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GEMMOLOGICAL EXHIBITION 1948

Reviewed by *Gerald Carr*

COULD they do it again?

It was with this thought in my mind that I walked into the Goldsmiths' Hall on May 4th, the opening day of the second exhibition by the Gemmological Association. I was wondering if the Association could repeat the success of their first big exhibition. Had that been partially obtained because it had never been done on that scale before? After all, there was little fresh that could be shown in gems. No startling discovery of a new variety could be expected, no novelty for the next season.

In a few moments I realised that the Association had done it again—and better. An exhibition of gemstones had been presented which was not only fresh but lovelier, more interesting than the previous one. A year ago I had been fascinated by the beauty of many of the exhibits. Now I was fascinated by the beauty of the whole exhibition.

Queen Mary was an early visitor and the officers of the Association were presented to her. It was no wonder that she, with her expert knowledge of jewels and antiques, spent almost an hour looking at the exhibits. Or that she wanted to handle and feel the perfection of some of the delicate pieces of carved jade.

Every display case presented a different aspect of beauty and interest in its exhibits which reached a peak in the centre stand with its remarkable collection of flawless gems, large in size and fine in colour. Here were stones that would be the pride of any collector. As I looked at them, it occurred to me that the finest stones are too good to be with anything less fine than in an ornament of the best design made by skilled craftsmen. Such gems as the 68 ct. Brazilian topaz with its square cut or the oval fancy cut topaz from the Urals or the lovely black opals and beryls, were sufficient unto themselves, needing nothing else to emphasize their splendour. So with the Spodumenes—what an ugly name for such fine clear examples—which included a unique Kunzite, the pinky 93 ct. tourmaline or the 67 ct. aquamarine.

A principal attraction of the Exhibition was a fine collection of rubies, sapphires and emeralds. The corundum varieties were grouped according to locality, and visitors were able to compare Siam with Burma rubies, Ceylon sapphires with those from Kashmir, Siam and Burma. Ingeniously lighted were a specimen Star Ruby and a magnificent deep blue Star Sapphire.

A section of the Exhibition.

Her Majesty Queen Mary was an interested visitor on the first day.

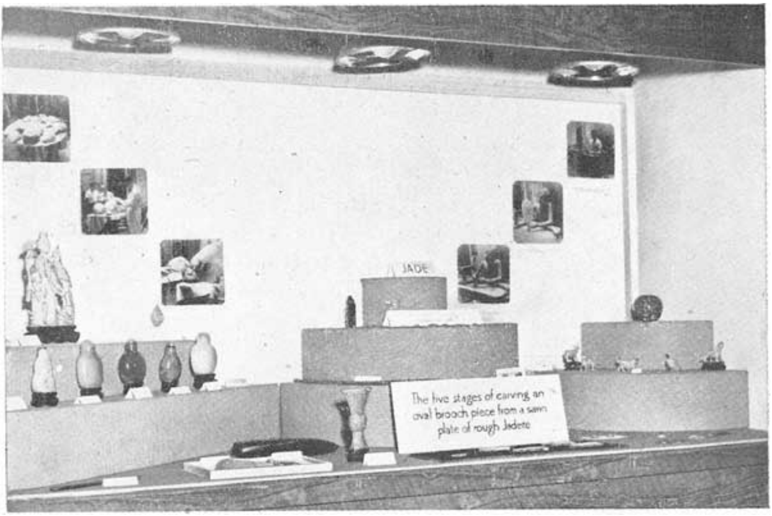
Yet it might be unwise to despise the work of the craftsman, for after all, though nature's forces first provided these stones, it was his skill in cutting and polishing that had brought them to perfection. So that even in the more common mineral such as quartz, the beauty of life had been uncovered by his hands.

How much more, perhaps, was the craftsman to be praised in the examples to be noted in the jade collections. And this does not mean only the modern craftsman who has the resources of science and the tools of a century of industrialisation. A collection of jade ornaments, emblems and clubs showed the art that could be attained by a native working without any metal. It might take him a lifetime to finish, but the objects made by those New Zealand Maories have a permanence far extending a human's span. Though even to-day the exact significance of the " hei-tiki " ornaments is not known, their appeal is instantaneous. The war clubs, also, or " mere pounamu," apart from their obvious efficiency and excellence as weapons, are fine examples of the craft of necessity which produces functional beauty.

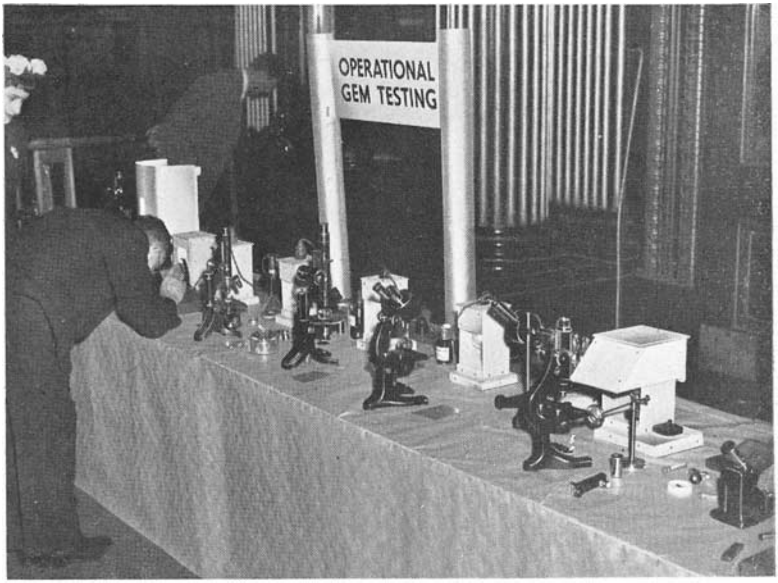
Then there were the examples of how man had used his artistic imagination in making the natural patterns of nephrite fit into the things he wanted to make, such as snuff bottles or the realistic green apple, even slightly bruised, that made one think of the cheapness of Victorian wax imitations. Delightful, too, were the jadeite miniature carvings of elephants which demonstrated the range of colour.

Star stones always have a special interest, and here the Gemmological Association had a cleverly arranged rotating collection, each stone coming below a spotlight to display its stars. The stones included a 12-ray sapphire, a cat's-eye, garnet and—a neat piece of workmanship—a rose-quartz doublet. Just to remind visitors that gemstones often do finish up in a mount, one display case showed examples of this. It included the unusual example of a sphene and diamond ring and brooch and also had a lovely pink topaz in a gold bracelet.

Another case had a collection of cut sphene and showed interesting examples of natural opal formations that resembled an oak tree, a boot and other objects. While here again man had made nature's " lapses " serve his purpose in carving vases and bottles from amethyst, aquamarine and tourmaline.



Jade window shows varieties of colour ranges and styles of carving.



An operational laboratory enabled visitors to make intimate observations of gem testing technique.

Then in this Aladdin's cave of gems, one saw the great possibilities existing in even a single specie because of the great colour variations. There were beryl stones ranging from white to brown and pink to sea green, and corundum, too, in many colours.

In that case also was a 26 oz. piece of polished amber. A lovely piece of mineral and one that was recalled by the Royal visitor to the exhibition the moment she saw it. For Queen Mary had presented it to the Geological Survey and she was interested to see it once again.

Queen Mary also expressed surprise at the wide variations of colour and the unfamiliar colours found in the minerals exhibited in this case. She, too, in her tour round the exhibits with Dr. Herbert Smith, Dr. G. F. Claringbull and Mr. B. W. Anderson as her expert guides, had been particularly interested in the star stones and the jade, especially the snuff bottles, of which she has a collection.

Though these things were, perhaps as I thought, the high lights of the exhibition, there were many others of great interest. There was the comprehensive diamond exhibit with its strange collection of " freak " diamond crystals described by complicated names which mean all to the expert, such as " interpenetrating cube " and " twin octahedra." To the expert they were fascinating examples of nature's pranks.

The Association even allowed synthetics to present themselves there, though these man-made " gems " seemed out of place amid the splendours of the natural and large sized stones. There was an example of synthetic rutile, the only one in Britain, together with other imitation and synthetic stones dating in some cases from the first specimen made in the last century.

Finally, on many of the stands one could indulge in a grand orgy of gem testing and comparison. There were batteries of Chelsea colour filters, Rayner refractometers, spectroscopes, and other gem testing equipment and a display of elements periodically classified. And a helpful touch to the budding gemmologist was a stand showing what was needed and how the set-up might be arranged of a modest gem testing laboratory. Can the Gemmological Association repeat its success again? I think so.

* * *

The Council of the Association expresses its deep appreciation of help received from the following:—

ORGANIZERS: G. F. Andrews, R. Webster and H. Wheeler.

STEWARDS: Messrs. B. W. Anderson, S. F. Bones, L. F. Cole, A. T. Kemp, E. R. Levett, R. K. Mitchell, Dr. W. Stern, F. Ullmann, D. Wheeler and A. Farn.

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And to the Wardens of the Worshipful Company of Goldsmiths for so kindly placing the Hall at the disposal of the Association.

GEMSTONE INCLUSIONS

By DR. EDWARD GUBELIN, C.G., F.G.A.

GEMSTONES are generally considered either as a means of adornment or as a sort of capital investment. Very few people realize that in these jewels they have the revelation of natural monuments of a past that reaches back beyond the excavations of archaeologists in Mexico, Egypt and Mesopotamia, to many, many thousands of years. To those who are able to explore their secrets precious stones relate a story as interesting as that of the huge Pyramids erected by the Pharaohs at Luxor, and it would seem that their sublime internal spheres might best be called " The Fingerprints of God." If we wish to study the history of the origin of gems and to understand more fully the progress of our own mother earth, we must delve into the great book of Nature. Due to their great durability, precious gems are the finest proof of the continuous and timeless epochs of development to-day as well as in the illustrious ages when the old Kings of Egypt were flourishing in their splendour. Careful research and study of gems is as valuable to mankind as the ancient history of the Egyptians, and each small inclusion left behind from the primaeval age gives us a sign of its origin and creation, which is vitally important to natural history. The microscope alone is able to probe their innermost secrets and it is recognized as one of the most important instruments for revealing the internal features of gems. Through the eyes of this remarkable assistant we are able to see those peculiar characteristics and formations of other minerals, liquids, gas bubbles, flags, and feathers which we term inclusions and which are extremely important for distinguishing natural and synthetic stones, and for ascertaining a stone's provenance. On these guardians of the age-old secrets we shall to-day place our attention.

Of course, it would be impossible to give you here and now a complete layout of all the characteristics of inclusions which one could meet during the study of genuine stones and their synthetic or artificial counterfeits. Thus, the best way of gaining knowledge

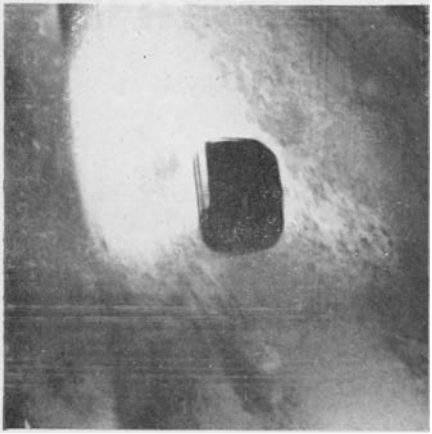


Fig. 1.

