explaining the formation ot chalcedony need far more study before convincing explanations can be advanced.

S.P.

SCHLOSSMACHER (K.). *Fortschritte in der Diamantsynthese.* Progress in diamond synthesis. Deutsche Goldschmiede-Zeitung, Vol. 59, No. 4, pp. 207-208, April, 1961.

During the last two years many other laboratories apart from the General Electric in the U.S.A. have produced synthetic diamonds. The General Electric Co. says that the first stones produced were dark and weighed only a few thousand of a carat, now they weigh up to a tenth of a carat and are of very good industrial quality.

E.S.

SOME EXPERIMENTS WITH COLOUR

By NORMAN H. DAY

There must be many who read with interest the article by B. W. Anderson, entitled " Revolutionary Experiments in Colour Vision ", which appeared in the October, 1959, *Journal of Gemmology.*

He described in outline the history of experiments with colour and the results of experiments carried out by Dr. Edwin H. Land and his colleagues, of the Polaroid Corporation of America, during the previous five years. These investigations into a previously unnoticed chromatic phenomenon have given rise to new ideas in the conception of how the eye works regarding colour vision.

An important new discovery in the field of colour is of great interest to gemmology; many gemstones can be described as Nature's most permanent colour filters and Dr. Land's work could produce new principles in the understanding of the nature of their colour.

After reading B. W. Anderson's article my head buzzed with ideas. So as the saying goes . . ." Seeing is believing ", I started making a Camera/projector to repeat some of Dr. Land's experiments. Despite the crudeness of my equipment, the results obtained underline the fundamental nature of the phenomenon. In this article I will describe the practical experiments that I have carried out and leave the interested reader to consult the published works of E. H. Land[1] where he describes in a full and understandable way how this new discovery effects the whole conception of colour vision.

To begin with Land made a pair of black-and-white lantern slides of a group of coloured objects. One is referred to as the " Long Record " and the other as the " Short Record". Both are taken through the same lens and from the same viewpoint. The Long Record Negative is exposed using a light filter transmitting light above 5850Å and absorbing all light of a shorter wavelength. The Short Record negative is taken using a light filter which passes light below 5850Å and absorbs all light of longer wavelengths. (Figs. 1, 2 and 3). When we examine a pair of positive transparencies made from the negatives, such as those illustrated in Fig. 5, the Long Record shows the " R " red section with less density than that section on the Short Record. The densities vary according

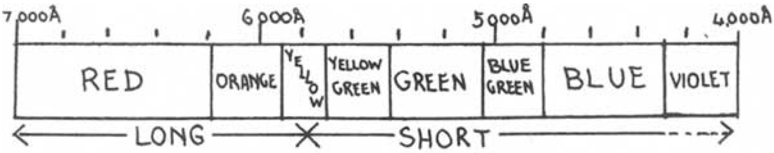


FIG. 1. *The visible spectrnm*

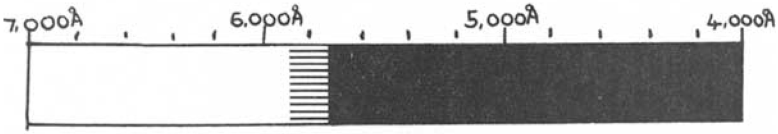


FIG. 2. *Absorption spectrum of filter used to make Long Record*

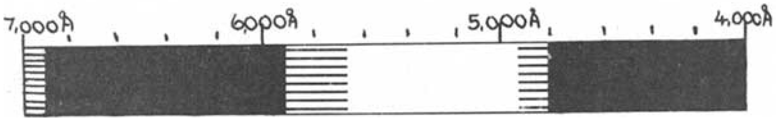


FIG. 3. *Absorption spectrnm of filter used to make Short Record*

to the light transmitted by each filter. Having made a suitable Long and Short Record Land proceeded to carry out some of Newton's original experiments with colour.

Newton's Original Experiments

Newton passed a narrow beam of white light into a large glass prism, refraction causing dispersion of the various component wavelengths of the white light so that a band of " rainbow colours " were produced on a screen placed in a suitable position. The rainbow colours, which we know as the visible spectrum, could be re-combined to form a patch of white light. Further, if some of the spectrum is blocked out, for instance, by allowing only the red and green parts to re-combine, then the apparent colour is yellow, the colour half-way between the original two colours.

