Gems and Gemology

Emerald Sévigné—Brooch. From the Romanoff Jewels. Article on Page 466.

FALL

1947

GEMS & GEMOLOGY

GEMS & GEMOLOGY is the quarterly official organ of the Gemological Institute of America. In harmony with its position of maintaining an unbiased and uninfluenced position in the jewelry trade, no advertising is accepted. Any opinions expressed in signed articles are understood to be the views of the author and not of the publishers. Subscription price: $3.50 a year.

Robert M. Shipley, Editor

VOLUME V FALL, 1947 NUMBER 11

In This Issue:

Cover: Figure 8 in "Jewels of the Russian Diamond Fund"; a superb emerald brooch. Reproduced from "Russia's Treasure of Diamonds and Precious Stones."

●

THE GEMOLOGICAL INSTITUTE OF AMERICA
(UNITED STATES AND CANADA)
Established 1931

541 South Alexandria Ave. Los Angeles 5, California

CONTRIBUTORS IN THIS ISSUE

Robert M. Shipley, Jr., whose article on the Pearloscope appears in this issue, is former Director of Education and Research for the Gemological Institute of America, co-author of North American mail courses in Gemology and of *Advanced Gemology*, published 1937. He has been responsible for developing many of the scientific devices which have become important as gem-testing instruments, and many of the tests now used by gemologists throughout the United States and Canada. These achievements have included the development of dark field illumination for the more accurate examinations of inclusions in such instruments as the Diamondscope and Diamolite, the use of the polariscope for gem identification, and the perfecting, in 1935, of the first gem-testing polariscope.

He lives in Cloverdale, California, in a house overlooking the Russian River. Such of his time as is not devoted to correcting students' papers or perfecting instruments for the G.I.A. is spent in playing with his two sons or listening to his superb collection of classical recordings.

A reserve officer in the Army, he left the G.I.A. a year before Pearl Harbor to become engineering officer in the Photography Laboratory at Wright Field. He went to England as engineering officer on the staff of the 8th Air Force, and returned to civilian life in 1945.

Dr. Kathleen Lonsdale (nee Yardley), whose discussion of the two types of single crystal diamonds appears on Page 455, became research assistant to the late Sir William Bragg, Director of the Royal Institution, London, following her graduation from London University in 1922.

Her work has included the determination of crystal structures by X-ray methods, the preparation of mathematical tables necessary to the X-ray crystallographer, investigation of the magnetic properties of crystals, and measurement of the vibratory movement of atoms in crystals.

In 1945 she became one of the first two women ever to be elected to Fellowship of the Royal Society of London, and she is a member of the Council of the Mineralogical Society of Great Britain.

This summer she visited the United States as Special Research Fellow at the National Institute of Health, Bethesda, Maryland, and managed to pay a visit to G.I.A. international headquarters in Los Angeles before sailing on the "Queen Elizabeth" for home, where she will develop a new school of X-ray crystallography at University College, London.

The New "Linde Stars"

Man-Made Star Rubies and Star Sapphires

by

RALPH J. HOLMES, Ph.D.

Instructor in Mineralogy, Columbia University, New York City
Member Advisory Board, Gemological Institute of America

Jewelers should have little difficulty in distinguishing from real star rubies and star sapphires, the new synthetic star stones announced for the first time by the Linde Air Products Company on September 23rd. Although synthetic corundum of gem quality has been available for nearly half a century, the announcement of these star stones was, to say the least, startling.

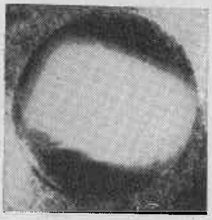


Fig. 1—*Synthetic star ruby. Magnification 2x. White band shows limit of zone of needle-like inclusions.*

The producers claim to have discovered the method of making these stones in the early days of the war, but the pressure of war work made production impossible until the present. Wide publicity was given to the new material before it was released to insure that the public was properly warned of its true nature. No information concerning the method of production or the nature of the rough material has been revealed. Rough material is unobtainable, the company having decided to release nothing but cabochon cut finished stones. The largest stone so far produced weighs 109.25 carats. Most of those on the market range from 4 to 15 carats. The entire output is being released through Max Duraffourg Inc., 576 Fifth Avenue, New York, who acts as distributor for the Linde Company.

The new star stones are sold in three qualities: A, B and C. These grades seem to be based largely on color although perfection, strength and orientation of the star and general appearance of the stone are all taken into account. The colors are deeper than most natural star stones and are sufficiently different from those of natural stones to cause many jewelers to question them on this basis alone. The color of the blue stones approximates more closely the color of natural star sapphires than the red ones do that of natural star ruby. The prominence of the belted structure does not seem to be regarded as a factor affecting quality since many "A" quality stones have a definite banded appearance.

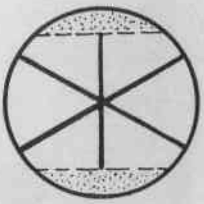


Fig. 2—*Synthetic star ruby. Diagram showing relation of star to central band of needle-like inclusions.*

Material Available for Study

Two stones of fine quality, one red and one blue, were very kindly made available by Mr. A. K. Seeman of the Linde Company. These served as the basis for the present study, and all tests and detailed examinations were made on these stones. In addition, some half-dozen stones in Mr. Seeman's possession and thirty-six made available by Miss Rouxel of Max Duraffourg, Inc., were examined.

Fig. 3—*Synthetic star sapphire. Photomicrograph. Magnification 200x. Closely spaced interlacing needle-like inclusions arranged in three sets making angles of 60° with each other. Dark lines intersecting at right angles are the cross hairs of the microscope.*

Observation with the Unaided Eye or Loupe

The stones so far produced should offer no serious problem to the well-informed jeweler. The details of structure and appearance are so different from those of real star rubies or sapphires that one should have no difficulty in spotting an unmounted synthetic with the aid of nothing more than a loupe. A mounted stone deeply set in a gypsy style ring might give some difficulty. However, observation under the microscope should remove doubt in any case.

Even on casual inspection, one is aware of the extraordinary intensity and sharp definition of the star. In addition, the rays of the star are unusually straight. Equally obvious in practically all stones is the wide belt or band extending over the top of the stone. This belt, which is lighter in color than the two ends of the stone, is shown in the photograph, Fig. 1. It is a consequence of the peculiar distribution of the inclusions producing the star. The network of included needles is restricted in distribution to a relatively thin layer conforming more or less closely to the upper surface of the cut stone. As a consequence of this distribution of inclusions, the interior of the stone, its under side and two opposite ends are more transparent and darker in color than this belt over the top. Observing the stone from above, one sees a broad, light-colored central zone or band and two narrow, clear, dark zones at either end as shown in Fig. 1. The asterism is related to these needle-like inclusions, since the two rays of the star end abruptly at the boundary between the central inclusion-filled band and the clear dark zone at either end of the stone. This results in a pronounced two-fold symmetry as far as the star is concerned. Four rays extend all the way down to the base of the stone, whereas the ends of the remaining pair stop at the edge of the clear zone. This is shown diagrammatically in Fig. 2. If the stone is viewed on edge, around the base, against a strong light, there is observed a pronounced variation in transparency as the stone is rotated.

The direction through the two clear ends is decidedly more transparent than that across the cloudy belt. Of nearly fifty stones examined, only two failed to show such a distinct belted character and even these exhibited an appreciable variation in transparency when viewed around the edge of the base. *Curved color bands and irregular but generally curved cloudy streaks consisting of a multitude of tiny air bubbles are also of common occurrence. Bubbles seem to be of far greater frequency in these stones than in ordinary synthetic corundum.*

Dichroism

Both the red and blue stones exhibit dichroism, the red more strongly than the blue. This is in part due to the paler color of the blue stone. The dichroism of the blue stones is not too unlike that of natural blue sapphire. The dichroism of the red stone, however, exhibits in one direction an orange color which tends much more toward the yellow than does natural ruby of comparable hue.

Microscopic Examination

Examination under the microscope should prevent any confusion between this material and natural star rubies or sapphires. Under a magnification of 50x, the pale belted zone of the stone is seen to consist of a close-packed mass of needle-like inclusions in three sets which make angles of 60° with each other. They occur in much greater abundance and seem to be much shorter in length than those commonly observed in natural star ruby and sapphire. The close spacing of these needles is apparent in Figs. 4 and 5. The minute size and vast number evidently accounts for the sharpness and intensity of the asterism. The needle-like inclusions are arranged symmetrically about the optic axis of the crystal as one would expect. In virtually all cases, the stars are very well centered. Both stones examined provided excellent uniaxial negative interference figures, providing further evidence that the material is corundum. *(Continued on Page 478).*

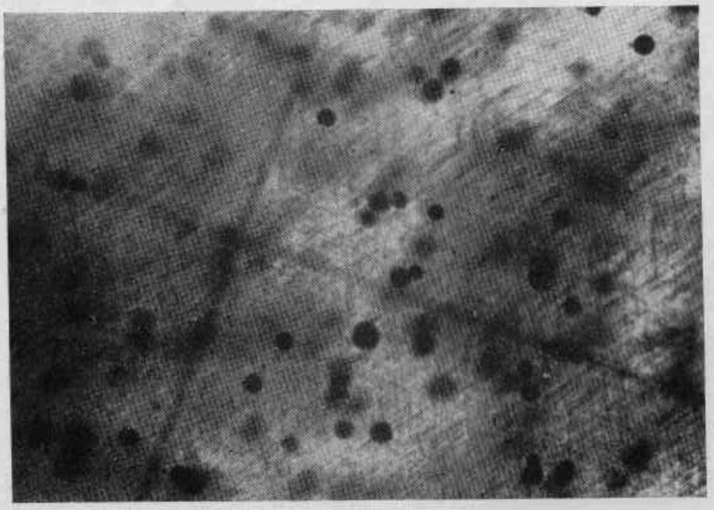


Fig. 4—*Synthetic star sapphire. Photomicrograph. Magnification 200x. Spherical bubbles and interlacing needle-like inclusions. Dark lines intersecting at right angles are the cross hairs in the microscope.*

Single Crystal Diamonds Are of Two Types

New X-Ray Method Distinguishes "Perfect" From "Mosaic" Specimens

by

KATHLEEN LONSDALE, D.Sc., F.R.S.