Well developed idiomorphous Rutile crystal in a Burma Corundum. 100 ×

Fig. 2.

Well developed crystals of Rutile in a Burma Ruby. 75 ×

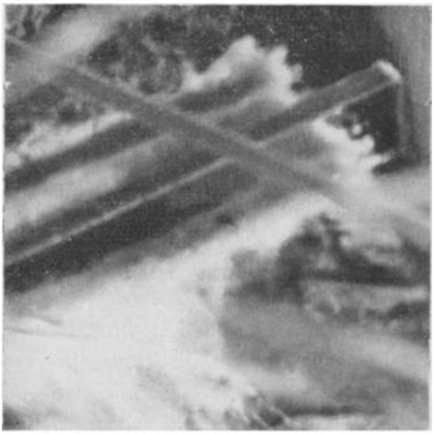


Fig. 3.

" Venus-hair," i.e. Rutile needles in a Quartz. 120 ×

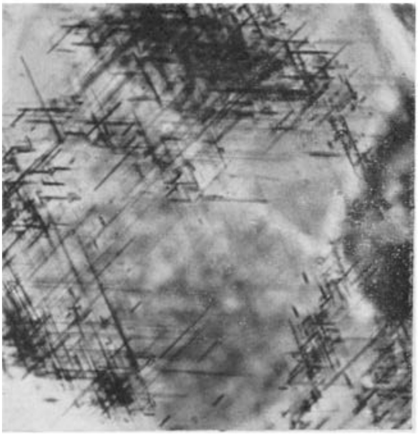


Fig. 4.

Patches of Rutile needles in a Burma Ruby. 75 ×

is for each one to examine personally as many stones as possible and through this experience will quickly follow an ease in distinguishing the natural from the synthetic, and eventually one may quite easily know them by their typical marks of their place of origin. In this following lecture I shall deal with the most important aspects of this question and those problems which will be most likely to occur with you.

We owe a great debt of gratitude to the researches of Sir David Brewster, H. Vogelsang, H. Geissler and Henry Clifton Sorby, who were among the first to discover the great importance of inclusions in the study of minerals. They established the fact that in many gemstones one could observe various liquid inclusions consisting of carbonic acid, water, or carbon dioxide and water.

In connection with this brief lecture and description of inclusions I feel obliged to mention one authority—Prof. Dr. H. Michel from Vienna—who is worthy of the outstanding merit of being the first pioneer to recognize the gemmological importance of the many inclusions in gem stones in differentiating between natural and synthetic stones. He dismissed the idea that inclusions were only flaws on the beauty of a stone and turned scientific interest on to these so-called imperfections. He was a true promoter of modern investigation of inclusions, and from his research substantial facts have been effectively developed.

An inclusion is any substance incorporated in another material—particularly in a crystal. Inclusions may be of the same chemical compound as the enclosing mineral, foreign chemical compositions or empty cavities. Perfect conditions during the growth of a crystal such as uninterrupted growth, absolutely pure mother-liquor, steady pressure and heat, etc., are very rarely found in nature. Therefore any gem may be considered as having some imperfection, even if it be so minute as to be hardly visible to the human eye.

While the fanciful inclusions, the liquids, the crack-like formations and irregular feathers within gemstones fire the imagination and stimulate one's curiosity, they represent a scientific value over and above their fascinating appeal. Mineralogists and gemmolo-

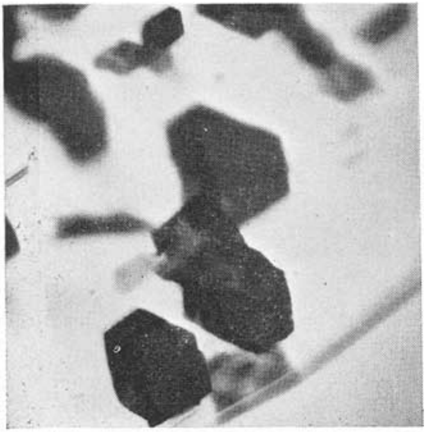


FIG. 5.

Biotite scales in a Peridot. 50 ×

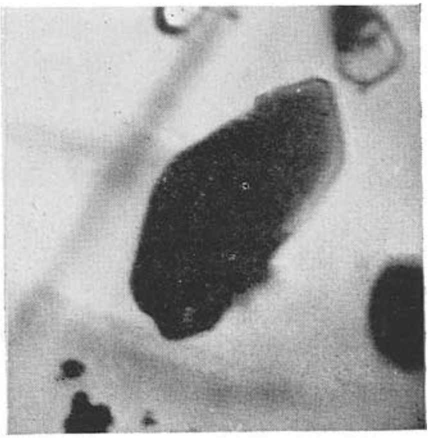


FIG. 6.

Scale of Phlogopite in a Ceylon Sapphire. 75 ×

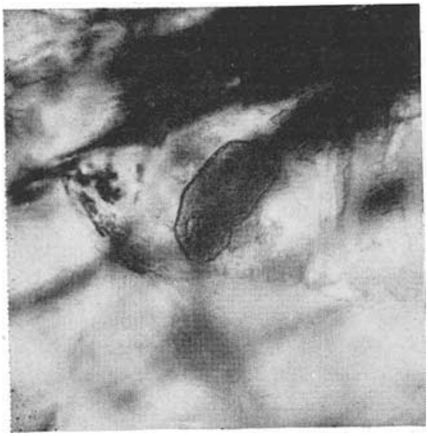


FIG. 7.

A xenomorphous flake of mica in a Siberian Emerald. 50 ×

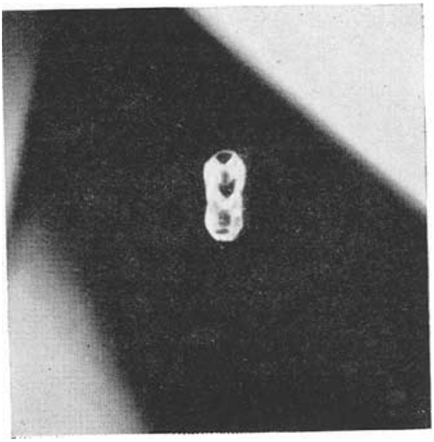


FIG. 8.

Resorbed Quartz crystal in a Diamond. 100 ×

gists will be interested in the genetic problem of the occurrence and from this point of view inclusions may be classified as:—

Pre-temporary inclusions which consist mostly of solid enclosures—crystals and amorphous or earthy matter—whose substance belonged to a previous phase of formation. As a gem grows, layer after layer of molecules is deposited on its surface, i.e. the growing planes, and any foreign minerals which exist in the mother-liquor may become embedded.

Con-temporary inclusions may either be drops of the mother-liquor or rising gas bubbles which were surrounded by the growing host mineral. Also minerals belonging to the same or foreign mineral species may crystallize simultaneously with the host mineral and deposit themselves on its accretion faces. Such impurities which come in contact with faces of the growing jewel are finally enclosed by succeeding molecules which build up around the pollutions. This is called a formation of inclusions during growth.

Post-temporary inclusions develop after a mineral has formed, when they may be produced by chemical alteration of certain parts or areas or by recrystallization in a different form of the chemical element of which the mineral is composed, or internal cleavage cracks may form long after the gem has been gathered from the earth.

As the geologist or mineralogist will study gem inclusions in minutest detail for their revelations of age-long development, the jeweller and gemmologist will appreciate them for their highly diagnostic importance and conclusive distinction between genuine stones, and between these and their counterfeits. Thus the enchanting world of inclusions appeals to the sense of beauty and imagination of the gemmologist, and offers him as well very valuable opportunities for practical application. Consequently, he will especially study and rely upon the phenomenological pictures of internal paragenesis.

What, then, is the nature of inclusions found in precious stones? We may distinguish between the following types:

1. Solid Inclusions (Inclusions of same or foreign minerals).
2. Internal Cavities (Liquid or gaseous inclusions).

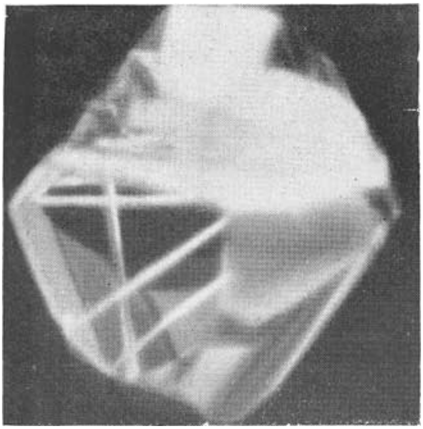


FIG. 9.
Included corundum crystal enclosing rod-like foreign minerals, in a Ceylon Sapphire. 100 ×

FIG. 10.
Opaque corundum crystal surrounded by a liquid feather in a Siam Ruby.

FIG. 11.
Cluster of Pyrites in an Emerald from Colombia (El Chivor Mine). 40 ×

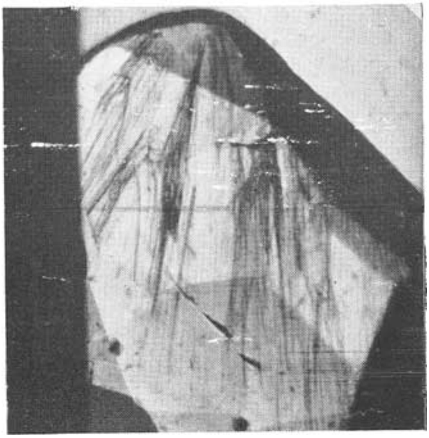


FIG. 12.
Byssolite fibres in a demantoid. 40 ×

3. Feathers and Flags (Cracks and fissures filled with gas or liquid).
4. Growth Phenomena (Zonal structure and irregular distribution of colour).

These internal peculiarities, which are used for purposes of distinction, are thus the traces imprinted upon the stones by the process of formation. This process not only differs in the case of natural and synthetic stones, but is somewhat different in stones of the same species and variety according to their place of origin. Moreover, these inclusions are also typical of the various species themselves.

1. **Solid Inclusions** (Inclusions of same or foreign minerals) may be of the most varied form, type and colour. In distinguishing between those enclosed minerals the difference in nature is not of general importance, which is fortunate, as this usually presents a difficult problem. Sometimes they are large and distinct, and can be referred to known mineral species, but more generally their true nature is difficult to determine. The term " microlites " is often used to designate the minute enclosed crystals ; they are generally of needle-like form, sometimes quite irregular, and often very remarkable in their arrangement and groupings. Crystallites is an analogous term to cover those minute forms which have not the regular exterior form of crystals, but may be considered as intermediate between amorphous matter and true crystals. Sometimes included crystals can readily be identified by means of their habit, their colour, or their arrangement and form of crystal faces. It has been possible up to date, therefore, to ascertain the existence of the following foreign minerals in gemstones:

1. Coarse crystals or long slender needles of Rutile. (Figs. 1-4.)
2. More or less good idiomorphic tablets of mica (biotite, phlogopite, muscovite). (Figs. 5-7.)
3. Well-developed crystals of quartz, corundum, pyrite, sillimanite, byssolite, zircons, garnets, magnetite, diopside. (Figs. 10-16.)
4. Zircon inclusions with radio-halos. (Fig. 17.)
5. Stalked actinolite, hornblende and augite. (Figs. 18-20.)
6. Rhombohedral iceland spars or precipitation of calcite. (Figs. 21-23.)

