The
Pocket Book
for
Travellers

The

Pocket=Book

for

Jewelers

Lapidaries

Gem & Pearl

Dealers

BY

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VIENNA

PART I

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Pearls

THE EXAMINATION OF PEARLS

1. GENERAL REMARKS

Ever since the Japanese succeeded in cultivating pearls, that is in growing them by artificially covering a ball of mother-of-pearl with pearl substance, it has become necessary to abandon the old crude investigating methods, and to take recourse to finer methods of examination.

Previously, only the surface of the pearls was examined and the quality judged by the examination of the pearl surface, whereas it has now become necessary to examine the interior of the pearl to gain a real clue to the establishment of pearl values. Heretofore, the inner condition of the pearls was taken into consideration only insofar as it influenced the surface. It will be necessary to base the hereafter following description of the methods for the examination of pearls upon some elementary facts concerning the structure of the pearl mussel, and its shell and the internal construction of the pearls and their qualities in order to make the methods more clearly unterstood.

Pearls are products furnished by certain mollusks. They consist of layers of lime and organic substances and are mostly round in shape.

If we are to understand the generation of pearls it is necessary to first regard the animals which produce these
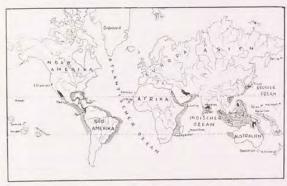

Fig. 1.

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pearls and understand their internal structure. Pearls can be generated by those mollusks which have an internal section laid out with mother-of-pearl. Pearl mussels are all the varieties of the Margaritifera margaritifera (Maleagrina, Avicula) which shortly can be characterized as the Pearl Mussel.

There is a large number of varieties as for instance the Margaritifera margaritifera Persica in the Persian Gulf, the Margaritifera margaritifera Mazatlantica on the Western American coasts, and the Margaritifera margaritifera Martensi in the Japanese waters. The latter is much smaller than the Margaritifera margaritifera measuring up to 12". There are a whole lot of other varieties. Other mussel varieties to be considered are the varieties Ostrea, Mytilus, Pinna and the Snail variety Strombus Gigas, furnishing the beautiful pink red pearls and finally the Haliotis furnishing mostly green or dark pearls.

These are all marine varieties. The accompanying Fig. 1 shows the territorial location of the marine pearl mussel. The cross hatched sections depict the territories in which the pearl mussel exists and the dark parts thereof show the sections in which pearl fisheries are operated.

Fresh water pearls, especially the variety called Margaritana margaritifera occur in the fresh waters of many lands, in America as well as in Europe. In Central Europe, especially in Bavaria, the Oberpfalz and Ober Franken the fresh water pearls have been cultivated for

Fig. 2.

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Fig. 3.

centuries and in former periods the culture of fresh water pearls was at times considerably extended and fine specimens produced. At the present time the trade is completely stagnant.

China has the fresh water pearl called Dipsas plicatus, a fresh water pearl mussel used to a great extent for the covering of small Buddha figures with mother—of—pearl by introducing these small tin castings into the mussel. All of these mussel varieties and a lot of other mussels have the quality to secrete pearl substance from the outer shellcovered mantle skin of the animal.

Fig. 2 shows the structure of the soft body of a pearl mussel. The topmost part of the coverlayer towards the observer has been cut off in order to show the gillflaps The other flap of the top cover adheres to the shell and the animal extends its foot between the two coat flaps and gillparts. On the right side below the foot one sees the section of the cut off closingmuscle. The left part of the shell shows the depressions in the places in which the muscle grips. Between the gills are the other parts of the animal body, the digestive tract, the blood vessel system and the other organs. We are mostly interested in the other cells of the coatcover because these are the ones which have the faculty to secrete the substance, building up the shell.

Fig. 3 shows a marine pearl mussel Margaritifera margaritifera Martensi, its cover removed and with bent back mantleflaps and gills.