Reader in Crystallography, University College,
University of London, England

EDITOR'S NOTE: A foreword to Dr. Lonsdale's article has been prepared at our request by Dr. Ralph J. Holmes, Instructor in Mineralogy, Columbia University, New York City. We believe it will be helpful to have his impressions of the most significant points discussed by the author.

FOREWORD

Diamond is of interest not only to the jeweler. Because of its remarkable physical and other properties, it has been the subject of a vast amount of scientific research. The optical, physical and other properties of a crystal are dependent as much, or more, on internal structure and texture as on chemical composition. In the following article, Dr. Lonsdale, a leading authority on crystal structure and X-ray diffraction, discusses the relation of the properties of diamond to its crystal structure as revealed by modern X-ray methods. All specimens of a given species have the same structure, but not the same texture. The term "structure," in the case of a crystalline material, refers to the orderly arrangement of its component atoms. The term "texture" applies to the perfection and uniformity of the atomic arrangement (crystal structure) throughout the entire crystal.

Crystal structure can be ascertained by a study of the position and intensity of the spots, or lines, on X-ray diffraction patterns. From these, one can calculate not only the symmetry or pattern of the atomic arrangement, but also the spacing between the atoms within the crystal. On the basis of texture, one may distinguish between two types of crystal: (1) "Perfect" Single Crystal: In some cases, there is perfect continuity in the arrangement and spacing of the component atoms throughout the entire crystal. These are referred to as "perfect" single crystals. (2) "Mosaic" Single Crystal: Many crystals that appear to be single individuals on casual inspection are, in reality, a mosaic made up of a vast number of exceedingly minute "perfect" crystals (crystallites). The minute units of which such "mosaic" single crystals are composed are usually microscopic or submicroscopic in size and are grouped in nearly parallel position, much as bricks are arranged in a wall. Such subparallel "mosaic" single crystals behave almost like "perfect" single crystals. In fact they are usually distinguishable from "perfect" single crystals only by slight peculiarities in their X-ray effects. These *"mosaic" single crystals are not to be confused with crystalline "mosaics" such as jade or carbonado, orientated entirely at random, in which there is no approach toward parallelism of the crystallites.*

"Perfect" single crystals usually cannot be distinguished with certainty from "mosaic" single crystals consisting of subparallel crystallites by standard X-ray diffraction methods using a narrow parallel X-ray beam.

Dr. Lonsdale describes a relatively new technique employing a strongly divergent X-ray beam which produces a picture known as an absorption pattern. Such a pattern (see Fig. 1) is entirely different from the patterns of parallel lines or symmetrically arranged spots provided by ordinary X-ray diffraction methods. Since "perfect" single crystals do not give absorption patterns, this method enables one to distinguish between "perfect" single crystals and "mosaic" single crystals. Most gem diamonds are "perfect" single crystals and do not give such patterns.

Dr. Lonsdale points out some interesting consequences of the structure of diamond. We usually think of diamond as having a closely packed crystal structure. Actually it is a rather open one; and if all the open spaces in the diamond lattice were filled with carbon atoms, diamond would have a specific gravity more than twice as great as it actually has. She also points out that the factor which determines hardness is not so much the close packing of atoms as it is the distribution of electron bonds between adjacent atoms, which also determines the stability of the crystal.

It will surprise many to learn that the remarkable hardness and chemical stability of diamond is a consequence of its monomolecular character. A "perfect" single diamond is actually one enormous molecule. As a consequence of this fact, diamond can be decomposed only by breaking down the intramolecular electron bonds themselves. A diamond crystal can also be looked upon as consisting of long chains of carbon atoms extending in many directions. This monomolecular character and interlocking chain structure gives diamond its great stability, as evidenced by its high melting point, incompressibility, and small thermal expansion.

Dr. Lonsdale makes clear that there is still work to be done by the scientist before all is known about the internal architecture of diamond. —R.J.H.

Scientists Who Have Studied Diamond

It is not surprising that the diamond has long excited the curiosity of scientific investigators, for it is the aristocrat of the mineral world.

Robert Boyle, known to many generations of schoolboys as the Father of Chemistry and the son of the Earl of Cork, was one of the first to study the diamond from a scientific point of view. Isaac Newton, the great physicist and mathematician, the tercentenary of whose birth was recently celebrated in many parts of the world, Lavoisier, the French chemist, Biot and Arago, Humphrey Davy, Michael Faraday, Reynault, Berthelot, Petit, Laplace, Berzelius, Fizeau, Crookes, Parsons, Moissan, Friedel, Nernst, Herschel, Brewster, Dewar, W. H. and W. L. Bragg, DeBye, Ewald, Raman—all of them well-known for their love of science and their careful experimental work—have all at some time or other investigated the properties of diamond.

Uses of Diamond

Diamonds are of course important industrially. They are used in drilling, in engraving, in cutting and polishing, as tool-tips, as bearings in watches and meters, and as dies for the drawing of fine wires. But these aspects are more likely to attract the attention of the technician than that of the pure scientist. Diamonds are attractive to the general public because of their great beauty and durability in wear and also, to some extent, because of their value and portability; but these things by themselves do not attract the scientist.

Influence of Optical and Physical Properties on Beauty

The scientist knows that the beauty of the diamond is due to its high refractive index for ordinary light and to its high dispersion of light rays of different wave-lengths. The refractive index is a measure of the speed of the light rays inside the crystal; the dispersion is a measure of the variation in speed for light of different colours. A high refractive index means that light, on entering a diamond, is very much slowed down; and if the diamond is properly cut the light rays will be bent right round and will return towards the observer; different rays are bent by different amounts according to their colour. These two aspects of the behaviour of light in the cut stone give the gem diamond its remarkable brilliance and fire. The great hardness of the diamond is responsible for its wearing capacity and for its ability to cut or scratch other hard substances. The scientist, however, wants to go one stage farther back and find out the cause of the high refractive index, and why the diamond is so exceedingly hard.

Outstanding Physical Properties

In fact, diamond is attractive to chemists and physicists because of its unique chemical, physical and mechanical properties. It has a very high melting point (3700° C. approximately), showing that it is a very stable solid, not easily broken down, not easily separated into its constituent atoms. It is chemically stable, also; not affected at all by the usual chemical reagents. Its refractive index is almost double that of water and sixty percent higher than that of glass. Its elastic constants, which measure its resistance to various forces of deformation, are about twice those of corundum (synthetic sapphire) and its breaking strength about five times as great, although corundum is very strong indeed. Diamond has a very small coefficient of thermal expansion and a very high thermal conductivity (higher than that of many metals), so that it can be heated in a blowpipe and then dropped into liquid nitrogen without suffering disintegration, unlike glass, for instance, which will so easily crack even when dipped in boiling water.

Properties Dependent on Crystal Structure (Atomic Arrangement)

Some of these properties depend on the way in which the atoms are arranged in the diamond crystal. Dr. Switzer has explained how X-ray photographs of crystals can be taken by various techniques, and has shown that the various diffraction patterns observed are evidence of a precise, orderly arrangement in space of the atoms making up a crystalline solid. Amorphous substances and liquids give only a diffuse, hazy ring on an X-ray photograph, whereas crystals give a pattern of discrete spots or lines. The diffraction patterns of X-rays given by different crystals are often very beautiful; but they are more than beautiful; they are very informative. The *positions* of the spots on the photograph can be measured and interpreted to give the geometric pattern which is the basis of repetition in the crystal; for example, whether it is cubic, hexagonal or rectangular (orthorhombic); which is like knowing the plan of a house without any information about the furniture. The *intensities* of the diffraction spots supply further knowledge about the kinds of atoms that are present and their arrangement relative to one another. It is even possible to measure the distribution of the electrons and thus to know very precisely what are the directions and, to a certain extent, the nature of the forces holding the atoms together. Many of the properties of solids, such as density, cleavage, refractive index and thermal and electrical conduction, depend largely on the actual arrangement of the atoms; that is, on the crystal *structure*.

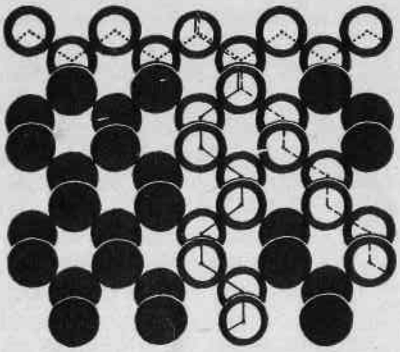


Fig. 1—*Structure of DIAMOND, with three types of long chain shown. Each carbon atom is surrounded in space by four other carbon atoms arranged tetrahedrally about it, but only three of these can be shown on a flat diagram.*

That is why diamond is so different from graphite; both, if pure, are composed of carbon atoms and nothing but carbon atoms, but the arrangement of the carbon atoms and of the electrons in the atoms is quite different in the two substances. Graphite consists of flat hexagonal layers of carbon atoms, closely bound to each other in the layers but with the layers loosely stacked together; its density is only 2.3 grams per cubic centimeter, whereas diamond, with its cubic structure, has a density of 3.5 grams per centimeter. Diamond is crystal-clear; graphite black and opaque. Graphite is a conductor of electricity; diamond an insulator. Diamond is the hardest of all known substances, while graphite is so soft that it can be used as a lubricant.

Properties Dependent on Crystal Texture (Perfection and Uniformity of Atomic Arrangement)

But there are other properties which depend not on structure but on *texture*. In discussing crystal texture we are taking account of the fact that crystals are seldom perfectly regular throughout their whole volume. They are more often composed of smaller crystallites, put together in different ways. Sometimes the little crystallites (which may only be one ten-thousandth of a centimeter in linear dimensions) are like the bricks in a wall, parallel though separate. Sometimes they are only approximately parallel, although their disalignment is still small enough for them to behave, as a whole, like a single crystal. Sometimes they form a spiral about a single axis or are distributed radially from a centre. Or sometimes they are completely disorientated although forming one solid block. Strength, breaking load, and toughness are properties that depend markedly on texture. An ordinary piece of polycrystalline metal is much stronger than a single crystal of the same metal, because single crystals usually have well-defined directions along which atomic planes can slip over each other, causing faults; whereas in the polycrystalline metal, slip is prevented by the presence of neighboring crystallites of different orientations. In the same way, a gem diamond can be cleaved and this, while it may be useful, can also be a weakness. Boart and carbonado are forms of diamond in which the component crystallites are not parallel, and they are tougher and harder even than gem diamonds, because in them cleavage is prevented.