E. H. Land repeated this last experiment using two different sections from the yellow part of the spectrum. As would be expected the result was a yellow patch of light. He then took the Long and Short Record that he had made; passing the longer yellow light through the longer record and bringing it to focus on a screen.

The picture was in yellow monochrome according to the densities on the black and white transparency. He then passed the shorter yellow light through the Short Record and brought it to focus exactly superimposed on the other picture. Now instead of a monochrome yellow picture all the coloured objects depicted were *in their natural colours.* Red objects were red; yellow were yellow; green, green; blue, blue; purple, purple; brown, brown; and more surprising, white was white and grey was grey.

For further research into this chromatic phenomenon Land transferred the transparencies to a pair of projectors mounted side by side and focused onto a screen. Instead of the nearly monochrome light of the Newton experiment he used light filters; these pass a much wider band of wavelengths. So long as the Long Record was illuminated with a filter transmitting light of a longer wavelength than the filter being used to illuminate the Short Record there was colour on the screen. Further, he found that if when the Long Record was illuminated with a red filter and no filter at all (white light) was used for the Short Record the screen was fully coloured. In the case of the last experiment it has been found possible to record the coloured picture produced on the screen upon an ordinary normal coloured photograph; but, in the cases when smaller parts of the spectrum are used, the screen, though it appears coloured to the eye, does not record on the colour film; thus illustrating the great adaptability of the human eye.

In 1959 Land demonstrated a whole series of experiments using projectors to the American Academy of Sciences; these are recorded in the proceedings of the Academy.[1]

Mr. David Grey, a colleague of Dr. Land made a monochromator and together they examined combinations of wavelengths from the whole visible spectrum. From these results they have found the limits in producing colour; charts illustrating these and other measurements are included in Land's " Experiments in Colour Vision ".[1]

Apparatus required to repeat the experiments using filters

To make the negatives of the Records, Land used a process camera. This type of camera divides the light, after it has passed through the lens, into two parts by means of half-silvered prisms.