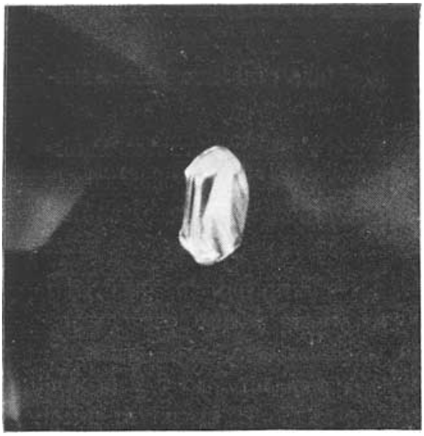


FIG. 13.
A zircon crystal embedded in a Diamond. 100 ×

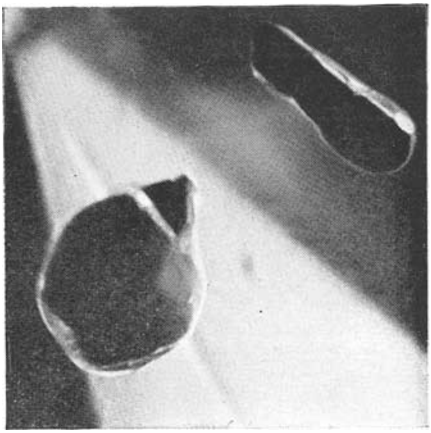


FIG. 14.
Pebbles of Garnet in a Diamond. 100 ×

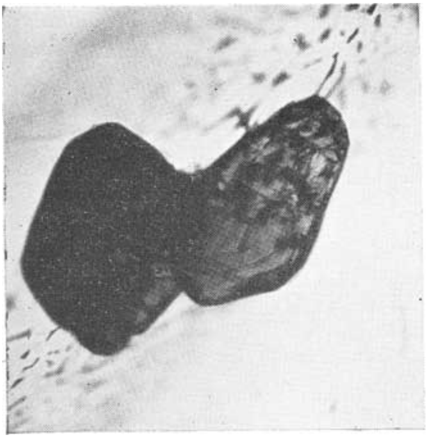


FIG. 15.
Rounded grains of garnet in a Ceylon Sapphire. 125 ×

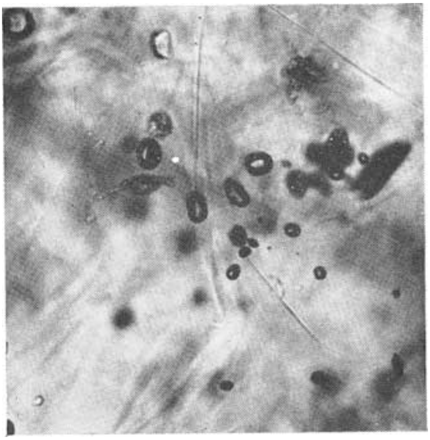


FIG. 16.
Diopside and zircon crystals and swirls in a Hessonite. 75 ×

In addition to these most frequently occurring foreign minerals one may encounter:

> Prismatic crystals of tourmaline, tabular crystals of hematite and ilmenite, sharply defined octahedrons of spinel and diamond, dendritic formations of manganese and iron oxides, moss-like inclusions of chlorite, further on anatase, goethite, yellow copper ore, and so on. (Figs. 24-27.)

The most interesting among these inclusions are the rutile needles and the zircon inclusions. (Figs. 28, 29.)

The rutile needles appear chiefly in sapphire and ruby, where they lie according to the hexagonal structure, i.e. parallel to the prisms of the second order of these stones at angles of 60 degrees and can easily be distinguished from inclusions of a different nature. These rutile needles serve as the best hall-mark of the genuine corundum in contrast to the synthetic. Arranged very closely together and of very delicate habit, they are one cause —so-called " silk "—of the six-rayed stars in star-sapphires and star-rubies. Even in their precious shell the enclosed zircon crystals remain radio-active, emitting radium rays and thus producing a radio halo in the surrounding substance. Such zircon inclusions, with radio halos, are a typical mark of corundums from Ceylon.

In the shape of the bounding surface it is often possible to find crystal faces which show that at this point one small idiomorphous crystal is enclosed by the other, called the host. Such well-formed outlines permit the crystal to be classified according to crystal system. Often, on the other hand, the shape is that of ellipsoidal or rounded grains with merely one crystal face here and there, or even quite without any. The boundaries between these solid mineral inclusions and the host are sharply demarcated, and if the refraction of light is about the same, few or no total reflection phenomena present themselves ; that is to say, they are transparent. The colour may vary greatly. With dark ground illumination it is frequently possible to observe the red interior reflections of the hematite tablets. In the case of a colourless mother-gem there is, of course, no confusing element and the inclusion is visible in its own colour.

Among solid inclusions, microscopic, irregularly formed glass inclusions play a special part. They resemble in shape an irregular

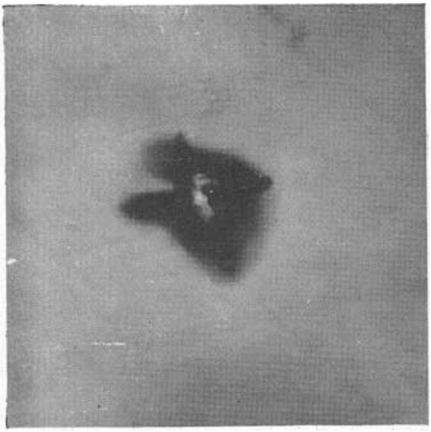


FIG. 17.

Radio-active zircon surrounded by a radio-halo in a Ceylon Sapphire. 25 ×

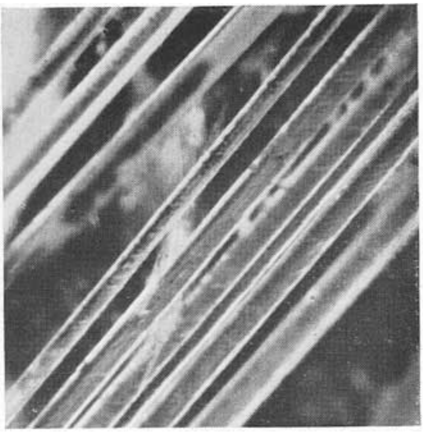


FIG. 18.

Rods of Actinolite in a Quartz. 20 ×

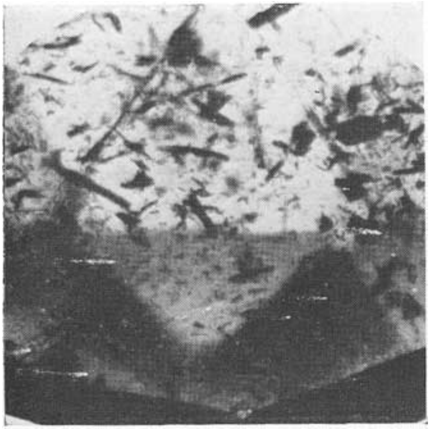


FIG. 19.

Amphiboles in an Almandine from Trincomali, Ceylon. 40 ×

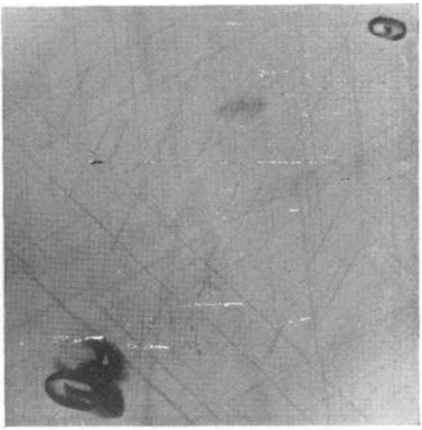


FIG. 20.

Needles of an Amphibole variety and grains of radio-active Zircon in a Ceylon Almandine. 25 ×

solidified drop of previously molten glass and may very often remind one of the gas bubbles in artificial materials. They provide sure proof that the minerals in which they are found have solidified in the presence of a molten mass. Glassy inclusions of this sort are sometimes embraced by obsidian, peridot, feldspar, and garnet.

Besides all the afore-mentioned inclusions there exists another sort of most curious solid inclusion, which is the product of post-growth precipitation within the host mineral and sometimes indicates the commencing of a chemical and subsequent alteration of the mineral from its inside. (Fig. 30.)

2. **Internal Cavities.**

A.—Liquid Inclusions.

Liquid inclusions are of very different nature, both in origin and appearance. They include the solution from which the gem was formed, or water, carbon dioxide, carbonic acid and other liquids. Such cavities arise in a growing crystal when in the process of growth free spaces remain open and are enclosed by the growing substance in accordance with the crystallographic laws. The law of the growth of a crystal is portrayed in its confined form by crystal faces which coincide with the crystallographic directions of the mineral ; this same law asserts itself in the enclosure of a free space. Once again crystal faces are formed, but these are turned inwards in the embracing crystal and surround the cavity in the form of its walls. Such a cavity walled by crystal faces is called a "negative crystal." (Fig. 32.) These negative crystals appear in many gems and their filling can be of varied nature. It is either a gas or a liquid (it is doubtful that a true vacuum ever occurs in a mineral ; during formation there should be some gas present—if only water vapour or carbonic acid—to fill any such space), and in both cases these have no colour of their own, so that they are seen in the hue of the enclosing mineral. In the case of a gas filling the total reflection phenomena at the boundary of host and gas are so strong that broad dark seams appear, or the negative crystal may become altogether black and opaque. In the case of a liquid filling the difference in the refraction of light is not so great, so that the black reliefs are much narrower. Liquid inclusions need not always contain pure solutions, but they may also be a mixture of liquid and gas, and consequently one may clearly recognize rounded gas

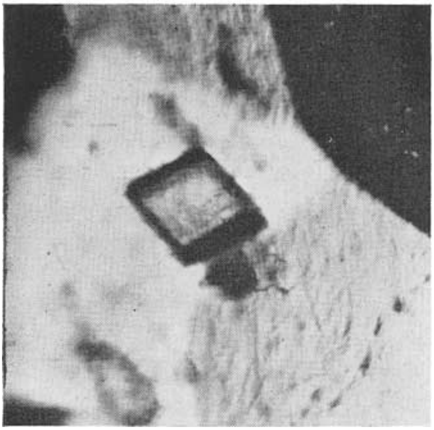


FIG. 21.