Fig. 4 shows a section of the point of the mantle and adjoining parts of the shell. The mantle itself consists of the tissue (bg) with the outer epithelia (a e p) towards the exterior, called the ectoderm, and

the inner epithelia (i e p) towards the gills. The ectodermal cells secrete the secretion forming the shell. The second fold of the mantle secretes the organic skin which covers the shell towards the outer portion, designated in Fig. 4 with p e and in Fig. 6 with K. Thereafter follow the other layers towards the interior. The space between mantle and shell (s p in Fig. 4) is called the mantle shell space. The mantle is fastened by a system of muscles to the shell along the socalled mantle lens (m in Fig. 4).

Fig. 5 shows schematically the arrangement of the soft musselbody inside the shell of the mussel (p = Periostracum), (Pr = prism layer), (pl = mother-of-pearl layer), (ep = outer epithelia), (ip = inner epithelia), (hg = tissue), (k = gills), (f = foot).

The animal builds its shell in principle of the fol-

Fig. 4.

lowing substances (Fig. 6). First of all it secretes a layer of a grey, brown, greenish organic substance (K called periostracum, consisting of conchyoline and forming the outer cover of the shell, then follows towards the inside a layer of carbonate of lime (arragonite or calkspar depending upon the variety of animal) and an organic substance, the con- chyoline. This zone is called the prism zone, owing to the parti- cular arrangement of the prisms at 90° to the shell surface.

Thereafter mostly follows a zone of thin sheets of arragonite with conchyoline substance, which layer is commonly called the mother-of-pearl layer and which causes the mother-of-pearl gloss.

The construction of the shell may be complicated by repetitions of these layers or a light layer (h S) may be inserted with an inner mother-of-pearl layer (i P m), and an outer mother-of-pearl layer (a P m), but a shell always consists of these mentioned three layers which are secreted while the animal is growing.
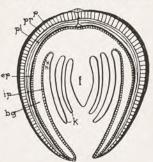
Fig. 5.

Fig. 7 shows the enlarged section through a shell which exhibits from right to left: periostracum, prism layer, inner and outer mother-of-pearl layer, following one another. Repetitions of conchyoline de- posits show as green spots on the shell surface "oil spots" Fig. 8.

Fig. 6.

The gloss of the mother-of-pearl or nacre is not caused by a colora- tion of the minute arragonite sheets but is generated by the interference of lightrays reflected by the sur- faces of the consecutive layers of these thin blades. Each layer of arragonite and conchyoline mea- sures about 0.0004—0.0006 mil- limeters. (In principle these are

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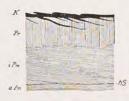the same colors as originate when Kerosene is thinly distributed over a water surface.) The lustre, gloss and color play of the mother-of-pearl is caused partly by the mentioned interference of the lightrays and partly by the color phenomena originated through the lightdiffraction of the faint designs of the surface acting as screens.

Fig. 7.

Under very great enlargement the upbuild of the mother-of-pearl from individual layers of lamellated arragonite is discernable by a faint streaky design (W. J. Schmidt). The streaks are caused by the overlapping of the individual layers.

Fig. 9 shows immediately the analogy with the screens of diffraction.
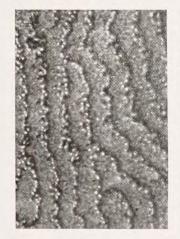
Fig. 8.

Fig. 10 show a section through the prism layer, the cut being conducted parallel to the shell surface.

Pearls are nothing but spherically shaped shells. The globe is formed by spherical layers which follow one another more or less concentrically from inside out, whereby colorful changes may take place. Cut open pearls show this construction very plainly, sometimes the pearl consists entirely of prism substance or entirely of pearl substance, mostly of both of these materials in various changes. Paramount for the beauty of the pearl is the conditon of the outer layers.

Fig. 11 shows a thin cut through a fresh water pearl. The pearl consists of a small nucleus of conchyoline sub-

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Fig. 9.

stance surrounded by irregularly disposed layers of prism substance. The last coverings of mother-of-pearl substance even up the irregularities of the prism layers.

Fig. 12 shows the section of a pearl consisting of regular concentric layers of mother-of-pearl.

The surface of the pearl shows the same design and shading as depicted in Fig. 9 for the mother-of-pearl. It is a sure sign of the genuine natural pearl as far as the surface is concerned. Fig. 13.