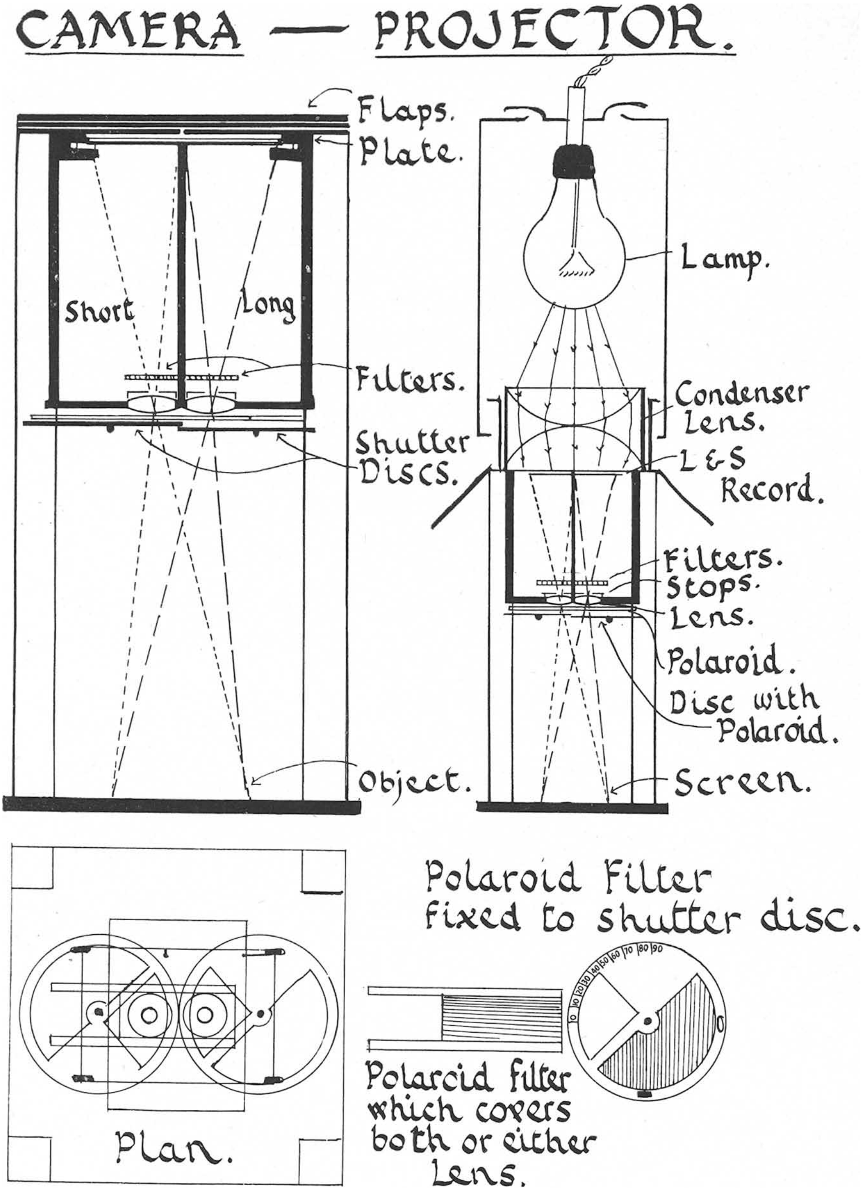

CAMERA — PROJECTOR.
Flaps.
Plate.
Short
Long
Filters.
Shutter
Discs.
Object.
Lamp.
Condenser
Lens.
L & S
Record.
Filters.
Stops.
Lens.
Polaroid.
Disc with
Polaroid.
Screen.
Plan.
Polaroid Filter
fixed to shutter disc.
10 20 30 40 50 60 70 80 90
0
Polaroid filter
which covers
both or either
Lens.

Fig. 4.

Fifty per cent is reflected through the red filter onto the Long Record negative, the other 50 per cent is reflected through the green filter onto the Short Record negative.

To produce the combined image of the two positive records on the screen he used a pair of identical projectors fixed side by side. In front of each projector's lens are fitted a pair of polaroid filters (polaroid itself is one of Land's important discoveries). One filter remains stationary, while the other can be revolved. When they are orientated in a parallel position the maximum amount of light is passed; as the filter is turned less light passes until, when crossed, no light is transmitted. By this means the amount of light reaching the screen from each lens can be controlled.

To build the apparatus it seemed that a pair of identical lenses was necessary. The only pair that I possessed with a suitable focal length were the objectives from a pair of opera glasses. These had a focal length of 105 mm. and were only partly corrected. From the illustration (Fig. 4) it will be seen that I made a camera, divided into two compartments, and fitted to a stand so that it had a fixed object-lens-image distance. One of the lenses produces an image of the object on one half of the plate, while the other lens forms a second image on the second half of the plate. It could be argued that this arrangement is similar to that used in a stereoscopic camera and that the twin negatives are not strictly identical, but when a two-dimensional object, e.g., a coloured picture, is used with a small stop this difference is insignificant.

When making the negatives, the camera is used in the dark-room; four flaps cover the plate during exposure. The size of the plate is $2\frac{1}{2}'' \times 3\frac{1}{2}''$. During exposure the plate, emulsion side downwards towards the lens, rests on four clips, the thickness of the plate from the bottom of the recess. The positive transparency rests on the bottom of the recess the clips being turned one side out of the way; the positive faces upwards away from the lens. In this way the emulsion/lens distance remains the same. Below the plate recess on the long side is a long pin and on the short side is a short pin: during the exposure these shadows record (see Fig. 5). They are a great help in placing the positive in the correct position.

One side of each compartment opens to allow access to the back of the lens so that the stops or filters can be changed.