It has been shown earlier in this article that the positions and intensities of the X-ray diffraction spots will give precise information about the *structure* of crystal. It is much more difficult to determine anything precise about the *texture* of diamonds or other crystals. But generally speaking, the size and shape of the diffraction spots and their diffuseness can be used for this purpose, and so can the absorption of the crystal for X-ray.

Use of Divergent X-Ray Beam to Distinguish Between "Perfect" and "Mosaic" Single Crystals

In particular it is possible to take X-ray photographs using a widely divergent, instead of the usual parallel beam; and these distinguish with certainty between a "perfect" and a "mosaic" (group of subparallel crystallites) single crystal. These are absorption photographs and show patterns of white lines on a greyish background. Using suitable X-ray film, they can be taken in a few seconds, but it is only the mosaic crystals which show any considerable absorption of the X-ray beam in the Bragg reflecting positions, and it is therefore only the mosaic diamonds which give good divergent beam patterns. Really perfect crystals give weak Bragg reflections and no absorption pattern at all; their divergent beam pattern is just a complete blank, and this, in

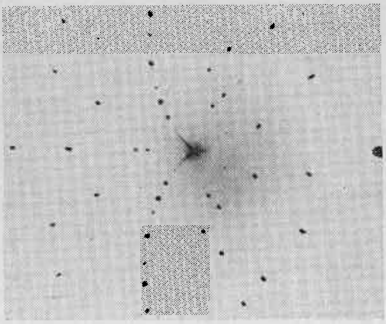


Fig. 2—*X-ray diffraction pattern from a gem diamond, using a cylindrical beam of X-rays, ½ millimeter diameter; note the streaks coming from the central reflection.*

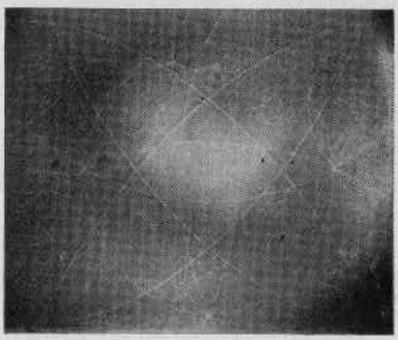


Fig. 3—*X-ray diffraction (absorption) pattern from a mosaic diamond, using a divergent beam of X-rays. A gem specimen would not show any lines at all. This mosaic is made up of very small, discontinuous, but parallel, blocks.*

fact, is what is obtained for the best gem specimens of diamond.

Crystal Structure (Atomic Arrangement)

Let us now consider the structure of the diamond (which is fundamentally the same for both perfect and mosaic specimens); that is, the way in which the framework of carbon atoms is built up to form the crystal. The fact that diamond is intrinsically so hard might make us imagine that the atoms must be packed together as closely as possible. This is not at all the case, nor would an experienced scientist expect it to be so. The atoms of lead are close-packed, but lead is quite a soft metal. The atoms of tungsten are not close-packed, but tungsten is hard. It is the forces between the atoms, and not their packing, that decides the hardness. The atoms of diamond really form quite a lacy openwork structure. Robert Boyle, who first measured the density of diamond in 1690, gave it as 3.4, not far from the modern value of 3.515 grains per centimeter. But if the carbon atoms were close-packed, the density would be 7.653 grains per centimeter. In other words, it might have been possible to pack into the space occupied by a diamond more than twice the number of carbon atoms that are actually there. Diamond owes its hardness, its remarkable resistance to abrasion, not to the compactness of its structure, but to the remarkable stability of that structure, in an engineering sense. What is this structure?

A Diamond Crystal Is One Huge Molecule of Interlocking Chains of Carbon Atoms

The carbon atom has fourfold valency; it is capable of sharing electrons with four other atoms. In marsh gas (methane, CH_4) the carbon atom shares its electrons with four hydrogen atoms; in the commercial solvent and grease remover CCl_4 (carbon tetrachloride), it shares with one hydrogen and three chlorines. Each group CH_4, CCl_4, or $CHcl_3$ is a molecule which is not easily broken up. But in diamond, each carbon atom is tetrahedrally surrounded by, and shares electrons with, four other carbon atoms and each of these is similarly joined to other carbon atoms, and so on; so that the whole diamond is just one large molecule containing millions of atoms. Another way of describing the structure is to say that it consists of interlocking chains of carbon atoms, each chain being of immense length.

Ordinarily the break-up (by melting or vaporization) of a crystal consists in the separation of its molecules from each other, the molecules as such persisting in the liquid or vapor phase. Since the whole diamond is one molecule, the break-up of the diamond would involve the breakdown of electron bonds, and this does not take place except at very high temperatures or under enormous strain. The small thermal expansion of the diamond, its incompressibility and its other unique mechanical properties, simply mean that the atomic structure of the diamond is so stable that it cannot be altered except with great difficulty. Similar mechanical properties are also associated with the *length* of long chain molecules, such as those which exist in the paraffines, the fatty acids used in the manufacture of soaps, and in fibres such as cellulose or nylon. The reason why flowers in the field can sway to and fro, but do not move up and down, is simply that the fibres which compose and in general are parallel to the flower-stalk are flexible, but are not compressible along their length. In diamond the flexibility is prevented by the way in which the chains of atoms are interlocked; the incompressibility persists and is uniform in all directions because the chains exist in all the major directions. Similarly, it is found by experiments on substances like the long chain paraffines that the refractive index of light travelling along the length of the chains of atoms is much greater (the speed of the light being much less) than that of light travelling in directions at right angles to that length. Since the diamond structure can be regarded as being composed of chains of atoms pointing in all directions and interlocked with each other, it is only to be expected that its refractive index should be uniformly high. This, too, is a consequence of the stability of the atomic and electronic arrangement in this remarkable crystal.

All Diamond Has Same Structure but Differs in Texture

Although all diamonds have the same fundamental structure, yet diamonds do differ in texture. Some are perfect; some are mosaics. Gem diamonds are always perfect, or nearly perfect, single crystals. Their hardness is that characteristic of the particular electronic configuration of the lacework structure of carbon atoms we have described. They are clear and uniform in texture. They give X-ray diffraction patterns which are characteristic, and by means of which they can be identified without possibility of doubt, even if they are only a hundredth of a milligram in weight.

Still Something to Be Learned About the Structure of Diamond

Yet there are a few peculiar spots and streaks on the X-ray pattern given by gem diamonds which cannot be explained on the basis of this simple structure alone. Mosaic and obviously imperfect diamonds do not give these peculiar effects. Diamonds which do not give these extraordinary spots and streaks are transparent to certain light rays in the infrared and ultraviolet regions which are heavily absorbed by the gem specimens. These facts are not explained by the presence of possible impurities. Indeed, there is at present no explanation of them. We can only say that there are known to be two kinds of diamond, one of which is a mosaic of crystallites of a known structure; the other—and this kind includes all gem diamonds—has a very similar structure but with some subtle differences not yet understood. There is, in fact, still work for the scientist to do.

Announcements

R. D. Edwards, of Edwards & Company, 1115 Walnut Street, Kansas City, Missouri, has recently accepted the invitation of the G.I.A. to serve on the Examinations Standards Board of the Institute as representative of the National Wholesale Jewelers' Association.

Mr. Edwards is now serving as President of the National Wholesale Jewelers' Association. His firm, Edwards & Company, are endowment members of the Gemological Institute of America. Mr. Edwards has also lately been elected a director of the Jewelry Industry Council.

The G. I. A. Pearloscope

by

ROBERT M. SHIPLEY, JR.

The Pearloscope illustrated here was designed to furnish a more up-to-date and versatile, and at the same time less expensive, form of endoscope than the French-made instrument which has been used for more than twenty years. The new instrument was designed by the writer and developed by Almer M. Newhall, Jr., at the Gemological Institute's instrument - manufacturing facility, located at Cloverdale, California.

The G.I.A. Pearloscope is a complete, optical pearl-testing instrument, designed to embody both the double mirror and single mirror methods of endoscopic pearl testing, plus the provision for "candling" necklaces or single pearls. All component parts of the instrument are permanently aligned, and it is therefore at all times ready for use, saving the time usually spent on setting up such equipment. Like the French endoscope, it is usable under ordinary room conditions but its effectiveness is increased in a darkened room.

Importance of Pearloscope

For the wholesaler or the retailer catering to a discriminating clientele, the G.I.A. Pearloscope meets a very definite need in its special field. Not only is it the only available instrument for pearl "candling" but it is the only type of endoscope now manufactured, older models no longer reaching the market. For those who are looking for a reliable time-saving means to distinguish natural from cultured pearls, it will be a welcome addition to their laboratory equipment.

Double Mirror Method

The needle which most nearly fits the drill of the pearl to be tested is fitted on the cone below the rotating stage. To facilitate insertion of the needle, the stage is raised to its topmost position by means of the large knurled wheel set on the base of the instrument. After the needle is in place, the knurled wheel is turned counter-clockwise to lower the stage, allowing the needle to project through the hole in the stage.

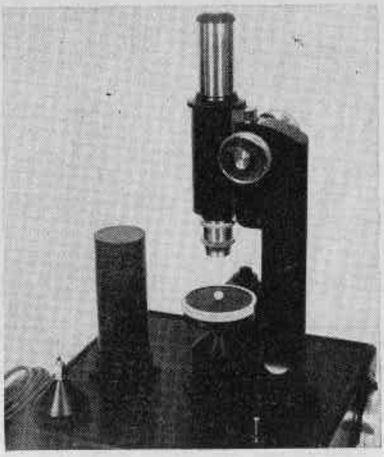
The pearl to be tested is slipped over the needle, and the light switch is set in vertical position. This turns on the lamp in the substage, sending a powerful beam of light through the hollow shank of the needle to a tiny mirror, set at 45°, near the top of the needle. From this mirror the light reflects onto the drill-wall of the pearl. A second mirror is set in the tip of the needle, also at 45° to the shank. The microscope is focused, by reflection from the upper mirror, on a section of the drill-wall just above the spot illuminated from the lower mirror.