To the question of the origin of pearls there are various answers. Each injury to the shell is healed by the secretion of the shell substance from the outer layers of the mantle. Thereby often occur formations which are called shellpearls and should really not be called pearls at all. We will hereafter confine the name of pearls to spherical formations which are formed loosely inside the pearlmussel. Foreign substances which have reached the inside of the mussel either accidentally or by piercing the shell or by opening the shell, are often covered with layers of mother-of-pearl substance secreted by the ectoderm. This often results in globular pearls which sometimes are glued to the inner shell surface by the exudated pearl substance.

Fig. 10.
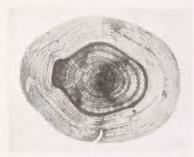
Fig. 11.

Fig. 12.

Around the middle of last century the socalled parasite theory was established. One imagined tailed larvae of worms penetrating into the interior of the mussel and causing the formation of pearls by irritation. Dubois called the pearl "the glistening sarcophagus of a worm". Though this surely may sometimes be the cause

Fig. 13.

of the formation of pearls, however just as surely it is not the only cause of pearl formation.

Newer researches, especially those made by the Zoological Institute of Marburg, have shown that the formation

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of pearls takes place also without outside irritation. The mussel secretes cartain yellow bodies which are enclosed by the ectoderm, the outer layer of the mantle, and then penetrate into the interior of the mussel. Thus a pearl sac is created in whose interior the yellow body comes, forming the nucleus of the pearl in which it can afterwards very often be found. The pearlsac is in its interior equipped with a layer of those ectoderm cells which exude the secretion causing the formation of the shell.
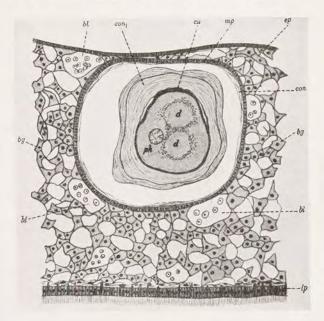
Fig. 14.

Fig. 14 (from I. Meisenheimer Naturwissenschaftliche Wochenschrift, Jänner 1907) shows a closed pearlsac in the tissue of the mantle.

Each free pearl is generated in a pearlsac lined in the interior with ektoderm cells. This is an indispensable necessity because only this kind of cells is able to secrete the substance from which the pearl is built up. No matter whether the pearl formation is caused through injury or by introducing foreign substances or by parasites or via the yellow bodies, before mentioned, always ekto-

derm cells must collaborate to cause the formation of the pearl. It is therefore of the greatest scientific interest when mentioning that in 1913 the German zoologist A'-verdes succeeded in artificially creating pearls by injecting with a syringe transplanted ektoderm cells into the interior of the mussel. These transplanted ectoderm cells are always the ones which create the pearls.

The chemical consistency of the pearls, their specific weight, their color and other qualities change with the cause of their formation and also with the climatic conditions under which they were formed and with their
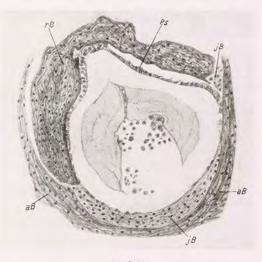
Fig. 15.

location inside the animal. On an average 90% $CaCO_3$, 4% to 6% organic substance, 2% to 4% water are combined in the pearl. The specific gravity is between 2.65 to 2.72, it changes according to the construction of the pearl.

As above mentioned the German zoologist Alverdes succeeded already in 1912 to 1913 to artificially form pearlsacs by the operative transplantation of cells of the outer epithelia of the mantle (ektodermal cells) into the tissue of the mussel, thereby creating pearls.

Fig. 15 shows such a pearlsac artificially created by the injection. Ps are the ectodermal cells injected by the syringe. They formed a still partially open pearl—

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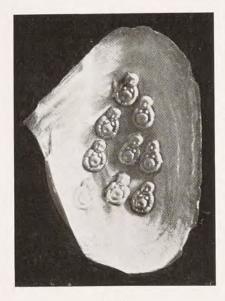
Fig. 16.

sac and pearl-substance has been secreted by the ectodermal cells, as far as these cells have spread. This picture is from an original work by Prof. Alverdes.