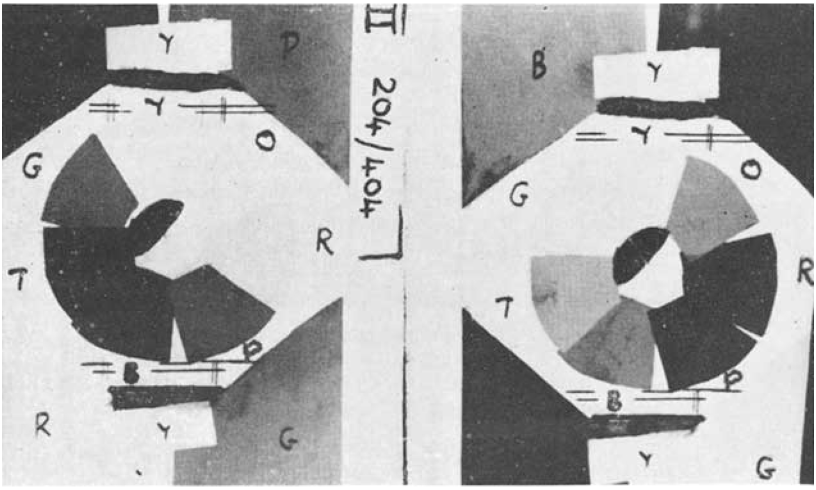


Fig. 5 *The Long and Short Record. Plate II.*

To the side of each lens is a disc so made that one quarter is open, a second quarter is filled and acts as a shutter, while the other half is filled with polaroid. A rectangular polaroid filter is so arranged that it can cover both lenses or each lens in turn. This filter and the filters in the discs are so orientated that when they are parallel the maximum amount of light is transmitted. As the disc is turned less light can get through, until, the disc being turned 90 degrees, the filters are crossed and no light is transmitted. The discs are calibrated in degrees and it is useful to use this scale to indicate the amount of light being transmitted.

To use the camera for projection the flaps at the top are left open. The positive is placed in the recess; upon this is placed the condensing lens. The condenser consists of a pair of plano-convex lenses mounted convex side facing convex side. A 2½″ × 3½″ plate requires a 5″ diameter condenser. Above the condenser mount is a ventilated box containing the lamp: this bulb can be adjusted to the optimum position. This whole set-up is similar to that used in many photographic enlargers.[2]

Making a Long and Short Record

In many of his experiments Land used Wratten Filters No. 24 and No. 58. I have for many years been interested in the use of light filters and have built up a complete range of Ilford gelatin filters. Naturally I was anxious to use these. A complete description of these is given in " Colour Filter Book ", published by Ilford.[3]

The Wratten series of Filters is made by Kodak and fully described in " Wratten Color Filters ", published by Eastman Kodak.[4]

These two ranges of light filters are not identical, though by using these two books it is possible to choose many which match in the essential requirements.

Using a camera, I placed on the Long side Ilford 204 Tricolour Red, which absorbs all light below 5800Å and transmits all the longer wavlengths. On the short side was placed Ilford 404 Tricolour Green; this transmits light of wavelengths 4900Å to 6000Å and absorbs most other wavelengths.

The emulsion chosen was Ilford H.P.3, which is panchromatic medium grain with moderate contrast. Full technical information, including wedge spectrogram, filter factors, development, etc., are given in " Technical Information Books ".[5]

The object, a coloured chart (Fig. 5), was illuminated from 5 ft. with two 75 watt lamps, the type with built-in reflectors. The lens stop used was f.25 and the exposure was one second on the " short " side and nine seconds on the " long " side.

The recommended developer at the temperature and the time to obtain a normal negative should be used. If the subject has a short tone range, such as that in Figs. 5 and 6, it will be found that a positive made from Ilford Contact Lantern Plates gives the best results, while in the case of Fig. 7 the gemstones with their highlights have a much longer tone range: in this case I found Ilford Ordinary N30 plates made the best positive.

Using Filters to produce full colour

The first subject from which I made a pair of records was a haphazard arrangement of coloured squares of paper. This was quite successful, but in order to arrange so that the densities of the black and white Records could be easily compared, the chart, Fig. 5, was made. This chart was made from papers from an Ostwald Book (see footnote on the Ostwald Colour System*) from the NA range in which the hues are on matt painted paper. The NA paints have 83·4 per cent saturated colour, 5·6 per cent white and 11 per cent black pigment. In the third chart (record III, Fig. 6)