Idiomorphous rhombohedron of Iceland spar in a Colombian Emerald (Muzo Mine). 75 ×

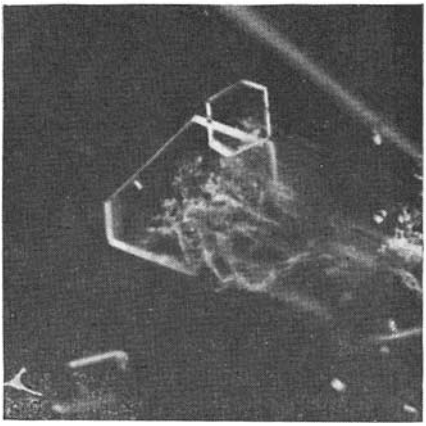


FIG. 22.

Calcite tablets in a Ceylon Sapphire. 75 ×

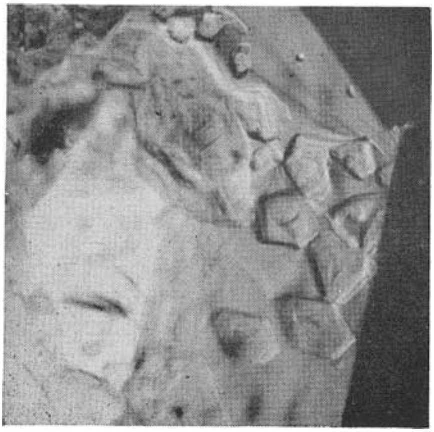


FIG. 23.

Precipitation of calcites formed by exsolution in a Colombian Emerald (Muzo Mine). 50 ×

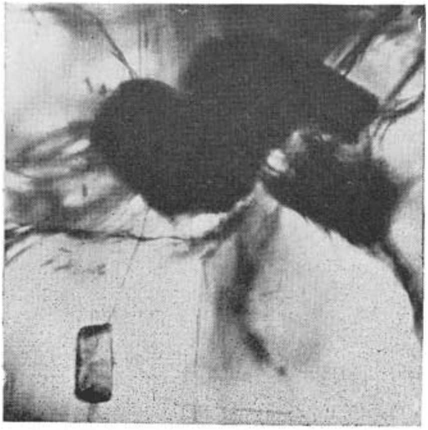


FIG. 24.

Brookite crystals in a Cordierite. 30 ×

vesicles which float in the liquid, such as in a spirit level, and which are called " libella " in liquid inclusions. Well idiomorphously developed negative crystals are not the rule ; on the contrary, irregularly formed cavities are more usually encountered in gemstones. (Fig. 33.)

To determine the chemical constitution of these liquid inclusions is of the first importance for both mineralogy and gemmology. It is now known that the great majority consists of water or dissolved salts—no doubt tiny quantities of the mother lye in which the stones came into existence. Some also contain gas in a content consisting mainly of water, part of which has been proved to be liquid or gaseous carbonic acid. (Fig. 34.) Chemistry has ascertained that the " critical temperature "—e.g. the temperature above which carbonic acid can exist only in the gaseous state—is that of 31.1 degrees C. By various other methods (spectral investigations) as well, the presence of carbonic acid in negative crystals has been set beyond doubt. (Fig. 35.)

The gaseous phase does not always occur in the form of a bubble. If a quantity of liquid diminishes in a cavity, the liquid may take the shape of a drop surrounded by a border of vapour against the walls of the enclosure. The gas may fill wide parts of the space and such inclusions seem to be typical for topaz and tourmaline and beryls.

As I have told you previously, these liquid inclusions, which are such a fascinating and important feature within gemstones, are not always pure, and especially interesting are inclusions which consist of two or more non-miscible liquids in one and the same cavity. The behaviour of the enclosed liquids in the surrounding liquid is very similar to that of gas bubbles. Their shape is usually long, and as a result of very slight differences of light refraction between the individual liquids the borders are very fine. In almost all cases these liquids consist of water and carbonic acid and they may be encountered in practically all gemstones. (Figs. 36-39.)

A still higher development of the filling is provided by the three-phase inclusions. These are cavities which contain the three states of aggregation (e.g. the three phases of matter) at once, that is when one or more crystals and one or more gas bubbles are bedded in the liquid which fills the cavity. Such three-phase inclusions have taken form particularly in beryls and are both the

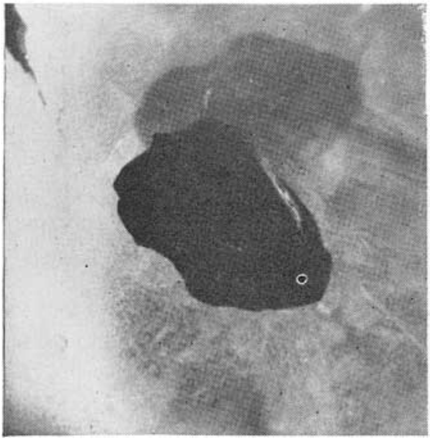


FIG. 25.

Parcel of haematite tablets in a Ceylon Corundum. 75 ×

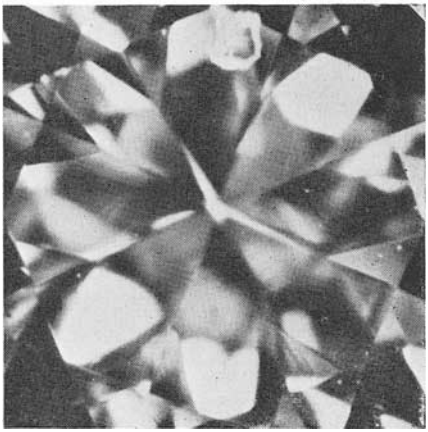


FIG. 26.

Diamond octahedron in Diamond. 100 ×

FIG. 27.

A distorted diamond octahedron in a Diamond. 100 ×

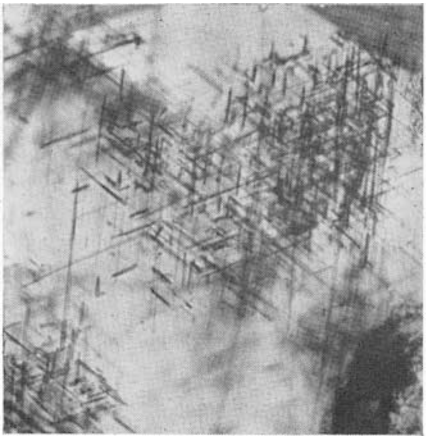


FIG. 28.

" Silk " formed by acicular rutile crystals in a Burma Ruby. 75 ×

most important characteristic for this species, as well as the essential feature for disinguishing between Colombian and Ural emeralds. One never ceases to wonder at the many beautiful forms of these three-phase inclusions, which are such a gorgeous sarcophagus of God's most delicate wonders. (Figs. 40-42.)

Occasionally one may have the lucky chance of finding a gemstone with the very rare type of inclusion in which the included liquid substance is actually in the state of re-crystallization. This interesting process of forming new microscopic crystals of unknown nature often takes place in flat liquid filled cavities in Siam sapphires and chrysolites from the island of Zebirget in the Red Sea. (Figs. 43 and 43a.) The chapter on internal cavities ought not to be concluded without mentioning the ingenious arrangement of parallel, hollow or liquid filled tubes in chrysoberyl which are responsible for the flattering wavy sheen of the cat's eye.

B.—GASEOUS INCLUSIONS.

In natural crystallized stones gas appears only in negative crystals, either alone or with liquid, and in the latter case gives simultaneous proof that the cavity in question contains a liquid. In natural glasses of volcanic origin, such as moldavite and obsidian, in synthetic stones, glass imitations and doublets, there occurs a very special type of cavity—the gas bubble. These gas bubbles trapped in synthetic stones and air bubbles imprisoned in glass imitations and in the conjunction plane of doublets and triplets, are unintentionally mingled with the artificial substance. Because of strong total reflection they are always black with at the most one bright spot in the middle. (Figs. 44, 45.)

In man-made glass the appearance of air bubbles is somewhat different, and therefore it is not difficult to differentiate between natural and artificial glass. Gas or air bubbles occur in synthetic stones in a considerable range of form and size, the bubbles appearing as small black dots either singly or in groups, sporadic medium-sized or more rarely bigger bubbles up to coarse and very large bubbles may often be seen. In addition to these bubbles occurring singly or in groups, one may frequently observe whole clouds of very fine vesicles and the entire stone may be densely filled with small gas bubbles, interspersed here and there by individual bubbles of larger size. In assembled stones (doublets and

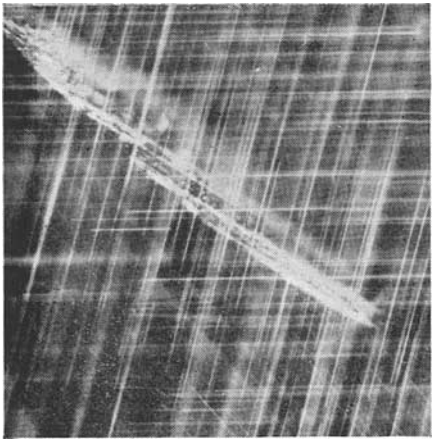


FIG. 28a.
" Silk " consisting of fine tubes in a Ceylon Ruby. 100 ×

FIG. 29.
Radio-active zircon surrounded by a radio-halo in a Ceylon Sapphire. 50 ×

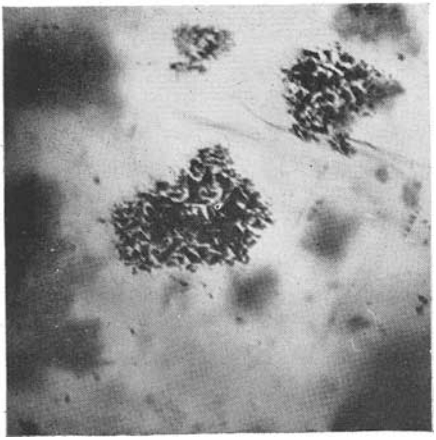


FIG. 30.
Beginning of pinitisation (chemical alteration) in a Cordierite. 50 ×

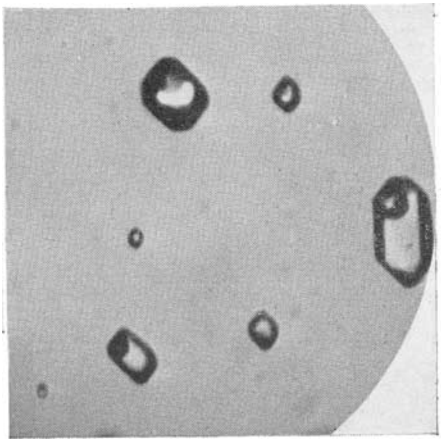


FIG. 32.
Negative crystals filled with liquid and a libella in a Cairngorm. 75 ×

triplets) air bubbles are usually found in the cement layer which pastes the two or three parts of the stone together. These air bubbles always lie in one plane, thus immediately betraying the stone as one which has been assembled. These round or elongated gas and air bubbles are the most typical marks of imitation jewels, whether synthetic or artificial. (Figs. 46-52.)