The test is made by moving the pearl up and down the needle by means of the large knurled wheel, while observing results through the microscope. If the pearl is genuine, a definite "flash" of light will be seen on the drill-wall when the mirrors are at or near the center of the pearl. The knurled wheel is calibrated in millimeters so that this central position can be verified; readings are taken with first the top and then the bottom of the pearl reflected from the upper mirror. If the pearl is genuine, the light flash will be seen approximately halfway between these two points.

Because of structural irregularities, one portion of a pearl may give a more distinct flash than another. By setting the pearl at the mid-point and rotating the stage on which the pearl rests, all portions of the pearl are covered and the flash, if present, may be adjusted to maximum brightness. The flash is sometimes difficult to see in a lighted room; therefore the instrument functions more efficiently in partial or total darkness. When the switch is in a vertical position, the knurled wheel is illuminated so that the calibrated scale may easily be read in a darkened room.

Single Mirror Method

If no flash is seen, the pearl is assumed to be cultured. This finding may be confirmed by the single mirror method. The light switch is thrown to its forward position, turning off the substage lamp and turning on the lamp in the round tower. This throws a small beam of light through the pearl and onto the top mirror. If the pearl is cultured, a definite line of separation will almost always be seen between the cultured outer layer and the mother-of-pearl core. The core appears dark with respect to the outer layer. If the outer layer be very thin, as in cheap cultured pearls, careful observation is necessary. A slight rotation of the plug at the top of the light tower to increase or decrease the intensity of illumination will often sharpen the contrast between the core and the outer layer. When a variable transformer is used, it may be used to control light intensity. However, for the double mirror test, the transformer control should be set for maximum brightness.



The G.I.A. Pearloscope

A genuine pearl may show a darker layer inside a lighter outer layer, but in such a pearl further examination usually reveals still other layers, usually extending one after another to the center.

Candling

When a necklace is to be tested, a general idea of whether its pearls are genuine or cultured may be determined without unstringing the necklace. This is accomplished by removing the needle from the substage mount and then drawing the necklace across the stage so that each pearl in turn is in position over the intense light beam. A genuine pearl will usually give the effect of even illumination, often with a definite round center shadow. A cultured pearl will often show definite straight "streaks" resulting from the parallel layers of the core. Some operators consider this form of candling to be

(Continued on Page 474)

Principal Crystal Forms of Gemstones

I—The Cubic (Isometric) System

by
RALPH J. HOLMES, Ph.D.
Instructor in Mineralogy, Columbia University, New York City

With this issue *Gems & Gemology* presents the first of a series of color plates illustrating the principal crystal forms exhibited by gem materials. The forms portrayed are the more common isometric ones.

Isometric (cubic) crystals contrast sharply with those of minerals belonging to the other systems in that they are usually neither greatly elongated nor flattened. As a matter of fact, they are found in no less than fifteen different geometric shapes (crystal forms). Of the fifteen forms possible in the isometric system, the only ones frequently encountered among gem materials are the cube, octahedron, dodecahedron, and trapezohedron, either alone or in various combinations. These are illustrated on Plate V of this issue, as follows:

Fluorite (C) consists of two large and two small cubes. Diamond and pyrite are commonly found in the shape of a cube. Most crystals consist of two or more forms modifying each other. The modification consists usually of a beveling of the edges, or a truncating of the corners of the major form present.

Cuprite crystal (A) is essentially an octahedron, a form consisting of eight equilateral triangular faces. It is modified by having each of its twelve edges beveled by the twelve faces of the dodecahedron. The octahedron is one of the most frequently encountered crystal forms of diamond, and is the basis of the diamond brilliant.

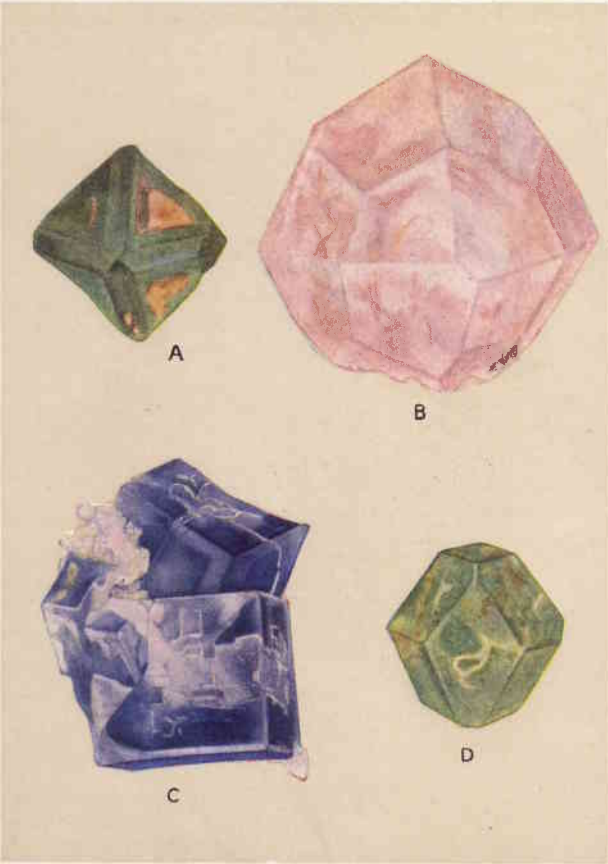
Cuprite crystal (D) is an example of the dodecahedron, a twelve-sided form, each face of which is rhombic, or diamond-shaped. Both garnet and diamond are found in this form.

Analcite crystal (B) is a trapezohedron consisting of twenty-four faces; each a trapezium. It is a form often exhibited by garnet. However, garnets are more often found with this form in combination with the dodecahedron.

The garnet, indeed, is one of the important gemstones in the cubic system. Plates VI and VII convey some idea of its color range in garnet, in both the rough and finished state.

Chemically, this gem exhibits such variability that the term "garnet" is regarded as a group name embracing several species — pyrope, almandite, grossularite, spessartite, and andradite. Rhodolite, an intermediate between almandite and pyrope, is sometimes also regarded as a distinct species.

Although we usually associate a particular color with each of the various garnet species, there is a considerable and, in some cases, an extreme variation in color among specimens of a given species. Andra-



Figures (A) and (D) are crystals of cuprite coated with malachite, from Chessy, France. (A) shows an octahedron modified by dodecahedron faces. The crystal (D) is a combination of an octahedron and cube. The trapezohedron (B) is a crystal of analcite, Seiser Alps, Tyrol. Although occurring in transparent colorless yellowish, reddish and greenish crystals it lacks sufficient durability for gem purposes. The blue fluorite (C) shows excellent twinning in the form of interpenetrating cubes. Fluorite, occurring in a wide range of attractive colors, is widely used for ornamental objects but lacks the durability necessary for common gem use.

PLATE V

Printed in England.

dite, for instance, is found in green, yellow, and black.

Most garnets are some shade of dark red, but they are also found in white, black, pink, yellow, green, orange and purple. Pyrope and almandite supply most of the reddish and purplish stones. Grossularite is the source of most of the yellow, yellow-brown, orange-brown and yellow-green stones and, in addition, a green, massive variety called "South African or Transvaal Jade." Andradite is the source of green demantoid and black melanite.

In acquainting oneself with isometric (cubic) crystals, the following important features should be especially noticed:

1. The general shape of the crystal (whether elongated or equidimensional).
2. The number of faces on a form (six on a cube, eight on an octahedron, twelve on a dodecahedron, and twenty-four on a trapezohedron).
3. The shape of the faces when ideally developed (square on a cube; equilateral triangular on an octahedron; diamond-shaped on rhombic on a dodecahedron; and trapezium-shaped on a trapezohedron).

THE GARNET—PAST AND PRESENT

by

KATHRYN LOWER

Although it is quite possible that the carbuncle of ancient and medieval times was the name given to all transparent red stones, it is equally probable that most of the stones were the red varieties of the garnet, since the mineral was so abundant and, because of its comparative softness, easily fashioned and polished by the primitive tools of the ancients.

As the seat of civilization is usually regarded as somewhere in the near vicinity of Asia Minor, it is interesting to note that since the first reference to the garnet that section of the world has been its principal source of supply and has remained until recent years the most important section where mining and fashioning of garnets was a major industry.

So highly regarded was the garnet by the Persians that it was considered a royal stone and was used to bear their sovereign's image. Egyptians used the garnet long before the early Greek goldsmiths had access to it, while the Jews, Arabs, Poles, Russians, and Romans favored the stone through the ages as evidenced by their use of it as a traditional birthstone. Anglo-Saxon and Merovingian jewelry shows flat-polished slabs of almandine inlaid in mosaic work.

Although known long before Biblical times, we learn from the Old Testament that the garnet, or carbuncle, was the first stone in the Breastplate of the High Priest and was given to Reuben. An ancient Hebrew legend tells of a carbuncle in the ark of Noah which gave light to all within. The Mohammedan Koran states that its red glow is all-pervading and that it gives forth the light of the fourth Heaven.