In Japan Kikichi Mikimoto since 1890 occupied himself with the raising of pearls in regular pearlfarms and also manufactured the socalled Japanese pearls or Japanese halfpearls. Then later on he succeeded in the same way as Alverdes in obtaining perfectly round pearls by operatively creating pearlsacs in live mussels. These pearls first appeared in the trade in the year 1921 as "cultured pearls" or "cultivated pearls" and are entirely different from the heretofore known "Japanese pearls". These Japanese pearls are obtained by the introduction of a foreign substance into the mussel between the mantle and the shell, whereupon they are covered with pearl substance by the animal. This process was known for a long time and used with Chinese fresh water pearls for the covering of small Buddha figures with mother-of-pearl substance (Fig. 16).

Fig. 17.

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By introducing a globular or semi-lobular piece into the space between shell and mantle one obtains a formation according to Fig. 17 (after T. H. Haynes, London).

This piece is cut out of the shell and transformed into a Japanese pearl as shown in Fig. 18 by turning half of same off and adding a mother-of-pearl half to form a globe.

Fig. 18.

Part 3 is the introduced piece, part 1 the covering of mother—of—pearl, part 4 the added turned piece of mother—of—pearl, parts 2 are shreds ob conchyoline sometimes secreted by the animal before covering the introduced piece.

In order to create fully round pearls the process is a little different: A ball of mother-of-pearl is wrapped into the mantle substance taken from another mussel. This artificially created pearlsac is introduced into a young animal after the same has been opened. The animal into which this mantle covered ball has been introduced remains undisturbed for 7 to 8 years and during this period the ball is covered by the animal with a covering of pearl substance within the healed in pearlsac of the mussel.

According to a report of the Imperial Japanese Society for the advancement of inventions, K. Mikimoto runs 8 musselfarms employing 1000 people and raising about 8 million pearl mussels every year. An investigating commission found 13 pearls in 15 mussels taken hapha- zard. The excess of young pearl mussels is occasionally sold at auction. The size of the cultured pearls varies between 2 and 6 grains, cultured pearls of 10 grains from the Marga- ritifera margaritifera Martensi are a great rarity, but there are larger musselvarieties from which pearls of 20 and 30 grains are obtained and those have lately appeared on the market.

In principle there are various kinds of cultured pearls. It is possible to create a pearl by injecting ectodermal cells into the tissue of the mantle of the pearl and the pearl is formed by the secretion of the ectodermal cells as shown by Alverdes. Mikimoto however has also cre- ated pearls without a kernel for experimental purposes.

Fig. 19.

It is also possible, as shown by Prof. G. Riedl experimenting on fresh water pearls, to use small seedpearls as nucleus around which then the pearl substance is secre- ted and the pearl enlarged.

The balls of mother-of-pearl may be substituted by balls of other substances without altering the result.

The sizes of the inserted kernels are different, they vary from very
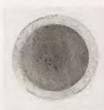
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Fig. 20.

small particles which are removed when drilling the pearl, to inserts of several grains in weight. The size of the insert as against the size of the pearl as a whole determines the value of the cultured pearl.

Fig. 19 and Fig. 20 show two cultured pearls with inserted kernels of different size.

Fig. 21 shows the section through a cultured pearl showing a wart on the spot where the pearl-sac has been tied up. The extension is filled with conchyoline or a mixture of conchyoline and prism substance. The market has up till now shown mostly cultured pearls with an insert of mother–of–pearl, the following elaborations refer therefore to this kind only.

It is necessary to examine closely the interior of the pearls in order to point out the difference between cultured pearls and accidental genuine pearls.

Accidental genuine pearls have sometimes a small foreign body as their kernel which however also may be lacking entirely, or they show small secreted grainy substances in their centre. One often finds a socalled "secondary kernel" which is generated by the secretion of conchyoline substance or prismsubstance or of both into the primary kernel. Mother–of–pearl substance may also alternate with the two other substances. The secondary kernel then shows as an ugly discolored internal region which is distinctly separated from the clear outside ball of the mother–of·pearl substance.