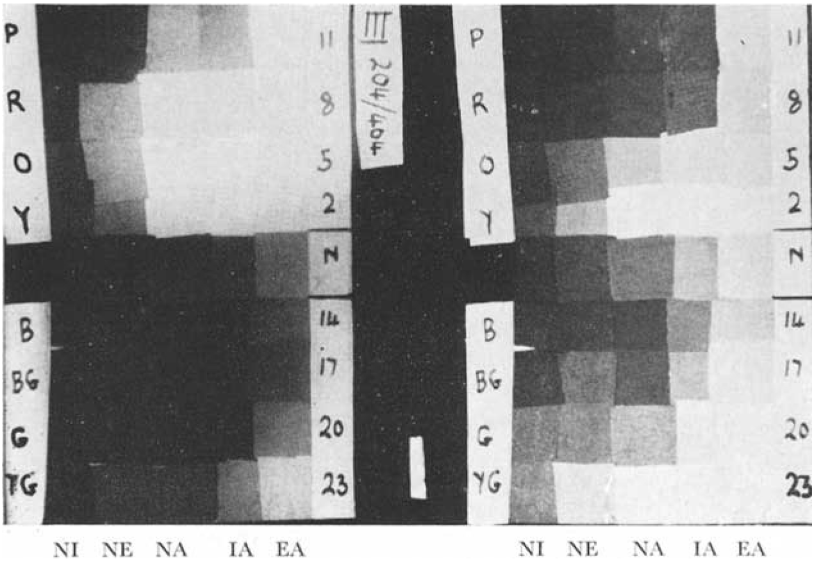


FIG. 6. *Long and Short Record. Plate III.*

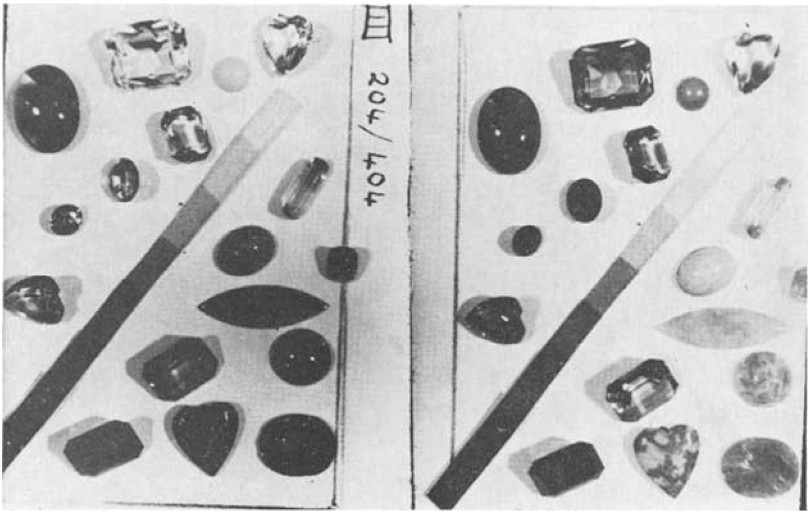
besides the NA Range, which are the brightest colours and are in the centre, above are the IA and EA ranges, which have an increasing proportion of white pigment, while below are the NE and NI ranges, which have an increasing amount of black pigment. The neutral scale runs between yellow and blue.

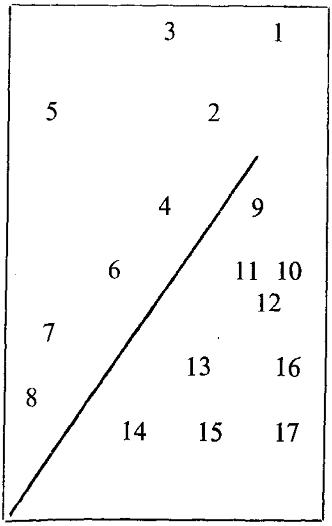
Record IV, Fig. 7 is of a collection of well known gemstones: despite the fact that it shows the undesirable stereoscopic effect, it is useful to use objects of well remembered colours.

To obtain adequate light for the projector I used a 500 watt pearl bulb, which in most cases can be used with a pair of f.25 lens stops. These are the same size as those used for making the negative. When the light is not enough the lens stops can be changed for a pair of f.12·5, giving four times as much light, or even a pair of f.4·5, which give thirty-two times as much.

Using my apparatus to demonstrate the phenomenon, plates II, III and IV were used in the following ten experiments.

The paired polaroid filters are adjusted to compensate the different transmission values of the light filters.





1. Citrine.
2. Coral.
3. Syn. Yellow Sapphire.
4. Cairngorm.
5. Amethyst.
6. Syn. Ruby.
7. Pyrope Garnet.
8. Amethyst.
9. Red/Green Tourmaline.
10. Demantoid Garnet.
11. Turquoise.
12. Bright Green Jadeite.
13. Syn. Blue Sapphire.
14. Syn. Lt. Blue Spinel.
15. Turquoise Matrix.
16. Malachite.
17. Dark Green Jadeite.