3. **Feathers and Flags** (cracks and fissures filled with gas or liquid).

Internal cleavage cracks and fractures may also be considered as inclusions. Many of them are more likely to occur after the formation of the mineral than during growth. The lack of cohesion between the atomic planes in certain directions results in cleavages between such planes. External blows or expansion and contraction resulting from changes in temperature may cause a separation to start along a cleavage plane. At other times, a separation which starts to develop along such a cleavage may break across adjoining atomic planes, producing internal fractures or feathers in directions other than cleavage directions. Such inclusions may be increased by alteration after the completion of growth of a crystalline substance. Liquids or gases may enter along slightly developed cleavage planes and alter the chemical composition or molecular arrangement within the stone, thereby forming inclusions. These feathers and flags are of the most varied form, size and position. They either radiate from the surface of the stone or they are shut in on all sides within the stone and cannot develop further. Enclosed air, liquid or newly-separated mineral substance may be found. The liquid is mostly distributed in the form of small drops which may assume the queerest forms. Generally it looks as though the whole flag had been decorated with very finely designed exotic hieroglyphs. The drops of liquid are often most bizarrely shaped or vermiform, hose-shaped, rod-like or formed in the shape of a tube. Whole broad systems of irregular channels of various non-miscible liquids may traverse the gems and may knit the most delicate mesh pattern. No lady's knitting could be fine enough for such a subtle work. The sum total of these drops —which is known as a flag or feather—is often similar to insects' wings in form and finish. If the single drops are studied under very high enlargement small libellas can be found in them. Fine films of air or liquid on the cleavage cracks and fractures are

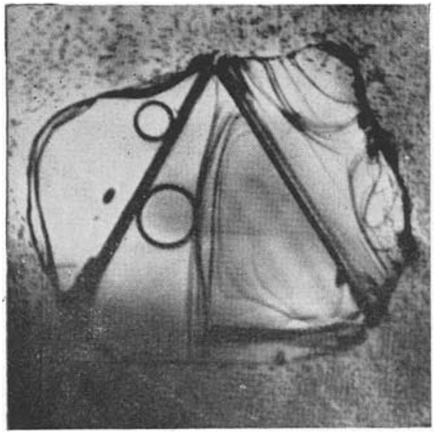


Fig. 33.

Flat cavity filled with liquid and libellae in a Ceylon Sapphire. 75 ×

Fig. 34.

Cavities filled with CO_2 in an Aquamarine at ordinary room temperature. 50 ×

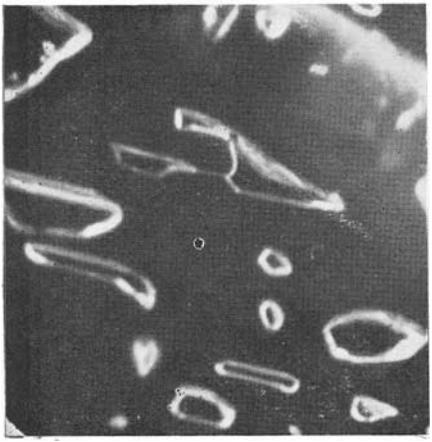


Fig. 35.

Same cavities after Aquamarine was heated above 31.5°C. All liquid carbon dioxide has evaporated (no bubbles visible). 50 ×

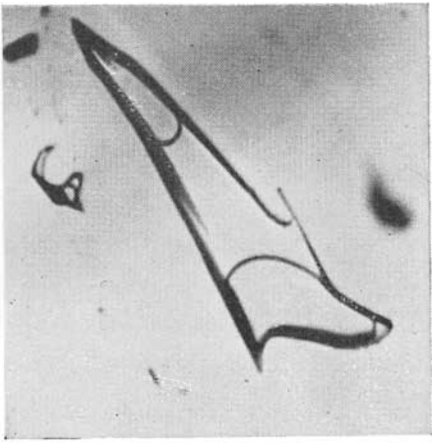


Fig. 36.

Large cavity with non-miscible liquids in a Topaz. 75 ×

noticeable by reason of their total reflection phenomena. If such air or liquid filled fissure be examined under the microscope from above, and by looking perpendicularly through it, nothing at all will be seen except the delicate border of the film. If the stone is turned with its flag so that one may look obliquely through the air or liquid layer from the side, one will notice a brownish hue present. (Figs. 53-60.)

As I have just been talking about the fissures, I would like to mention a peculiarity of Cashmere sapphires—the well-known " haziness " which contributes to the attractive beauty of these stones. This hazy appearance is caused by curious and interesting veil-like formations which consist of wavy filaments reminiscent of a fine tissue woven in a hexagonal pattern, the single twines intersecting at angles of 60 degrees respectively 120 degrees. However, these are not rutile needles, as can be easily established. Increased magnification shows the individual fibres as consisting of tiny and subtle fissures, or hollow tubes of a slightly brownish colour generally lying across the direction of the wavy threads.

In emeralds, air-filled cracks or fractures often have a dendritic design and one has to be careful not to confuse them with enclosed solid inclusions of similar forms. American-made synthetic emeralds, as well as those from the German Dye Trust Industry, display liquid feathers of their own which are very easily recognized and which firmly betray the synthetic origin of these stones. Liquid inclusions shaped as feathers are the most characteristic type found in synthetic emeralds. These appear as most delicate, wisp-like, veil-shaped formations resembling cracked lacquer or scroll pattern. As we are at present dealing with the synthetic emerald I may mention another kind of typical inclusion which is a small, irregularly shaped solid inclusion sprinkled throughout the stone, probably particles of colouring matter. It must always be remembered that it is very easy for an expert to distinguish between genuine and synthetic emeralds as their specific inclusions are so different. (Fig. 61.)

4. **Phenomena of Growth.**

A.—TWINNING.

Crystals of the same nature or also of different substances may so intergrow that the crystallographic axis of one individual is parallel to those of the others. In twin crystals the individuals

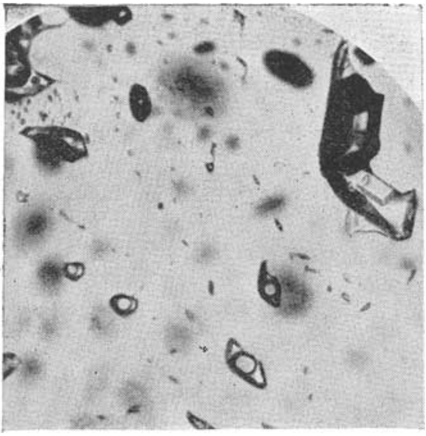


Fig. 37.

Cavities with non-miscible liquids in a Topaz. 75 ×

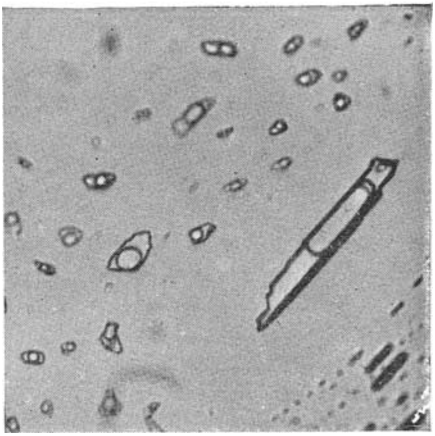


Fig. 38.

Cavities with non-miscible liquids in a Topaz. 100 ×

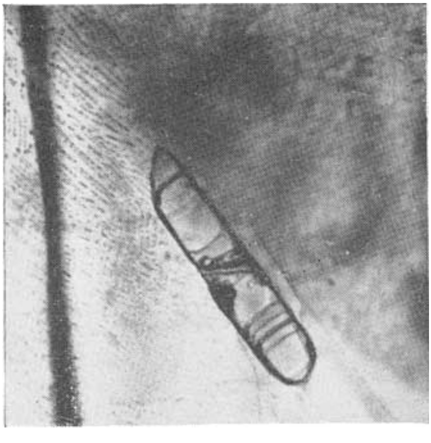


Fig. 39.

Typical long cavity with non-miscible liquids in a Ceylon Sapphire. 75 ×

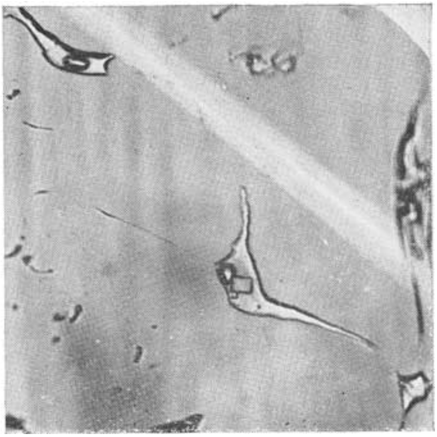


Fig. 40.

Beautiful three-phase inclusions in a Colombian Emerald. 75 ×

have intergrown in a definite manner, known scientifically as " according to a definite law." Parallelism of the separate individuals is not essential. There are two types of twins—contact twins and penetration twins. As the name implies, contact twins are those in which two crystals are in conjunction with one another. The two parts of such a twin have grown side by side and are so related that one part may be considered as having been rotated through 180 degrees around an axis known as the twinning axis. Penetration twins are those in which two individual crystals are so intergrown that they penetrate one another. A twin may consist of more than two individuals. This is the result of repeated twinning and polysynthetic twins are formed this way. Polysynthetic twinning frequently gives rise to characteristic fine, parallel lines, called twinning striations. These represent the boundaries between individual crystals, thus forming lamellae. Cohesion between twin planes is sometimes weak in corundum, in which species such lamellae frequently occur, and parting or false cleavage then results, very similar to true cleavage. (Figs. 62, 63.)

B.—ZONING.

One must not imagine that the growth of a mineral from its mother solution proceeds in such a continuous manner as the prenatal growth of a living creature within the protective tissues of the womb before birth. The flow of a solution from which the crystal grows is liable to have long or short interruptions and to be subjected to chemical alterations such as changes in the proportional amount of colouring agents. This is quite feasible, as the liquid in the immediate neighbourhood is variable in quantity and nature, and the character of the accompanying foreign particles is also liable to change. Therefore growth phenomena arise in nature from the continually varying new substances being deposited on the strictly flat faces of the growing crystal. For this reason the " striae " arising are always parallel and always absolutely straight, and they often meet at angles in groups arranged in parallel fashion among each other. Under the microscope one may thus notice a layered or banded structure which indicates the results of interrupted growth or continuously altering composition in the amount of the colour elements. This grouping is said to be a zoning structure. The zones may often be marked by layers of inclusions, as, for instance, rutile needles. (Figs. 64-68.)