The secondary kernel, however, always shows a structure of concentrical pearl layers or a structure crystallized in prisms in a strictly regular way from the centre to all directions. Regular accidental genuine pearls, show no deviation from their construction in various diameters. Fig. 22.

The almost universally used mother–of–pearl insert of the cultured pearl consists of more or less paral-

Fig. 21.

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lel, even layers and therefore
shows great physical dif-
ferences according to the
way in which it is examined,
whether parallel to the di-
rection of the layers or
under 90° (Fig 23) to their
direction.

Mother-of-pearl consists
of thin plates of Arragonite
with thin Conchyoline de-
posits which are disposed
parallel to the surface of
the shell. It is best to visua-

Fig. 22.

lize the construction of the mother-of-pearl substance by
comparing it to a wall of bricks. The individual layers
of bricks are separated by thin layers of chonchyoline

representing the mortar of
the walls. The thickness of
the layers varies between
0.0005 and 0.0015 mm, in
the different varieties the
average being about 0.001 mm.
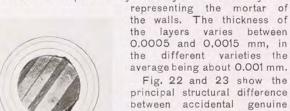
Fig. 22 and 23 show the
principal structural difference
between accidental genuine
pearls and the cultured pro-
duct with the mother-of-pearl
insert. Other differences are
the often occuring vacant
spaces around the insert of
cultured pearls, differences in
specific gravity, etc.

Fig. 23.

Equipped with this knowledge, it will be easy to follow
the consecutive sections, being a critical survey over the
methods for the discrimination between genuine accidental
and cultured pearls.

2. THE OPTICAL AND MICROSCOPICAL EXAMINATION

The only exact method for the determination of the value of a pearl is the microscopical examination under a special microscope.

The optical method has long been used for the examination of precious stones, but is comparatively new as far as the examination of pearls is concerned. The microscope permits not only the determination as to whether the pearl is genuine or cultured, but also reveals the internal construction of the pearl.

It shows internal cracks and ruptures, furthermore traces of illegiti—

Fig. 24.
THE PERLOMETER.

Indian Pearl, surface.   enlarged 280✕

Fig. 25.

mate manipulations like lacquering, coloring, glueing, mending, etc., it
also reveals whether the pearl has been skinned, old drillholes closed,
patched up, etc. Last but not least, of course the microscopical exami-
nation shows as to whether the pearl has an insert of foreign substance
or not, whether it is a genuine natural pearl or a cu-
ltured pearl with an insert.

Fig. 24 shows a special microscope built by Reichert
in Vienna, along the design by Dr. H. Michel and Prof.
G. Riedl and which as Perlometer is sold by G. L. Herz,
Burgring 1, Vienna, Austria.

The instrument consists in principle of a monocular or binocular
microscope and has two lighting equipments. The one is centrally
located beneath the microscope table, making it possible to have the
light penetrate the pearls which are placed on the microscope table.
A disk bearing variously sized openings, selected according to the
size of the paarls is rotatably fastened to the microscope table. Ano-
ther part of the lighting apparatus permits directing the light upon the
surface of the pearl for the microscopic examination of the pearl surface.

The observation of the pearl surface under the microscope shows
the fine design of the surface of the genuine pearl which immediately
distinguishes it from the host of imitations.

The fineness of the surface design and its regularity
determine the beauty of the surface; the more regular,
the more even the appearance and the more beautiful the

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Mikimoto Pearl, surface.   enlarged $420\times$

Fig. 26.

total effect of the pearl. The pealing of the pearl also changes its surface, the small arragonit plates disappear, which are set in front of the further growing lamellae.

Fig. 25 shows the surface of a genuine indian pearl at a magnification of $280\times$.

Fig. 26 shows the surface design of a cultured pearl at a magnification of $420\times$.

Fig. 27 shows the characteristic spotty design of a "pink pearl" from Strombus Gigas, a snail producing these pink pearls. The so called "silk" is a sign of genuineness of this kind of pearl.

If a pearl is artificially colored it is mostly possible to distinguish the coloring matter in the crevices of the surface design, whereas the lamellae themselves usually remain more or less free from the color which is wiped off after drying.