FIG. 7. *Long and Short Record. Plate IV.*

Set-Up	*Long Side*	*Short Side*
A.	204 Tricolour red.	404 Tricolour green.
B.	204 Tricolour red.	no filter
C.	no filter	404 Tricolour Green
D.	no filter	204 Tricolour red.
E.	404 Tricolour green.	no filter
F.	607 Spectrum orange.	606 Spectrum yellow.
G.	607 Spectrum orange.	605 Spectrum yellow-green.
H.	607 Spectrum orange.	no filter
I.	606 Spectrum yellow.	no filter
J.	205 Narrow cut tricolour red.	no filter

In Set-up " A ", using plate III the range of colours red, orange, yellow, green and blue are visible: the blues are rather greenish. Now remove Short Filter 404 Tricolour green and it is Set-up " B ", but the colours remain. The blue is true blue, the greens are not quite so vivid and the purple is distinguishable from dark red. Using Plate II, all colours are natural and the pure whiteness of the white is most noticeable. In "B" and Plate IV the colours of all the gemstones are natural despite a red line round part of each stone caused by the stereoscopic effect. The amethyst (5) shows typical bands of colour. The turquoise matrix shows the blue of the stone and the brown of the matrix, while the reds of the ruby and pyrope garnet are easily distinguished.

Set-up " C " with all plates shows monochrome green.

Set-up " D ": this shows near reversal of colours with Plate III. The red, orange, yellow, show up in various shades of green while the greens and blue show as orange and warm shades of brown. Using Plate IV reversal is distinct. The pink coral is bright turquoise blue, the synthetic yellow sapphire looks like the synthetic light blue spinel, the ruby is an apple green, turquoise is light brown and green jadeite brown.

Set-up " E " with all plates gives monochrome green.

Set-up " F " with Plate III. Red, orange, yellow green, but no blues; general overall greyness.

Set-up " G " with Plate III. Red, rather yellowish and blue, greenish.

Set-up " H " with Plate III. Full range of colours; some general greyness.

Set-up " I " with Plate III. Very pale colouring, greens show up best.

Set-up " J " using Plate III. This narrow cut red filter produces bright clear colours, but the red is a little too bright.

Wonderful and interesting as these demonstrations of the phenomenon are, the important thing is that from them Dr. Land has been able to form a new theory on how the eye computes colour from the stimuli it receives.

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1. Edwin H. Land. *Color Vision and the Natural Image. Part I.* National Academy of Science (U.S.A.), Vol. 45, p. 115. 1959.
   Edwin H. Land. *Experiments in Color Vision.* Science America. May 1959.
2. *Manual of Photography.* Ilford.
3. *Colour Filter Book.* Ilford.
4. *Wratten Color Filters.* Eastman Kodak.
5. *Technical Information Books.* Ilford.

* THE OSTWALD COLOUR SYSTEM.—Using the form of a sphere, the girdle is imagined as carrying the fully saturated colours of the spectrum and is numbered 1 to 24. From the top through the sphere to the bottom is a neutral scale A to P: white at the top through greys to black at the bottom. On the surface more white is mixed with the saturated colour the nearer it is to the top, while more black is added to the saturated colour the nearer it is to the bottom. Colours inside the sphere have more grey added according to their nearness to the neutral scale. In this way a colour can be given a position in the colour sphere which can be described by two letters and a number. This system is still used by some paint manufacturers, but for scientific work it has been superceded by the CIE System.

ASSOCIATION NOTICES

ANNUAL MEETING

The 31st Annual General Meeting was held at Saint Dunstan's House, Carey Lane, London, E.C.2, on Friday, 5th May, 1961. Mr. F. H. Knowles-Brown presided.

In commenting upon the work of the year (the annual report having been circulated) the chairman stressed the importance of international co-operation and said that as the synthesis and imitating of gemstones were on the increase it required the maintained vigilance of all gemmological organizations and groups frequently to exchange information and ideas and to continue their researches. The chairman also expressed appreciation of the work of Mr. Trevor Solomon whilst he was chairman of the Midlands Branch.

The following officers were re-elected:—

President, Sir Lawrence Bragg, F.R.S.
Chairman: Mr. F. H. Knowles-Brown.
Vice-Chairman: Mr. N. A. Harper.
Treasurer: Mr. F. E. Lawson Clarke.

Miss I. Hopkins and Messrs. E. H. Rutland and W. C. Buckingham were re-elected to serve on the Council.

Messrs. Watson Collin & Co., chartered accountants, signified their willingness to continue as auditors to the Association.

MIDLANDS BRANCH

The annual meeting of the Midlands Branch of the Association was held at the Imperial Hotel, Birmingham, on Friday, 21st April, 1961. Mr. A. E. Shipton presided.