FIG. 41.
Three-phase inclusions in a Colombian Emerald. 40 ×

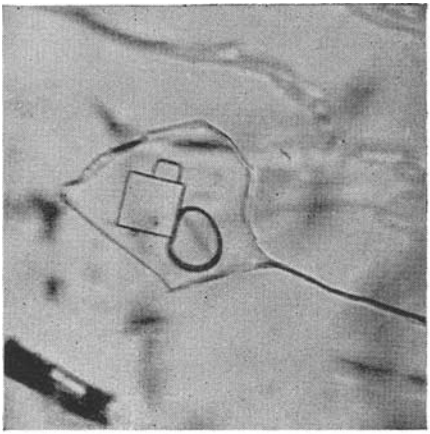


FIG. 42.
Three-phase inclusions in a Colombian Emerald. 250 ×

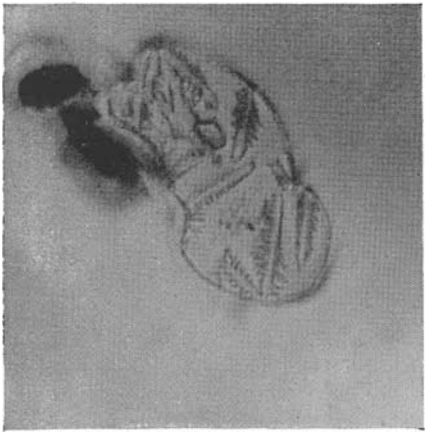


FIG. 43.
Recrystallisation in the liquid inclusion of a Siam Sapphire. 125 ×

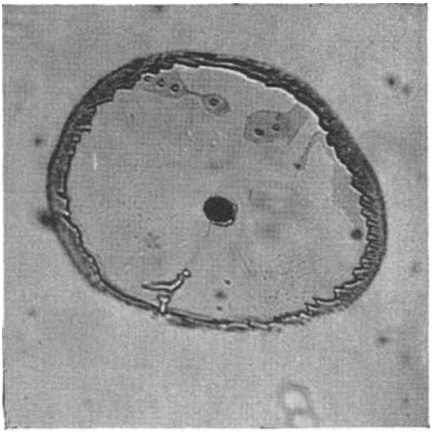


FIG. 43a.
Post-temporary formation of a solid inclusion in a Chrysolite (from Zebirget Island, Red Sea). 125 ×

In the case of a coloured mineral the banded or zoned structure is usually obvious by reason of differences between the colour or depth of colour of the neighbouring layers. With corundums, emeralds, tourmalines and other gemstones, zoning is frequently present. It quite frequently happens that the pigment of allochromatic minerals is unevenly distributed, or the colour may occur in irregular patches or blotches, as is often the case with amethyst, sapphire and Burma rubies. (Fig. 69.) The signs of interrupted growth we have just mentioned can be an important means of distinction between natural and synthetic stones, and for this reason I will treat them in detail. The synthetic ruby, sapphire and spinel grow in the form of a boule, and are thus quite different from the crystal habits of the natural gems. The new deposits of the substance in the case of such a boule, which generally has no distinct crystal form, are made on the flatly arched dome of the boule, and so the striae are also curved. They are distinct in synthetic corundums, but never appear in synthetic spinels. (Figs. 70-79.)

It is now said that a factory has succeeded in producing straight striae in synthetic rubies and sapphires, so I give you the following method for the distinction of natural and synthetic stones: straight striae are not common, but when they occur in groups meeting in a knee-fashion at an angle conforming to natural laws, you have an absolutely certain sign of the natural origin of the stone. In emeralds, where the layers are always straight, this rule does not apply, as in synthetic emeralds which are produced under conditions similar to those prevailing in nature ; one also finds straight striae. The safest means of microscopic detection for synthetic emeralds are the wrinkled wisp-like feathers of microscopically fine drops of liquid.

You have now heard much of the mystery and fascinating beauty of those wonderful formations of God's own magnificent designs in His most precious gifts to mankind. We so much admire the beautiful inclusions in natural gemstones, and I hope you now understand better how to distinguish these from the ugly inclusions found in man-made counterfeits.

My studies have drawn me more and more towards the conclusion that sooner or later gemmologists will abandon the orthodox present-day method of first examining gemstones for genuineness by tests for specific gravity, refraction and dichroism in favour of

FIG. 44.

Swirl marks and gas bubbles in a Moldavite. 30 ×

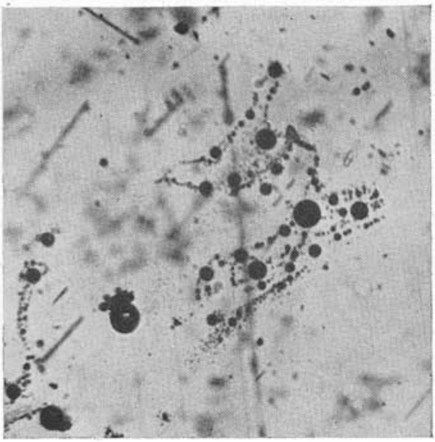


FIG. 45.

Typical air vesicles in the glass body of a doublet. 75 ×

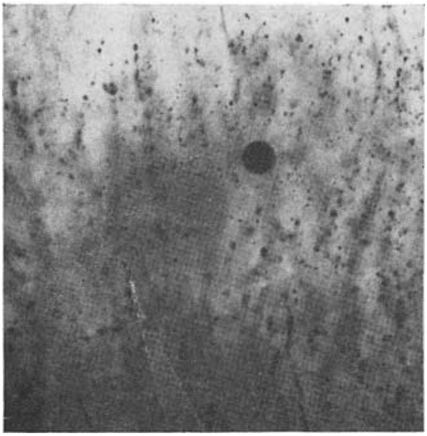


FIG. 46.

Dense cloud of gas bubbles in a synthetic Corundum. 50 ×

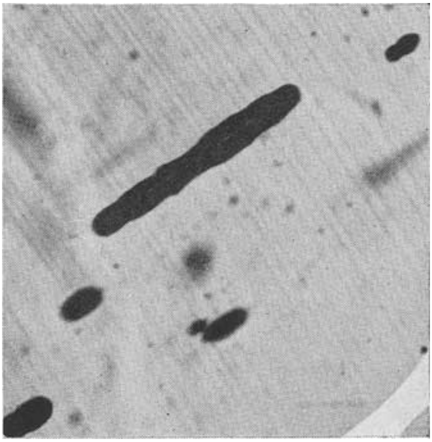


FIG. 47.

Long stretched gas bubbles and curved striae in a synthetic corundum. 75 ×

an approach through study of their inclusions, and I consider this means of identification amongst the first three most important gem-testing methods: the other two, of course, being the determination of refractive index and of absorption spectra.

Among all properties and characteristics of gemstones only inclusions are useful as an absolutely sure means of identification which can also be documented through photomicrographs. Weight, cut and external blemises of a stolen or lost stone can be completely altered, but the formation of typical interior inclusions remain always significant for a given stone, so that later identification of any stone accompanied with a photomicrograph is always ensured.

In a few outlines, then, I have sketched the nature of a branch of gemmology which is still in its youth—the study of inclusions. It owes its new impetus, though not its birth, to the necessity for creating some reliable methods of distinguishing between natural and man-made stones as well as between stones of different origin and provenance. This study will form the basis for the testing methods which the future will see employed in the realm of the gemstones. A great deal of work will still have to be done by mineralogists and gemmologists, as well as by chemists and physicists, if the numerous problems which inclusions conceal in their costly sealed up mansions are to be brought to their final and complete solution. But in return gemmology may await from the new discoveries among the internal parageneses of gemstones valuable results in many directions, both for itself and for the general benefit of jewel-loving mankind.

(See further illustrations on pages 32-39.)

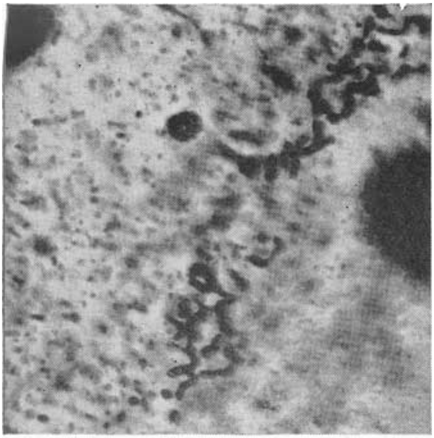


FIG. 48.
Gas bubbles and irregular gas filled hoses in a synthetic Corundum. 125 ×

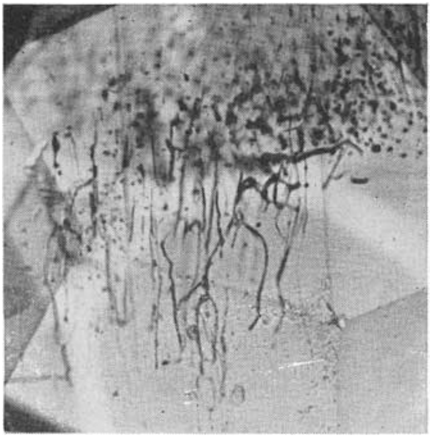


FIG. 49.
Irregular gas-hoses in a synthetic Corundum. 75 ×

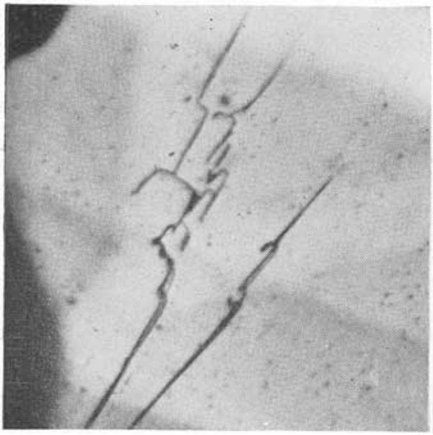


FIG. 50.
Irregular gas inclusions in a synthetic Corundum. 75 ×

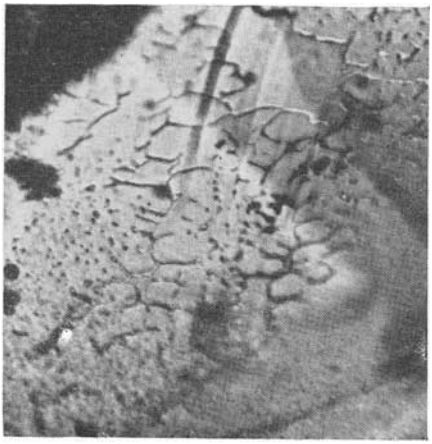


FIG. 51.
Irregular, net-like, gaseous inclusions in a synthetic Corundum. 125 ×

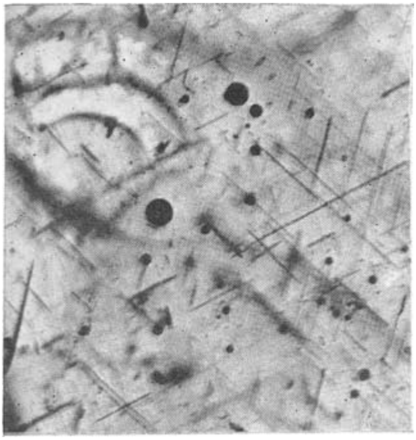


FIG. 52.
Phenomenological view of the inclusions in a doublet, i.e. rod-crystals of amphiboles in garnet-top and gas bubbles in glass pavilion. 75 ×