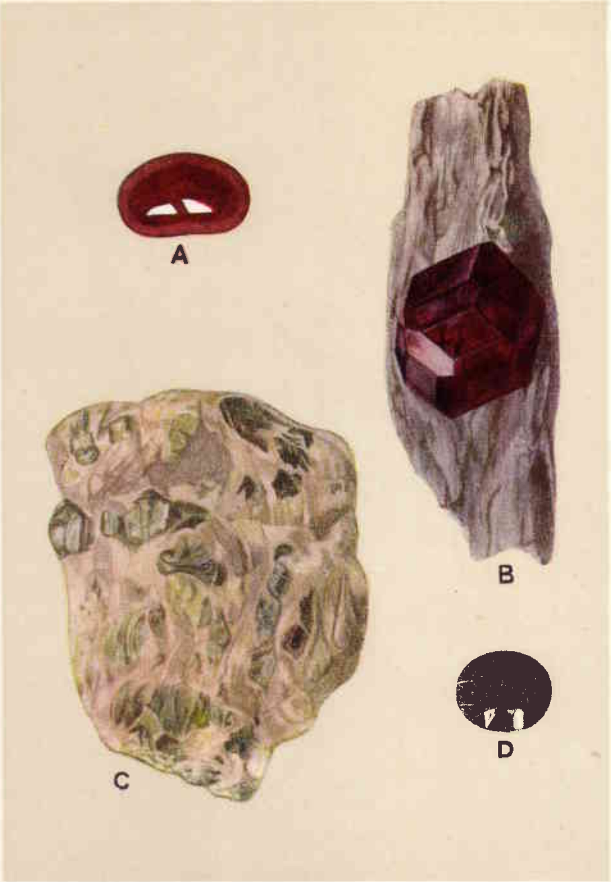
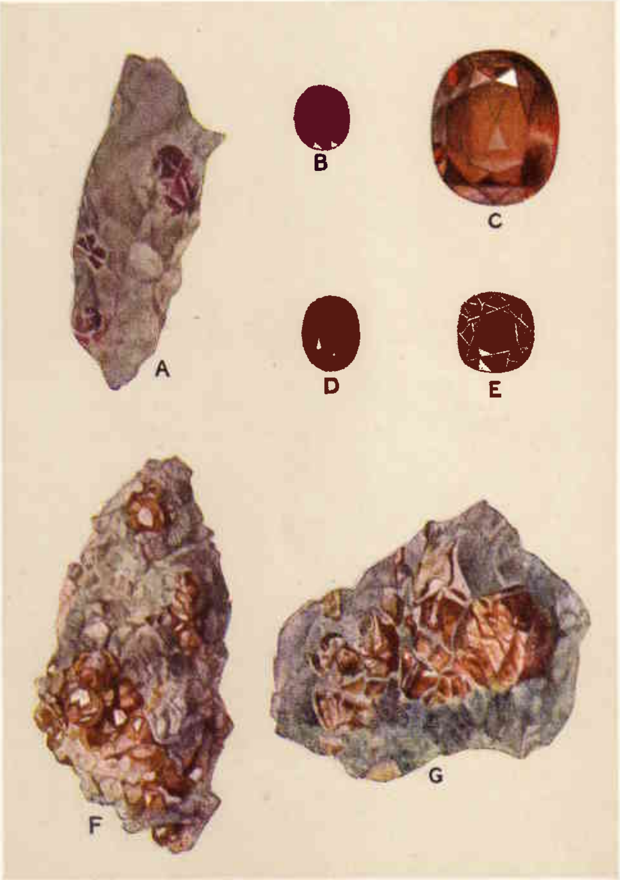


Figure A is a cabochon-cut red garnet. The red almandite embedded in gray mica schist (B) is typical of the garnets from Fort Wrangell, Alaska, a locality important as a source of well-developed garnet crystals but not of gem material. The crystal illustrated is a dodecahedron modified by the trapezohedron, a common crystal habit of garnet.

At (C) and (D) the beautiful green demantoid variety of andradite is shown. This mineral has the strongest dispersion (fire) of any natural gem, exceeding even that of diamond, and its high index of refraction makes it a stone whose brilliance compares favorably with that of zircon.

PLATE VI

Printed in England.



Crystals of pyrope are shown at (A) and a cut specimen with the typical "garnet" color is shown at (D). The paler and more purplish rhodolite is shown as a cut stone (B). Hessonite, a yellowish-brown variety of grossularite, is shown at (C) as a cut stone, and in the form of rough material at (F). Gem-quality spessartite (E) is often a yellow-brown color resembling closely the hessonite variety of grossularite. Rough spessartite is shown at (G).

PLATE VII

Printed in England.

In the period between the death of Alexander and the Roman conquest, great changes were seen in the work produced by Greek goldsmiths. During this time new gem materials, including the Syrian garnet of deep red-purple color, made their appearance. The softness of the new stone made it immediately popular with the medieval engraver and he used its convex top for engraving figures and portraits. These "carbuncles" were of good size and set in rings of hollow shells instead of bands of gold.

Early popularity of the garnet no doubt can be attributed to the fact that although exhibiting extreme toughness, the mineral is relatively soft and could be easily polished with emery (hardness of 9) which the ancients obtained from Naxos Island.

The term "carbuncle" is used by Agricola in "Natura Fossilium," written in 1545, and he states that the Latins derived the name Carbunculus from *carbo*, meaning little coal. The same stone, according to this writer, was called Anthracitidas by Theophrastus, or Acthracia by the Greeks. Both names come from the Greek root *anthrax*, meaning coal. No doubt the fiery red glow of the garnet was responsible for this nomenclature.

As with most gemstones, the ancients credited the garnet with potent powers and medicinal qualities. It was believed to cure inflammatory diseases, to reduce fever, and even to have a calming effect on quarrels. It was often worn as an amulet against accidents in travel. Believing its glowing light would inflict a more deadly wound, the Asiatics are said to have used the garnet as a bullet.

The garnet is the birthstone for January and the talismanic gem for May. It is called the emblem of faith, truth, and grace and is said to denote constancy and fidelity. By losing its color and splendor it is claimed the garnet warns its wearer of impending disaster.

During the Victorian era garnets were usually mounted in low carat gold and principally in many clusters of small faceted stones. One of the most popular gems of that period, their durability has permitted Victorian jewels fashioned of garnets to be in constant use since that time.

Jewelers' customers should be very much interested in garnets, for what other transparent stone excepting tourmaline could so lavishly supply the demand for color choice in emerald-green, deep red, delicate shades of pale rose, red, purple, cinnamon, yellowish-red, amber, brown, and pale green in all their varying intensities? It is only in the blue section of the color wheel that the garnet is unknown. In addition to this wide range of color, the garnet also shows the intriguing phenomenon of asterism.

Garnets appeal especially to those persons who desire a durable and beautiful gem at a reasonably low price; also to those who wish to make a selection from a wide range of colors. One of the principal selling points for the garnet is its resistance to fracture. All species, with the exception of andradite, are above quartz in hardness, and all species are extremely tough. Because they can be repolished readily with a normal loss in weight, they are extremely good buys.

Despite the common belief in its prolificacy, the garnet in good size and fine color is a rarity, and not

(Continued on Page 479)

Jewels of the Russian Diamond Fund

by

ALEXANDER E. FERSMAN †

PART IV

History of the Large "Ruby"

The King of Bohemia, Rudolph II, had a notable collection of precious stones. Among them was a red "ruby" the size of a chicken egg. The king received this stone as an inheritance from his sister, widow of the French king, Charles II.

After the death of the Bohemian queen, the stone was taken to Stockholm, and in 1777 Gustav-Adolph III presented it to Catherine the Great during his visit to St. Petersburg. Boecius de Boot, Jeweler of the Bohemian Court, gives its value as at least 60,000 ducats. Its weight was 255¾ carats. It was kept with the Diamond Fund collection in the Russian Winter Palace from 1777 to 1914. [The Diamond Fund jewels were transferred from St. Petersburg to Moscow during the first World War.]

In 1922, while inspecting the Diamond Fund collection, I studied and described this stone thoroughly. (See Figure 1.) Evidently of Indian workmanship, it resembles a bunch of grapes. It is not of clear water, and not immensely valuable, but very beautiful.

Mr. Aminov, Professor of Mineralogy at Stockholm, studied the model of this stone made in 1748, and determined that the specific gravity of the original stone should be about three, which does not correspond to the specific gravity of ruby. The appearance, color and specific gravity led us to conclude that it is not a "ruby" at all, but rubellite; in other words, it was pink tourmaline.

The Blue Stone of Pamir

The bright blue lazurit of Afghan has been the basis for legends down all the recorded length of history. By way of caravan it reached far Egypt, China, Rome and Byzantium. Through Afghan and Bukhar merchants the Russian tzars bought the beautiful blue pieces, which were much preferred to the spotty lazurit from the shores of Lake Baikal.

Up to the present the blue Afghan stone is inimitable. However, for a long time in Middle Asia, legends repeated that somewhere in the heights of Pamir there was a stone called "lazuard" by the Persians.

In 1930 an expedition of Soviet geologists started out to find this Pamir lazurit. The way was exceptionally difficult. Having ascended

Fig. 1—*Pink tourmaline (rubellite) representing a fruit. Mounted in a pin. Natural size.*

---

† *Translated by Marie Pavlovna Warner.*

over 3,500 meters, the expedition had to leave its horses and continue on foot along one of the rivers which had the name of Liadjuar-Dara, which means "River of Lazurit."

When the expedition [Fersman was a member] reached 5,000 meters, we found there a great glacier field covered by immense stones, fallen from the adjacent steep wall of marble and gneiss. And in this snow-white marble were veins and nests of lazurit, some bright blue, some delicately blue with beautiful passages into violet and green tints. Thus the Soviet scientists found the birthplace of real dark-blue lazurit.

Altho geologists discovered the Pamir stone for science, the natives knew of it before. A guide commented that he had heard of it from his father, and that in 1914 he, with others, tried to reach the place but all contracted "tutek," mountain sickness, and turned back.

This Pamir region of white marble produces other native stones. From mines at the mouth of the Kuga-Lial River, the East for a thousand years has been getting its red stones — bright rubies and pinkish-red spinels, called "lal."

Even at present the lazurit from Pamir is superior to that from the mines at Sliudianka in the Trans-Baikal region, and leaves far behind that found in the snowy heights of the Chilean Andes where, in the province of Kokimbo, American companies have tried to mine a pale blue lazurit.

Pamir lazurit surpasses even that from the old mines of Afghanistan, whose approach was punishable by death and where miners were chained for life, as the stone was considered sacred and belonged only to the Emir.

Among the noted samples of lazurit in the collection of precious stones of the Mineralogical Museum of the Academy of Sciences was a blue lazurit elephant. We found it by accident, during the Revolution, in the Fabergee store on Morskaia Street, St. Petersburg. We brought our find to the museum, studied it in detail, measured it, assigned it a number, and placed it on exhibit.