Lacquering of the pearl surface is also distinguished under the microscope, it shows a glassy surface. Surface parts which have been glued or puttied are immediately

Fig. 27.

recognized on account of the missing surface design. Imitations, no matter how well made, show no surface design whatsoever.

Fig. 28 shows the surface of a very good imitation under the same enlargement.

All parts of the pearl which have been glued, puttied and covered with pearl essence show a similar picture.

The examination of the pearl in translucent light by using the lamp underneath the apparatus table shows all internal defects and unevennesses in the construction of the pearl and internal cracks can be distinguished, followed up and measured.

The special and main object of this microscope is, however, the examination of cultured pearls.

When observing pearls under such penetrating light from a concentric source, the insert of the cultured pearl manifests itself on account of its usually striped appearance in translucent light. The inserted ball consisting of mother-of-pearl shows different transparencies when lightrays strike it under different directions. One direction of the lightrays shows the insert considerably lighter than the other direction different from the first one by 90°. By revolving the pearl it therefore gives pictures of varying lightness; this is a sure sign of a cultured pearl. The genuine pearl shows no differences in this respect; the genuine pearl having the same structure internally in all radial directions manifests no differences in light when revolved. It can, however, frequently be seen that the genuine pearl shows a distinct dark centre and the ap-

Fig. 28.

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pearance of same must not be taken as an indication of the cultured pearl. The difference in lightness in two positions just 90⁰ apart from one another is an indication of a pearl having a mother – of – pearl insert.

A still clearer sign of a cultured pearl is the appearance of stripes in the figure as indicated in Fig. 29 C.

Fig. 29.
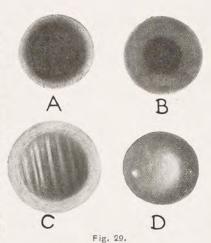
Fig. 29 A shows a cultured pearl submitted to lightrays striking it under 90⁰ to the direction of the layers of the mother–of–pearl. The stronger the outer cover of the pearlsubstance, the more indistinct are the effects of the light on the cultured pearl.

Fig. 29 E.

The various kinds of natural pearls give various pictures in translucent light. Venezuela pearls show for instance quite differently from pearls of the Persian Gulf. Dark Conchyoline deposits in the interior which alter the appearance of the pearl when pealed, show intense dark shadings.

Fig. 29 B shows the picture in translucent light of a genuine pearl, same growing gradually darker towards the center. When the pearl is revolved the picture does not change perceptibly, light and shade in their intensity remain the same.

When illuminating the pearl with the second lamp, movable in joints, and directing the light strictly upon the pearl, one sees an enhanced gloss in certain positions, the gloss seeming to come from the interior. This occurs in cultured pearls only. The enhanced gloss appears when the mother–of–pearl sheets act as a mirror. It is easy to observe this gloss on a regular mother–of–

Fig. 30.

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pearl ball. There are
two such positions in
which the pearl
shows an enhanced
gloss, these positions
being 180⁰ apart. The
gloss appears in most
cases as a concen-
trated somewhat red-
dish light on one spot.
Fig. 29 D shows this
phenomenon sche-
matically.

Fig. 31.

Natural pearls do not show this phenomenon. This
phenomenon appears weaker when the covering of the
pearl substance is larger.

Fig. 29 C shows the appearance of a cultured pearl in a schematic
way.

Fig. 32.
PERLOMETER, TYPE DE LUXE.

Fig. 29 E shows the cultured pearl photographed in translucent light and showing the telltale stripes on the outside in actual size.

Re the schematic pictures generally, it is to be observed that they are idealized in this respect that the specially favourable cases have been chosen as subjects for the illustrations.

The methods of examining pearls under translucent light, while they will tend to irritate the observer in the beginnig, permit however a quite correct judgement once practice has been acquired. Practice will tend to make quite delicate decisions possible. In order to obtain practice, it is advisable to begin to exercise with mother-of-pearl balls which have been drilled some parallel to the cirection of the layers, some under 90⁰ thereto.