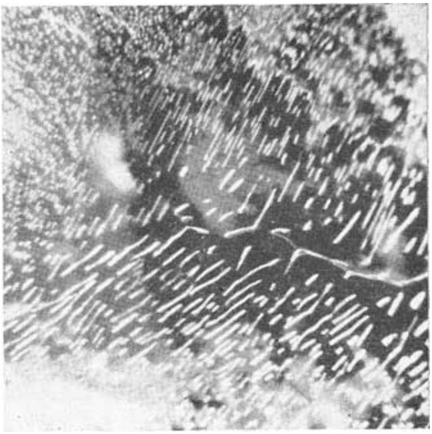


FIG. 53.
Liquid feather in a Ceylon Sapphire. 40 ×

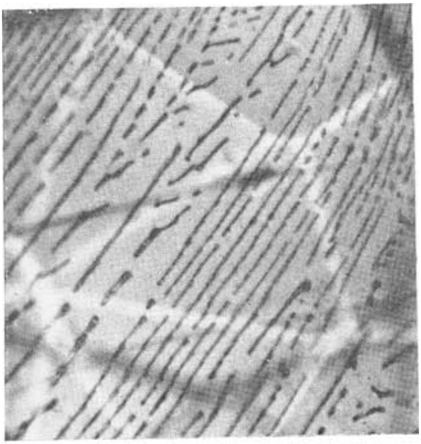


FIG. 54.
Typical feather in a Ceylon Sapphire. 75 ×

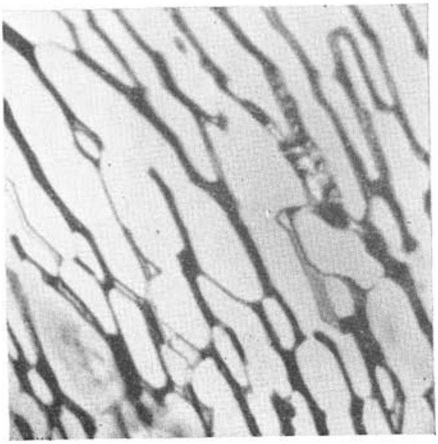


FIG. 55.
Liquid feather highly magnified in a Ceylon Sapphire. **125 ×**

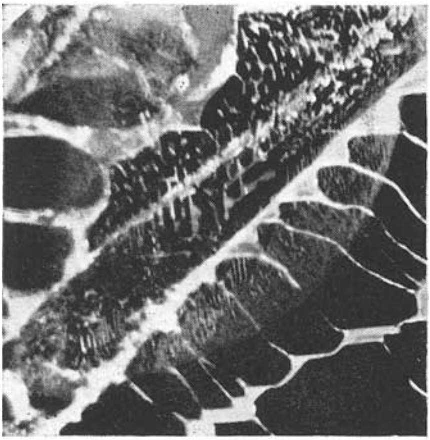


FIG. 56.

Strong magnification of intercommunicating channels forming a feather in a Ceylon Sapphire. 150 ×

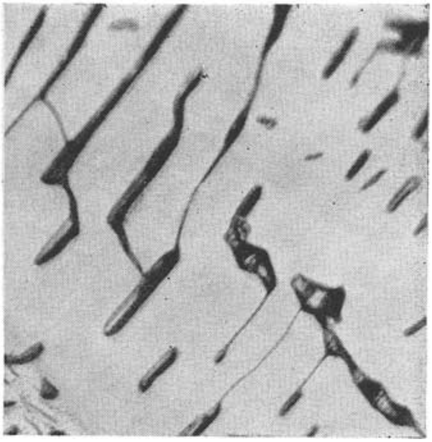


FIG. 57.

Single drops of fluid forming a feather in a Ceylon Sapphire. 250 ×

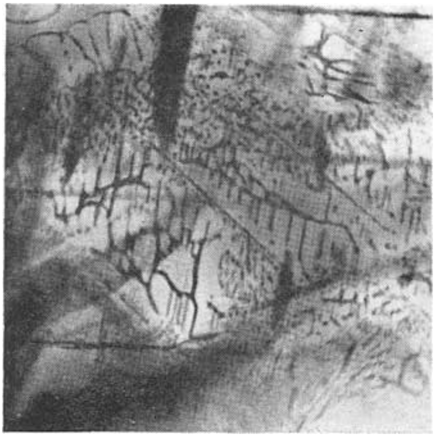


FIG. 58.

Scriptine-like design of a feather in a Siam Ruby. 50 ×

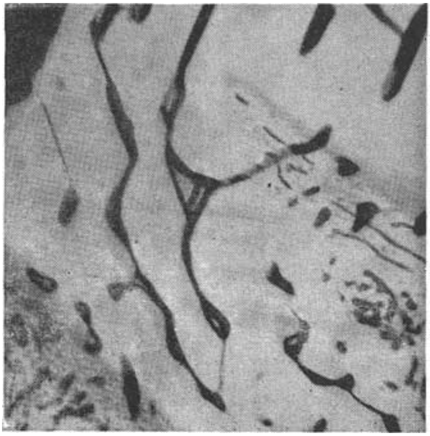


FIG. 59.

Liquid feather in a Ceylon Sapphire. 250 ×

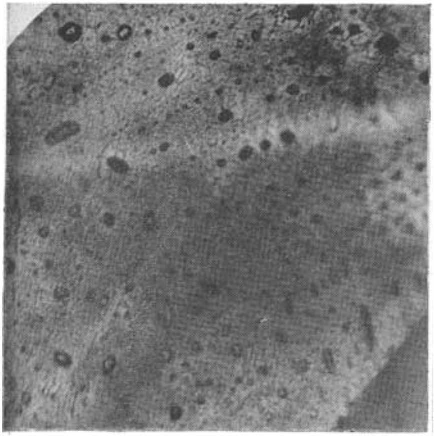


FIG. 60.

Liquid feather overlaid by a feather of crystals in a Burma Sapphire. 50 ×

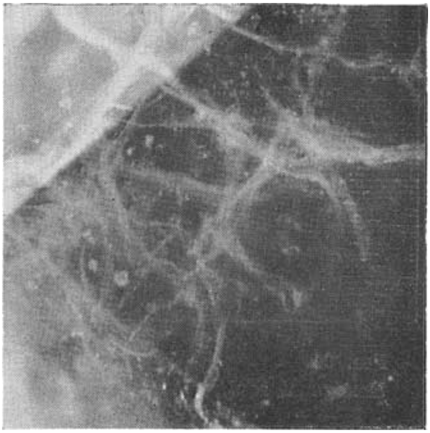


FIG. 61.

Wisp-like feathers in synthetic Emerald. 20 ×

FIG. 62.

Chequered pattern of polysynthetic twins of Siam Rubies. 40 ×

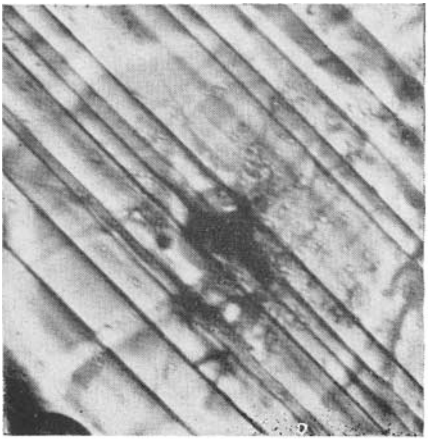


FIG. 63.

Lamellae caused by polysynthetic twinning in a Ceylon Ruby. 75 ×

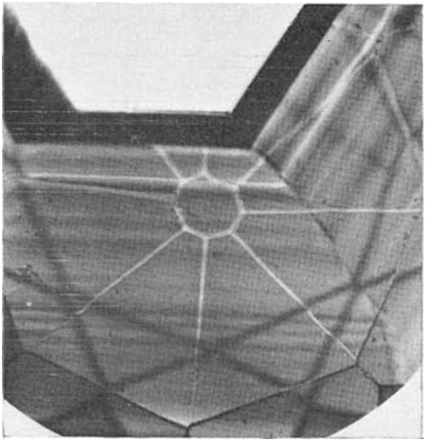


FIG. 64.
Hexagonal zoning in a Burma Sapphire. 40 ×

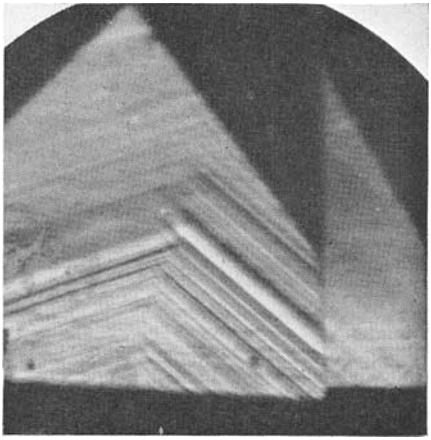


FIG. 65.
Angular meeting of zonal striae in a Burma Sapphire. 40 ×

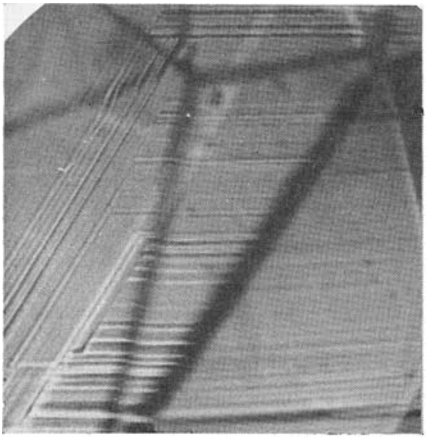


FIG. 66.
Typical zoning in a Ceylon Ruby. 40 ×

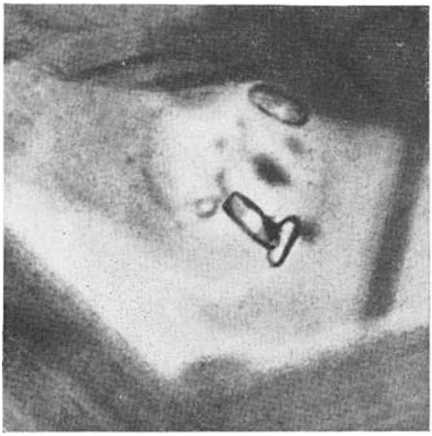


FIG. 67.
Zonal structure strongly marked by deposition of rutile silk in a Burma Ruby. 75 ×

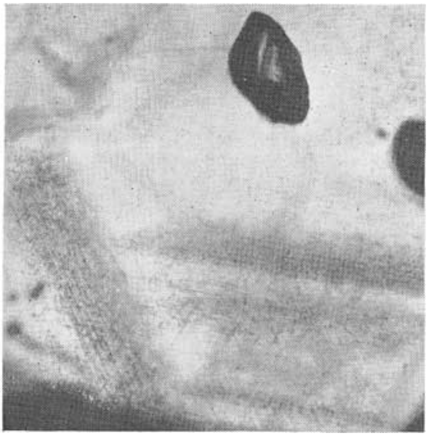


FIG. 68.