The elephant was remarkable. It was cut rather roughly by the method used by the Kishlaks, a mountain tribe of Afghanistan and India, but some fine artisan of the polishing shop had used this primitive cutting advantageously. Most striking was the lazurit itself, a monolith of bright blue, except for the head of the elephant, where a few small crystals of pyrite glistened. In place of eyes there were, in accordance with Indian practice, two small "diamonds" cut from rock crystal.

The elephant was in the museum for many years until — this is what happened:

In the spring of 1928 the Emir of Afghan, Ammanula-khan, was returning from Europe through the USSR. He was feted as an organizer of new Afghanistan. The Academy of Sciences showed him the ancient Arabian manuscripts concerning Afghanistan and the Russian jewels. We placed the stones in a brilliantly lighted room, on velvet, arranged according to Newton's scale of colors. The exhibit impressed Amanulla-khan tremendously. As a son of the East and a connoisseur of colored stones, he was enraptured. He paid greatest attention to the table of lazurit; especially to our elephant. This he held in his hands a long time, tenderly caressing its back, his eyes bright and talking rapidly in Afghan to his attendants.

"What do you think?" I asked my

comrades, "Should we present the elephant to him?"

From a scientific point of view it was not of great value to us, so I offered this piece of Afghan stone to Amanulla-khan as a remembrance of our museum. He firmly refused it, saying that he could not accept such a sacrifice from me, the director of the museum, even though I told him we generally collected only uncut stones and hinted that it would be agreeable to us if he could help us obtain some ores and stones from Afghanistan.

My words did not reach him. He continued to caress the blue elephant. Suddenly, with a swift motion and without turning around, he passed it over his shoulder to his adjutant, who hid it quickly. As if nothing had occurred Amanulla continued to examine the exhibit, passing from the blue lazurit to the green nephrit and yellow amber. I cannot conceal, however, that I was sorry to give up our elephant.

Sad to say, although Amanulla gave permission for a Russian scientific expedition to enter Afghanistan to examine the mines at Badakhshan and the lazurit mines at Firgama, when the expedition arrived the authorities postponed the visit to the mines. Meantime a revolution against Amanulla-khan started and the expedition turned back home.

What happened to our elephant? We are not sure. Upon his return, Amanulla-khan transferred all his presents to his summer palace at Faizabad. We learned later from newspaper notices that the palace burned and everything was stolen. But the blue color of lazurit does not suffer from fire and sometimes becomes brighter. Since the elephant was cut from one piece it could not easily be broken. It may have been spirited away to some wild settlement. Or perhaps some Mohammedan took it to a minaret, where it rests among other treasures of the East. This is all we know of the fate of the blue elephant.

The Emerald of Iakov Ivanovich Kakovin

One of the largest in the world, the history of this emerald is especially interesting, as it is known from first to last. In 1831 Mr. Kakovin, director of the Ekaterinburg cutting works, informed the government that he had discovered some emeralds. Those mined at Sretensk were especially notable, large and of bright color. In 1834 Mr. Kakovin received a very large emerald from these mines weighing more than 2226 grams. One side of this stone was polished by na-

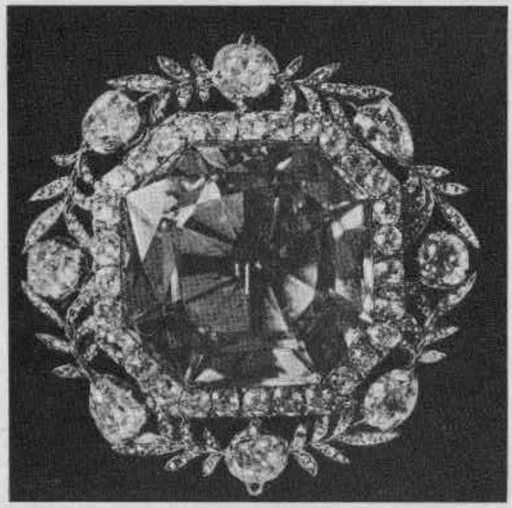


Fig. 2—*Brooch bearing a yellowish-green beryl (natural size). Part of the Russian Diamond Fund.*

ture, very clear and transparent in places. He fell in love with this stone and others and decided not to send them to the tzar's court. He hid them under his bed and in the corners of his house. But rumors of his avarice soon leaked out. St. Petersburg sent out a commission, which discovered his treasures. Kakovin committed suicide.

The report of the commission reads:

"Among these stones there is one of the best quality—a very grassy color. This is the most precious, surpassing the emerald which was in the crown of Julius Caesar."

The stones were packed and sent off to St. Petersburg, accompanied by a young cutter named Permikin. Mr. Permikin brought the stones to the director of the Department of Appenage, Hofmeister Lev Alekseevich Perovsky. Mr. Perovsky had a valuable collection of his own. These emeralds were added to it and for a second time the great emerald was delayed on its way to the Court.

I could not find out how Prince Kochubey was able to purchase the Perovsky collection, but this he did.

In any event, wishing to preserve his large collection (which contained the Kakovin emerald), he transferred it to his heirs on his estate Dikanka in the province of Poltava. Years passed and there were peasant disorders. The estate was burned and the collection strewn in the garden and pond. It was difficult to reassemble them, but finally three quarters of the collection was restored, including the emerald of Kakovin.

The son of Prince Kochubey then took the collection to Kiev where a catalog was made and published. But the young prince did not wish to sell the collection in Russia. He took it to Vienna, exhibited it and offered it for sale to the largest museums of Europe and America. But we, the Russian scientists, could not bear the idea of losing it to foreign countries. In the name of the Academy of Sciences, the late academician, V. I. Vernadsky, brought the matter to the attention of the State Duma. Vernadsky and myself were sent to Vienna for examination and appraisal of the collection. It proved to be very expensive. The Kakovin emerald alone was appraised by the jewelers at fifty thousand Austrian guldens, and the whole collection was worth over one hundred and fifty thousand golden rubles.

After much red tape, Tzar Nicholas II signed an order for the purchase of the entire collection. Prof. V. I. Krjijanovsky came to Vienna, carefully packed all the valuables, and sent them to St. Petersburg. The cases were brought to the old museum, where it was discovered that two cases had been stolen enroute. With trembling hands we started to check the contents. To our relief, it was the less valuable stones which were lost.

Acceptance of the collection by the Academy of Sciences, represented by V. I. Vernadsky, A. P. Karpinsky and F. N. Chernyshev, was a moment of great solemnity. So to the mineralogical museum of the Academy of Sciences came the famous emerald of Iakov Ivanovich Kakovin, the largest in the world, weighing 2,226 grams. In 1935 this emerald, together with the Academy, was transferred to Moscow, to the halls of the Orlovsky menage. During the German invasion the stone was temporarily returned to the Urals, but since victory it is again in Moscow.

Pearl Identification by X-Ray Diffraction

Mappin's Gemmological Laboratories, Montreal

by
WILLIAM H. BARNES, M.Sc., Ph.D.
Senior Research Officer, National Research Council, Ottawa, Ontario
Formerly Associate Professor of Chemistry, McGill University, Montreal, Quebec

PART III—RESULTS

Editor's Note: For figure numbers under Figure No. 15, see two preceding issues of Gems & Gemology.

Off-Centre X-Ray Diffraction of Natural and Cultured Pearls

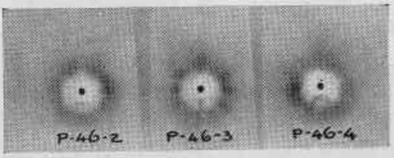


Fig. 15

Off-centre X-ray diffraction photographs of natural pearls, therefore, may be expected to show such rectangular patterns. To illustrate this point, the natural pearl employed for the photographs reproduced in Figure 15 was displaced by 1 mm., 2 mm., and 3 mm., respectively, along a line at right angles to the X-ray beam from the centred position in which pattern P-46-2, Figure 15, was obtained. The corresponding diffraction patterns, P-46-5, P-46-6, and P-46-7, Figure 16, given in these settings, clearly show the change in the diffraction effects from the halo (P-46-2, Figure 15) when the beam was passed through the centre of the pearl, through distorted rectangular patterns (P-46-5, P-46-6, Figure 16) to an almost ideal rectangular pattern (P-46-7, Figure 16) as the direction of the beam approached within about 1.5 mm. of the surface of the pearl along a line through its centre and perpendicular to the X-ray beam. This corresponds to the displacement from A to B, represented in Figure 14. Thus, although a rectangular pattern is indicative of the cultured origin of a pearl if the X-ray beam passes through the centre of the specimen, it does not immediately permit distinction between a cultured and a natural pearl if the direction of the beam is appreciably off-centre.

Fortunately, the difference between the radial distribution of the pseudo-hexagonal axes of the crystals in the natural pearl and their parallel arrangement in the mother-of-pearl core of the cultured pearl permits experimental separation of the two types. Thus, in Figure 17, a natural pearl and a cultured pearl are shown diagrammatically at A. The directions of the pseudo-hexagonal axes are indicated by the radial lines in the former and by the parallel vertical lines in the latter and the geometric centre is shown as a black dot. The horizontal mother-of-pearl layers in the core of the cultured

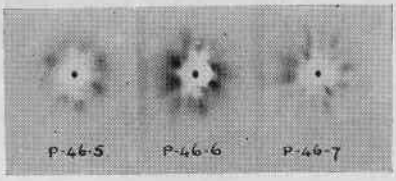


Fig. 16

pearl are not represented in the diagram. The X-ray beam in diagram A is to be imagined as passing through the centre of each pearl in a direction normal to the plane of the figure; its trace (exaggerated) is represented by the small circle around the centre. The plane of the flat photographic film is parallel to the plane of the diagram and its edges are vertical and horizontal respectively. In other words, the diagrams have been drawn as though the eye were viewing the pearl from the X-ray tube along the direction of the X-ray beam. In the setting represented at A in Figure 17, the diffraction pattern from the natural pearl will be of the hexagonal, or halo type, as in Figures 15 and 18, whereas that from cultured pearl will be rectangular with the trace of the pseudo-hexagonal axis vertical as in Figure 19, P-42-28 to P-42-31, inclusive.