The Perlometer furthermore also has the socalled Cardiometer, an apparatus which permits the study of the internal structure of the pearl. The first examinations in this direction were conducted by Messrs. C. Ryziger and R. Galibourg (Le grand Negoce 1923). They introduced mercury into the drill channel and used the concave surface of the mercury as a mirror for the interior of the pearl. The pearl is illuminated from the outside by a strong lamp. Enough light permeates and permits a close observation of the drill channel. F. E. Wright uses for the exploration of the drill channel a mirror consisting of a ball shaped wire of gold or another alloy, H. Michel and G. Riedl use mirrors made of special alloy wires cut off under 45⁰ and polished to a mirror finish. These mirrors give excellent sharp pictures.

Fig. 30 shows on the upper part a section and the lower part a view of the Cardiometer. Fig. 31 shows the Cardiometer alone and Fig. 24 the complete Perlometer, the Cardiometer mounted thereon.

The Cardiometer consists of a conical lower part b on whose central drillhole the pearl a, which is to be examined, is posted. The metal rod bearing the mirror on the upper end penetrates into the drill channel from below and may be moved up or down by means of turning disk d. It is thereby possible to arrest the mirror in any position within the drill channel. The mirror on the upper end of the metal rod is carefully ground under 45⁰ and polished and permits a close observation of all the peculiarities of the drill channel.

The pearl is intensely illuminated from the outside by an incandescent lamp. The lightrays from the lamp being condensed in the lens and concentrated at the centre of the pearl; thereby the drill channel is very clearly illuminated and the minutest details of its construction divulged. The picture in this mirror is than observed by either a binocular microscope or a monocular tube. The picture is so enlarged in the microscope that every detail of it can clearly by observed. The pearl is turnable around the mirror, thereby permitting the study of the drillhole in all directions, and in every position of the mirror.

There are two turning disks in the Cardiometer, the one previously mentioned directing the position of the mirror needle in hight, the second disk situated above the first one permits the turning of the pearl around the mirror needle. Both turning disks are equipped with graduations. Turning disk d, governing the vertical position of the metal needle permits vertical dislocations of the mirror reading 0,01 millimeters apart. This quality permits the measuring of the thickness of the mother-of-pearl kernel of the cultured pearl. The upper disk e which is also graduated, makes it possible to turn the pearl as many degrees as desired and reading this angle off the graduation.

Fig. 31 shows the Cardiometer alone. Here the lower turning disk is marked with 1, the mirror needle with 3; the upper turning disk with 2.

Fig. 33.

Fig. 35.

Fig. 36.

Fig. 32 shows a type of Perlometer equipped with a differend base.
Fig. 33 shows a Stereo equipment permitting the use of both eyes
for the observation with a monocular tube.
Fig. 34 shows the Perlometer with monocular tube alone. The

Fig. 34.

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Fig. 37.

types depicted in Fig. 33
and 34 permit a much
deeper examination of the
narrow drill channel than
the other type.

The difference in
principle between the
natural pearl and the
cultured pearl has
been shown before.
Natural pearls how-
ever are very rarely
internally symmetri-
cal and concentrical even though they may appear as
perfect balls on the outside.

Fig. 35, 36, 37 depict halfpearls in translucent light
and show that the various skins of the pearls which are
permeated by the lightrays have not exactly concentric ball
shapes.

Fig. 38 shows the wedgelike extension of the prism
sections towards the outer mother–of–pearl layers, so that
according to the position of the drill channel in the
pearl the layers
will be cut in
various thicknes-
ses by the drill
channel.

Fig. 38.

Fig. 39.

A pecularity of
the cultured pearl
is that in most
cases the skin of
pearl substance
does not immedi-
ately adhere to
the mother–of–
pearl insert, but
at least on some
spots there is first
a skin of con-
chyoline between
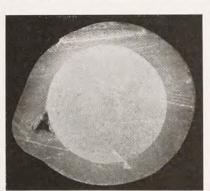
the ball and the outer skin. This conchyoline layer may be varying in thickness in different spots. One can very often see cavities above the mother-of-pearl kernel which sometimes appear as warts on the outside (Fig. 39) or are extended over larger portions of the surface. By measuring the drill channel of such pearls by transporting these figures into designs one receives pictures as 40 to 47.