Zonal structure accentuated by a deposition of rutile needles in a Burma Ruby. 75 ×

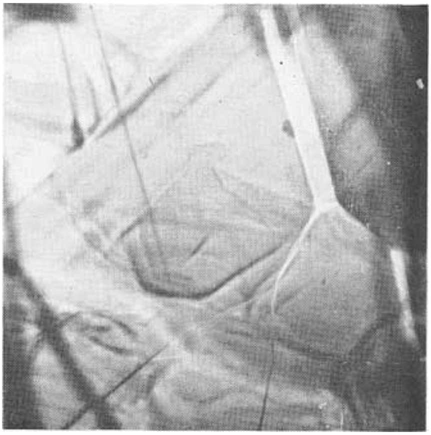


FIG. 69.

Distinctive colour swirls in a Burma Ruby. 30 ×

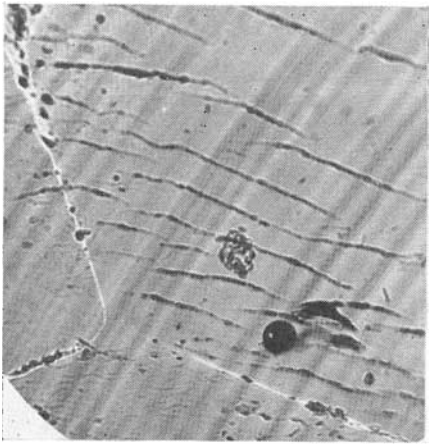


FIG. 70.

Surface cracks, curved striae and gas bubbles in a synthetic Corundum. 50 ×

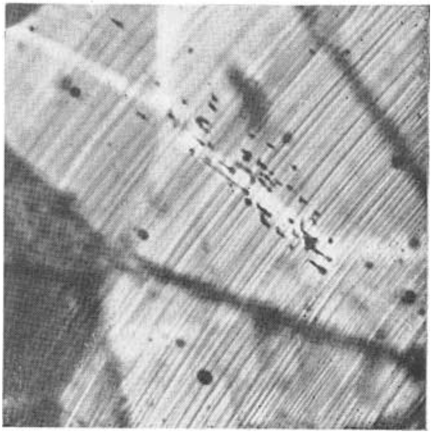


FIG. 71.

Curved layers and gas bubbles in a synthetic Corundum. 75 ×

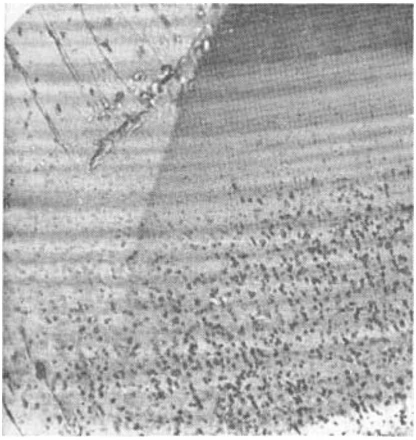


FIG. 72.

Curved striae and gas bubbles in a synthetic Corundum. 50 ×

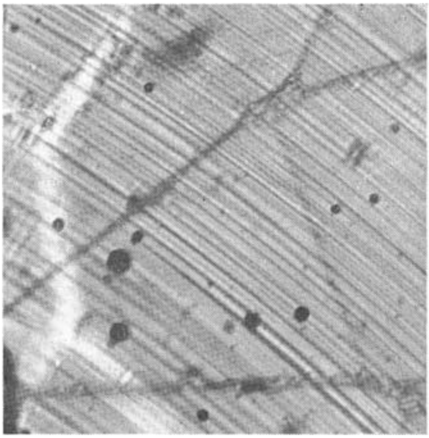


FIG. 73.

Curved striae and gas bubbles in a synthetic Corundum. 75 ×

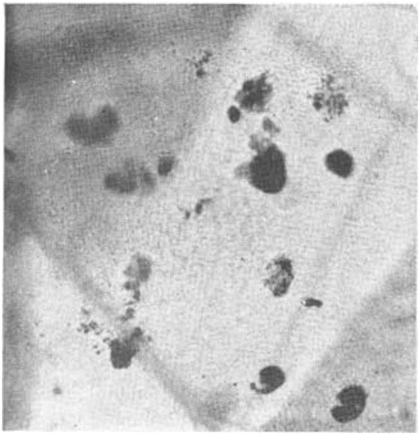


FIG. 74.

Undissolved (unfused) particles of colouring matter in a synthetic Ruby. 40 ×

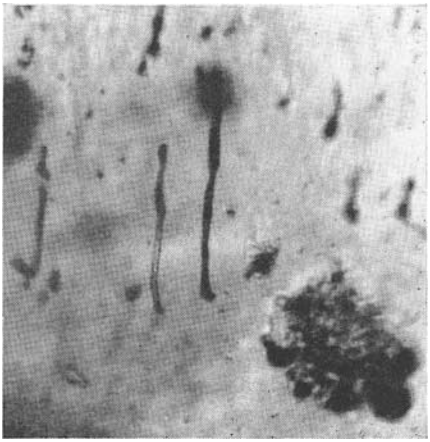


FIG. 75.

Gaseous inclusions and impurities in a synthetic Ruby. 125 ×

Fig. 76.

Anomalous extinction of synthetic Spinel. 10 ×

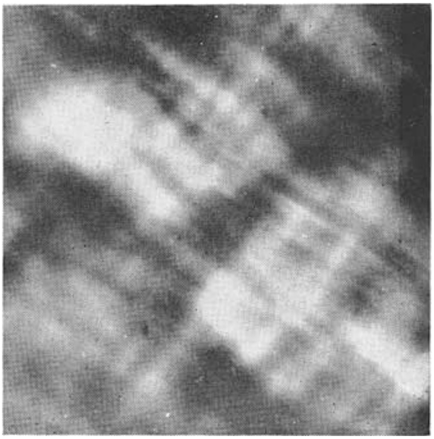


Fig. 77.

Anomalous extinction of synthetic Spinel. 10 ×

Fig. 78.

Anomalous extinction of synthetic Spinel. 10 ×

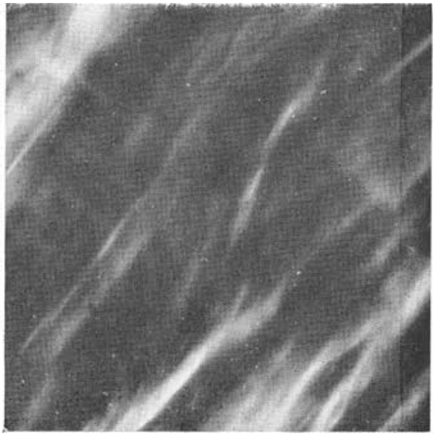


Fig. 79.

Anomalous extinction of synthetic Spinel. 10 ×

ASSOCIATION NOTICES

GEMMOLOGICAL PRIZEMEN AT THE BIRMINGHAM SCHOOL

A small exhibition of Gemmology was shown recently at the Birmingham School for Jewellers and Silversmiths on the occasion of the Annual Prize-giving at the School and this exhibit attracted considerable attention. Two students, Mr. A. D. Conway (Final Year) and Mr. Stephanides (Prelim.) received prizes of Five Pounds and Three Pounds respectively. The prizes were given in the presence of a large gathering by the Lady Mayoress of Birmingham, after speeches by the Lord Mayor, Mr. Cuthbertson, the Headmaster, Mr. Albert Carter and Mr. Ivan Short. The prizes in Gemmology will be awarded annually to students of the Birmingham School.

TALKS BY FELLOWS

Lecture entitled "The Romance of Gemstones," given by John F. Croydon, F.G.A., to St. Andrews Youth Club, Colchester, on 9th April.

N.W. Hull Conservative Association, 6th May, talk on Gemstones, K. Parkinson, F.G.A.

EXAMINATIONS IN GEMMOLOGY

The 1948 Examinations in Gemmology were held in June as follows:—

Preliminary: Wednesday, 23rd.

London, Edinburgh, Glasgow, Birmingham, Plymouth, Perth, Belfast, Manchester, Bristol, Bournemouth, Dublin, Surat (India), Calcutta (India), Crawley (W. Australia), Vancouver (Canada), Hilversum (Holland), Edmonton (Canada), Oporto (Portugal), Karachi (Pakistan), Johannesburg (S. Africa), New York (U.S.A.), Los Angeles (U.S.A.), Jos (Nigeria), Youngstown (U.S.A.), Miami (U.S.A.).

Dploma (Theory): Thursday, 24th.

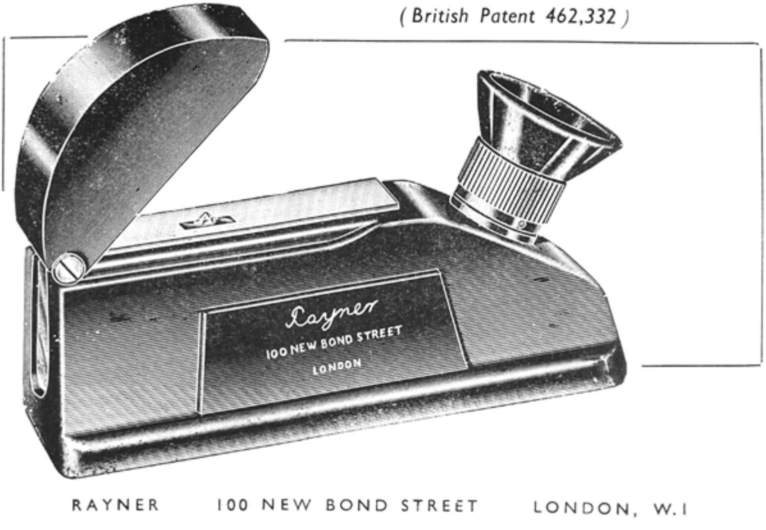
London, Edinburgh, Birmingham, Dorchester (Canada), Hilversum (Holland), Johannesburg (S. Africa), Chihuahua City (Mexico), Hong Kong, Colombo (Ceylon), Crawley (W. Australia), Los Angeles (U.S.A.), Jos (Nigeria), Miami (U.S.A.).

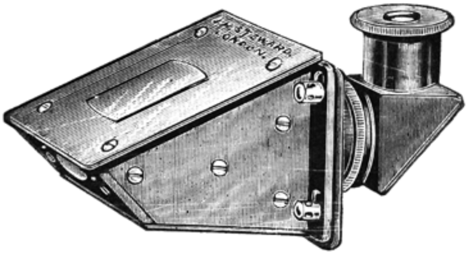
Diploma (Practical): Friday, 25th.

London, Hilversum (Holland), Johannesburg (S. Africa), Hong Kong, Colombo (Ceylon), Los Angeles (U.S.A.).

Diploma (Practical): Monday, 14th. Edinburgh.

Diploma (Practical): Friday, 18th. Birmingham.


Rayner
100 NEW BOND STREET
LONDON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