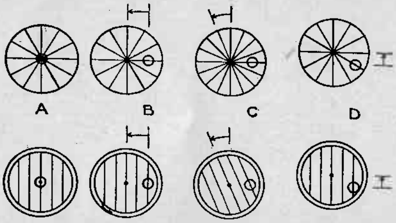


Fig. 17

Now, if the natural pearl be displaced horizontally in the plane of Figure 17 to the position represented at B, a rectangular pattern with the trace of the pseudo-hexagonal axis horizontal as explained in connection with Figure 14 is to be expected. A similar displacement of the cultured pearl to the position represented at B (Figure 17), however, should have no effect on its diffraction pattern; i.e., the trace of the pseudo-hexagonal axis should remain vertical.

If the natural pearl in the off-centre position represented at B in Figure 17 be rotated about an axis through its centre and parallel to the X-ray beam (normal to the plane of the diagram) to a position such as C (Figure 17) there should be no change in its rectangular pattern. This follows from the fact that the pseudo-hexagonal axes are distributed radially so that for any rotation of the pearl about an axis through its centre, as represented at C in

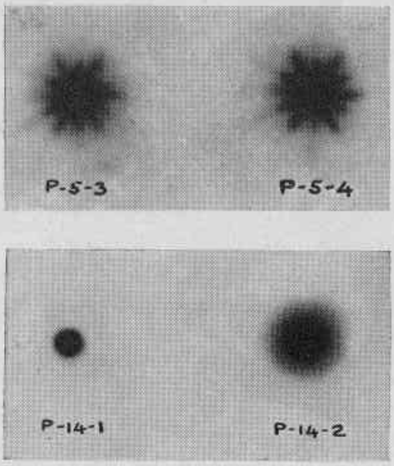


Fig. 18

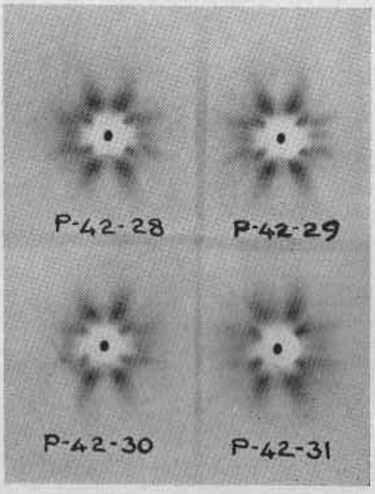


Fig. 19

Figure 17, the particular axes that happen to be in the path of the X-ray beam will still be horizontal.

On the other hand, the parallel alignment of the pseudo-hexagonal axes in mother-of-pearl should result in a rotation of the rectangular pattern in the same sense (clockwise or anticlockwise) and to the same degree as any similar rotation of a cultured pearl from a position such as that represented at B in Figure 17 to one such as that at C.

Finally, if the natural pearl in the off-centre position at B, Figure 17, be displaced in a straight line vertically upwards as represented at D (or downwards) the rectangular pattern should rotate clockwise (or anticlockwise) through an angle determined by the magnitude of the displacement, since in the new position the pseudo-hexagonal axes in the path of the beam are no longer horizontal. In the case of the cultured pearl, however, a similar vertical displacement from the position represented at B, Figure 17, to that represented at D, should have no effect on the orientation of the rectangular pattern.

Corresponding diagrams for a cultured pearl when the X-ray beam passes through the specimen below the geometric centre are shown in Figure 20. As in the previous set of diagrams (Figure 17) the small circle represents the trace of the X-ray beam and the black dot indicates the geometric centre of the pearl. In its initial position, A, a rectangular pattern with the trace of the pseudo - hexagonal axis vertical should be obtained from the specimen. No change in the appearance or the orientation of the pattern should occur if the pearl be given a horizontal displacement to a position corresponding to B, Figure 20. If the pearl in the off-centre position represented at B be rotated (for example, anticlockwise) about an axis coinciding with the initial position of the X-ray beam, the geometric centre rotates around the dotted circle shown in diagram C, Figure 20, and the upper end of the greater diameter passing through the centre traces the large broken circle. In spite of the eccentricity of rotation of the pearl, however, the pseudo-hexagonal axes in the path of the beam rotate in the same direction and to the same degree as the pearl.

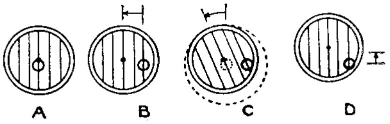


Fig. 20

Finally, if the pearl be displaced vertically (upwards, for example) from the setting represented at B, Figure 20, to one corresponding to diagram D, Figure 20, there should be no change in the rectangular pattern or in its orientation on the film. Thus, the diffraction patterns from a cultured pearl should be the same for each of the displacements relative to the X-ray beam represented in Figures 17 and 20, regardless of whether the X-ray beam passes initially through the geometric centre of the pearl (as at A, Figure 14) or vertically below (or above) the centre (as at A, Figure 20).

In connection with the X-ray diffraction photographs reproduced in this and preceding Parts I and II, it should be noted that much of the detail clearly visible in the original negatives is lost in the process of making a positive print on film, printing on paper from this, making a cut for reproduction and finally printing. This is due in part to the extreme range of blackening represented in X-ray diffraction photographs. Furthermore, X-ray negatives are examined by transmitted light, whereas the reproductions are examined by reflected light. Thus details clearly shown in the original negatives may be only faintly visible in the printed reproductions.

(1) a. Dauvillier, A., Compt. rend. **179**, 818 (1924); Rev. Scientifique **64**, 37-45 (1926).
  b. Shaxby, J. H., Compt. rend. **179**, 1702 (1924); Phil. Mag. **49**, 1201 (1925).
  c. Galibourg, J., and Ryziger, F., Compt. rend. **183**, 960 (1926).
  d. Mayneord, W. V., Brit. J. Radiology **23**, 19-30 (1927).
  e. Anderson, B. W., Brit. J. Radiology **5**, 57-64 (1932).
  f. Alexander, A. E., Am. J. Sci. **238**, 366-371 (1940).
(2) Pub. No. 138/3, Adam Hilger, Ltd., London, 1939.
(3) Bernal, J. D., J. Sci. Instruments **4**, 273-284 (1927); **5**, 241-250 (1928); **6**, 314-318, 343-353 (1929).
(4) Barnes, W. H., and Hampton, W. F., Can. J. Research, **B13**, 218-227 (1935); R.S.I. **6**, 342-344 (1935).
(5) Astbury, W. T., **Fundamentals of Fibre Structure.** (Oxford Univ. Press) 1933.
(6) Alexander, A. E., and Sherwood, H. F., The Gemmologist **10**, 45-48 (1940); Photo Technique **3**, 50-52 (1941).
(7) Barnes, W. H., **Gems & Gemology**, V, 359 (1946).

(To Be Continued)

Fellowships Awarded

Word has recently been received from the Gemological Association of Great Britain that Lester Benson and William Collison, C.G., both presently of the G.I.A. staff, have passed the Preliminary and Diploma examinations qualifying them for the title of Fellow of that Association. Their election as Fellows is scheduled for November 13th. Including these two, only nine men in the United States and Canada are privileged to use the title F.G.A.

Pearloscope

(Continued from Page 463)

as accurate as the radiographic method of pearl testing. However, candling cannot be considered a reliable process for a single pearl, though it is of value as a basis for a preliminary opinion as to the character of a necklace. Any questionable pearl may be removed from the strand and tested by the more accurate endoscopic methods. For example, assume that a necklace, upon candling, shows evidence that all but a few pearls are cultured; those not showing such evidence are then removed from the necklace and tested on the needles. If testing endoscopically then proves that these few are cultured, it is safe to assume that the entire necklace is cultured, and it is not necessary to test each pearl individually.

Maintenance of Equipment

The lenses in the substage condenser should be cleaned carefully whenever they show any dulling. Also, the mirror in the head of the light tower should be rubbed bright occasionally. A drop of #10 oil should be applied to each moving part twice a year.

For good results, it is essential that the needles be kept very clean. The shank and the lower mirror are easily cleaned by pumping U.S.P. alcohol through the needle with a hypodermic syringe. (Denatured alcohol will leave an oily film and should not be used.) The upper mirror should be lapped bright whenever it ceases to give a good image. This is done by first lapping on a stone, followed by polishing on a fine-grain chamois flat with a small amount of finely powdered jewelers' rouge.

The substage lamp may be replaced by turning the instrument on its side and inserting a new bulb in the socket. To remove the tower lamp, it is necessary to remove the slip ring from the bottom of the tube and slide the lamp socket out by pulling the wire. The socket should be replaced in approximately the original position, but its exact location is not critical.

GEMOLOGICAL DIGESTS

Mexican Black Opal

Mexico has long been famed among gem connoisseurs for its "water opal." Due to its rarity this stone does not compare with the Australian opal and is chiefly of interest as a collector's item. Even less known, however, is a variety of black opal from Mexico, which the writer obtained on a recent visit.

The Mexican black opal is a true opaque black, containing abundant, though slightly subdued, fire; it is free of the matrix which characterizes the Australian variety. Due to its novelty, the value of this Mexican opal has not been definitely established.

Everyone who handles opal can tell tales of the stone's sensitivity to heat and dryness; opals sometimes crack or break with seemingly little cause other than their innate perversity. Yet the Mexican black opal is actually raised to a red heat by the native lapidaries in order to improve its brilliance, without the stone suffering damage.

When first taken from the ground, the opal is a creamy white color and shows relatively little fire. In order to darken it and bring out its latent fire, the Mexican lapidary employs the following process which the author was privileged to observe closely.

Process for Baking

(1) The rough opal is cut into finished, polished stones and from among these are selected those suitable for baking. In order to withstand baking without breaking, a stone must be opaque in appearance, as opposed to the glassy or translucent color usually associated with opals. Such opaque stones are usually a trifle porous as well. The ability to choose correctly comes only with practice.

(2) A very fine-grained baking earth is compounded by mixing dust from the opal-cutting operations with finely pulverized fertilizer. This causes the earth to have cohesion; it resembles in texture the molding sand used in fine silver casting.

(3) The opals and the baking earth are spread in the patio early in the morning and allowed to remain in the sun until mid-afternoon. This drives off excess moisture and warms both opals and earth evenly.