In his report on the work of the year Mr. Shipton referred to the continued confusion in the jewellery trade about the use of the word " Topaz ". It was still extensively misused. There was the complication of the general use of the term " topaz " in Germany when citrine or golden quartz was sold. The amount of topaz proper which was used by the trade was very small. Mr. Shipton thanked the committee of the Branch for their help during his term of office.

Mr. W. W. Bowen was elected Chairman of the Branch, in place of Mr. Shipton who had been elected as Midland Region Chairman of the British Jewellers' Association, and Mr. J. Shaw was elected Vice-Chairman and Secretary. Mrs. M. Middleton and Messrs. K. Hoskyns, J. Rossiter and S. F. Watts were elected to serve on the committee.

GIFTS TO THE ASSOCIATION

The Council of the Association gratefully acknowledges the following gifts:

Specimens of synthetic emerald crystals produced by Professor W. F. Eppler and presented by him.

Welcher Stein is das? from S. Buzalewicz, Warsaw.

TALKS BY MEMBERS

Blythe, G.: " Gemstones ", Church of England Men's Society, Leigh on Sea, 11th April, 1961. Canvey Dining Club, 21st June, 1961.

Weller, C. J.: " Gemstones and their imitations ", St. Mildred's Guild, Croydon, 7th May, 1961.

NORWEGIAN GEMMOLOGICAL ASSOCIATION

The Norwegian Gemmological Association has recently elected Mr. A. Andersen, of Tonsberg, as their President. Mr. A. Oiesvold, Aarnes, has become Secretary and Mr. B. Petterson, Oslo, has been appointed Treasurer. The Officers who have retired are Messrs. H. Myhre and G. Sunde, both of Oslo, who played a leading part in the formation of the Association. They continue as members of the Council of the Norwegian Association and resigned their offices to allow younger members to play a leading part.

MINERALS OF BRITAIN

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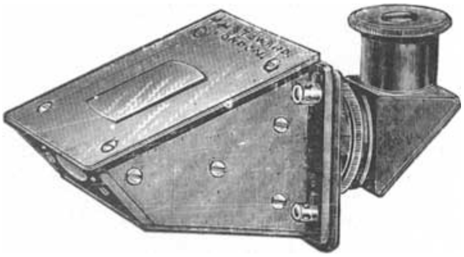

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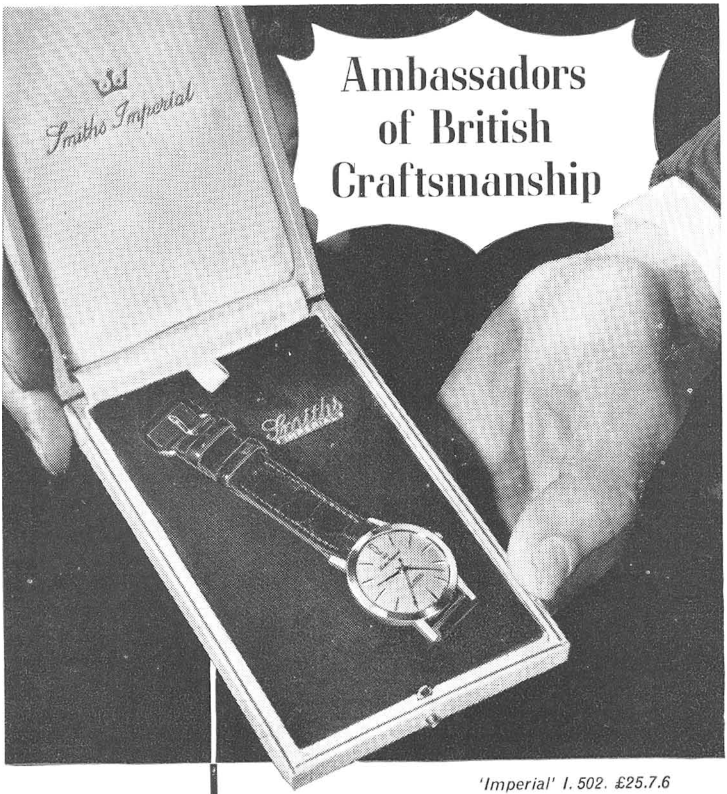
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Printed by F. J. Milner & Sons Ltd., Brentford and London