(4) A small (1 pint) spherical earthenware pot is half filled with the warm baking earth and evenly tamped. The opals are placed on top of this layer, then the pot is filled with the remainder of the earth and again tightly tamped. It is important that the tamping be thorough, otherwise the opals will heat unevenly and may break.

(5) The lapidary now places the pot deep in a bed of hot charcoal, on which the family supper is usually cooking, and goes off for a short siesta or to the near-by church to offer a prayer for the health of his black-opals-to-be; the cooking of opals is not so certain a thing as to cause one to lightly spurn divine assistance.

(6) Approximately 20 minutes after placing the pot in the charcoal, the lapidary removes the vessel, which by now is a bright cherry red; a blue flame may play around the mouth of the pit due to the emission of gas by organic material in the baking earth.

(7) The pot of opals is allowed to cool indoors until the following morning, when the earth is unceremoniously dumped into an ordinary kitchen strainer and the opals sifted out. This process is not devoid of interest, as it may reveal a batch of fine stones or only a heap of worthless fragments. The baking has turned the earth as black as soot and destroyed its cohesiveness. It is used only once.

The process which causes the opals to darken is not clearly understood and would be an interesting subject for study.[1] The explanation is probably to be found in the reduction of carbon within the stone; but whether the carbon was originally present within the stone or whether it is introduced by the organic vapors is not known.

The fact that these opals withstand such intense heat with relatively little breakage and show a marked increase in brilliance is of considerable interest. It would seem that the play of colors so typical of opal is, in this stone at least, independent of casual water content in the stone's interstices and due entirely to the optical configuration of the opal proper. It would be interesting to determine the water content of these opals before and after heating. —Dan E. Mayers

---

[1] Subsequent to writing the above, the author discovered that the blackening of the opals described was only "skin-deep." the stone turning white once more on being repolished. This shows rather conclusively that the coloring is caused merely by the deposition of soot in the pores of the stone near its surface.

Notes on Cutting and Polishing Scheelite

Scheelite is difficult to polish, which indicates that it has a high melting point. This, combined with a high coefficient of expansion, makes high pressure and lap-speed in polishing impossible. This drawback to its use as a gem is partially offset by its high dispersion and strong double refraction.

I have obtained interesting results in cutting and polishing a white scheelite reported to have come from southern California.

Polishing was, at first, difficult. Under a high-speed felt buff the material heated and shattered badly. An excellent polish was eventually obtained on cabochon forms with very fine levigated alumina on a hard felt buff, wet, with the slowest speed on a jeweler's polishing motor.

Flat surface polishing in a brilliant-cut scheelite presents a much more difficult problem. An excellent example of brilliant-cut scheelite was fashioned for me by Mr. A. Espositer, of Larchmont, New York, who roughed out the piece to the approximate proportions for a full cut brilliant of about the size of a 3- or 4-carat diamond.

In polishing it, with a view to obtaining a maximum amount of total reflection, Mr. Espositer tried everything—even to a very fine levigated diamond dust—without being able to arrive at anything which would give it a fine polish without cracking it, so that it still appears a bit milky.

If any method could be found to give colorless, brilliant-cut scheelite a high polish, a most lively brilliant would result. Though not of sufficient durability for use in jewelry, such a stone would make a fine museum piece. —Frank B. Wade

BOOK REVIEW

Two Recent Aids to Gem Identification

reviewed by

RALPH J. HOLMES

Gem Testing by B. W. Anderson (4th Edition), Heywood & Company, London, 1947, 224 pages, (17s. 6d.), and *Handbook of Gem Identification* by Richard T. Liddicoat, Gemological Institute of America, Los Angeles, 1947, 283 pages ($4.50).

Two new books designed to aid the jeweler in the identification of gem materials by modern scientific methods have appeared during the summer. The authors are both well-known gemologists. B. W. Anderson is Director of the Precious Stone laboratory of the London Chamber of Commerce. R. T. Liddicoat is Director of Education of the Gemological Institute of America. Anderson's book is a revised and considerably augmented edition of one first published in 1942, whereas Liddicoat's is a first edition.

These are practical handbooks whose scope is limited to a treatment of the essential features of gem testing instruments and detailed instructions required by the jeweler when identifying gems with the aid of such devices. The two books are designed to serve the same purpose and have much in common, but the presentation is radically different. Neither book presents a systematic description of gem materials. Such descriptions are to be found in Smith's *Gemstones* and Kraus' *Gems and Gem Materials.*

It is in the section dealing with the identification of the various gem materials that the two books differ markedly in presentation. Anderson takes each important gem stone and shows in detail how it can be distinguished from other materials that might be confused with it. Liddicoat, on the other hand, devotes individual chapters to stones of a particular color, the most obvious property of any gem material. If a green transparent stone is in question, one need only consult the chapter dealing with "green transparent stones." At the beginning of this chapter he will find a list of natural and artificial gem materials known to occur in that color. Following the procedure outlined in that chapter he will, by a process of systematic elimination, arrive at the identity of the stone. The treatment is certainly one that will meet with wide approval and should make the book especially useful as a laboratory manual for use in courses in gem identification.

One of the outstanding features of Anderson's book is the extended discussion of the application of the spectroscope to gem identification, a gem testing method that has not been sufficiently appreciated in America. An instructive color plate showing the characteristic absorption spectra of a group of important gem stones accompanies this discussion.

The numerous excellent photomicrographs in Liddicoat's book illustrating characteristic inclusions in natural and artificial gem materials add considerably to the book's usefulness. A knowledge of characteristic inclusions and internal structural features is essential in discriminating between synthetics and their genuine equivalents.

Both the subject matter and presentation differ sufficiently so that the two books are to a certain degree supplementary and both should find a place on the book shelf of every jeweler and gemologist.

(Note—Gem Testing may be ordered from the publisher, Heywood & Co., Drury House, Russell St., Drury Lane, London W.C. 2, England, or as an accommodation from the G.I.A. book department, for $4.50 a copy.)

Linde Stars

(Continued from Page 454)

Refractive Index

An attempt was made to determine the refractive index on the refractometer, but the backs were too rough and too curved to permit this. The low relief of the stones when immersed in methylene iodide (n=1.738) suggests an index in the vicinity of range proper for corundum.

Physical Properties

The specific gravity of both stones was determined. Since both were large (red—12.15 carats and blue 10.8 carats) accurate determinations could be easily made. The values obtained were as follows: Red stone 4.011; blue stone 4.004. This is in good agreement with the value for natural corundum which is usually given as 3.9—4.1.

When hardness points were used on the backs of the stones it was found that the 8 pencil had no effect, whereas the 9 pencil produced a scratch.

Means of Distinguishing Synthetic from Natural Star Corundum

The synthetic "Linde Stars" can be distinguished from natural star rubies and sapphires by attention to the following:

I—Indications (not proof) of synthetic origin:

- A—Unnatural color and dichroism, especially in the case of the red stones.
- B—Unusual strength of the star.
- C—Unusually sharp definition of the star.
- D—Asymmetry of the star [2 of the 6 rays (opposite pair) shorter than the other four rays].
- E—Unusually perfect alignment of the rays.
- F—Exceptionally close packing of needle-like inclusions when viewed under the microscope.

II—Proof of synthetic origin

- A—Belted appearance of stone (observation that needle-like inclusions are restricted to a superficial layer conforming in a general way to the upper contour of the stone.)
- B—Spherical bubbles.
- C—Curved color bands.

Conclusion

The data secured on the optical and physical properties would seem to establish that the material constituting these star stones is corundum. In common with their natural counterparts, they owe their asterism to the presence of crystallographically oriented needle-like inclusions, present in three sets intersecting each other at angles of 60°.

However, at this point the similarity ends. In natural star corundum, the needle-like inclusions are more or less uniformly distributed vertically throughout the stone. At least they are not restricted to a particular zone or layer, especially one conforming more or less to the surface of the cut stone. In these new synthetics, the needle-like inclusions seem to be restricted to a comparatively narrow zone more or less concentric with the upper curved surface of the cabochon cut stone.

In the light of this, some may raise the question as to whether these artificial star stones are in the strictest sense the synthetic equivalent of natural star rubies and natural star sapphires.

The Garnet

(Continued from Page 466)

necessarily the inexpensive stone many suppose.

Most expensive of the garnet group is the brilliant green demantoid. The finest of these are found in the Ural Mountains of Russia and are, in large sizes, rare. They are sometimes incorrectly called olivine, the mineral name for peridot, but the demantoid is much more rare, more costly, and has greater fire than olivine. The name "demantoid" comes from the Greek and means "diamond-like," which is justified by the adamantine luster and the high dispersion of the stone. In finer qualities, the green demantoid often approaches the depth of color of the emerald but is much more brilliant and has a higher dispersion, not to mention its greater durability. It is interesting to note that the demantoid in over one-carat size will command a higher price per carat than a star sapphire of comparable quality and size. In small sizes it is occasionally seen as calibre in channel settings.

In the trade the garnet will be found in cabochon (sometimes hollow back); brilliant cut; emerald cut; rose cut (especially in antique jewelry); and engraved or carved. Because of its wide variety of colors and appearance, the garnet is often mistaken for other gems; however, no imitations are made except glass or garnet and glass doublets, and few of these. The so-called "synthetic garnet" is usually a synthetic spinel.

GIFTS TO THE INSTITUTE

Recently Jack Klecka, in the diamond department of J. R. Wood & Sons, Inc., New York City, presented the Institute with a 1937 edition of *The Gemmologist's Pocket Compendium,* by Robert Webster, F.G.A.

From Robert Webster himself a copy of the 1947 revision of this book, much enlarged and carefully illustrated, has just been received. The two books are a useful pair in the Institute library, containing an excellent glossary and plates of synthetic and natural gems in addition to practical tables and reference data.

The Institute recently received a beautifully made miniature urn with cover, turned from Whitby Jet and embossed with gold. This urn is approximately one inch high and three-eighths of an inch in diameter. It was made by Mr. Frederick W. Hosbach of Penn Valley, Narberth, Pennsylvania. It will be added to the permanent collection of gems at the Institute's headquarters in Los Angeles.