Fig. 40.   Fig. 41.   Fig. 42.
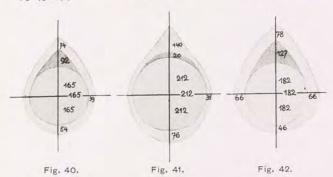
Fig. 40, 41, 42, 43 show sections of the pearls with onesided cavity, 44 a cavity on both sides, 45 a cavity on one end and a conchyoline layer on the other, 46 a prism layer over the kernel on one end, and 47 a wart construction without cavity above the kernel.

Fig. 48 shows how a conchyoline deposit over the kernel manifests itself on the pearl outside skin even through greater distance.

Fig. 49 and 50 are cuts through baroque cultured pearls containing two kernels and showing conchyoline deposits in several locations of the outer skin, as well as cavities in the section where both kernels touch.

Fig. 43.   Fig. 44.   Fig. 45.

25

Fig. 46.

Fig. 47.

Fig. 48.

Fig. 49.
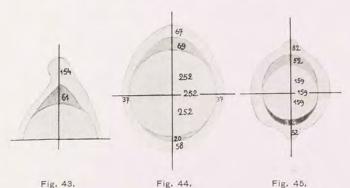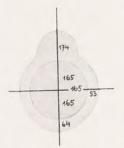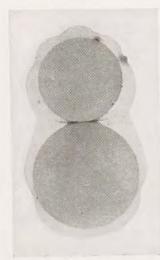
It is always advisable to observe both ends of the drill channel in order to examine as many details as possible of the interior of the pearl.

GENERAL DIRECTIONS FOR THE STUDY OF THE DRILL CHANNEL WITH A MIRROR.

It is foundamentally necessary to observe both ends of the drill channel. The drill channel is not always round, and the division line between the individual layers of the pearl appear as convex or concave lines curved towards the observer. In the tables I to IV of part

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II of the Pocketbook the sense of the curvatures has been retained as the same throughout. The lower part of these pictures corresponds to the upper part of the pearl and is directed towards the observer. A monocular tube shows the picture reversed. The natural pearls show no differences in the intensity of the light when the pearl is revolved around the needle, whereas the cultured pearl shows dinstict changes in the light intensity when the pearl is turned except in one case, viz., when the drill hole penetrates the mother-of-pearl layer under 90⁰ to the direction of the layers.

Fig. 50.

The cultured pearls show a kernel of grey color whereas the natural genuine pearl shows the interior in a reddish yellow to reddish tone, sometimes interrupted by layers of dark conchyoline or conchyoline with prism substance. Chonchyoline layers are however also to be found deposited over the kernel of cultured pearls as well as prism layers.
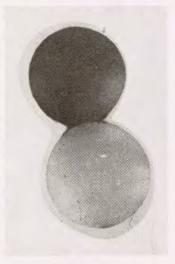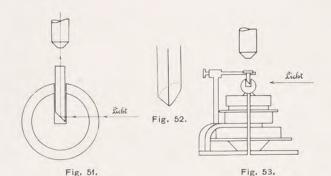
Genuine pearls show often internal cracks especially in old specimens. These cracks show a quite arbitrary conduct and sometimes discontinue after being followed up a short distance. They work as reflecting planes and are apt to cause quite strong changes in the lighting intensity of the observed pictures. However, the quite irregular course of these cracks and their slanting irregularity prevents the taking of these cracks for division lines between kernel and pearl substance in cultured pearls. (See Fig. 23, 24 of table III.)

The pictures showing the cracks show a grey coloring, but should really show in reddish yellow tints. Also cultured pearls may show internal cracks, these are very rare however and end abruptly at the division line between kernel and covering.

Characteristic pictures are shown by pearls with cavities around the mother-of-pearl kernel, which cavities

Fig. 51.

Fig. 52.

Fig. 53.

are either empty or filled with conchyoline and prism substance. By descending the microscope it is possible to follow these cavities into their depth and measure their extensions by reading the displacement of the needle. Very thin cavities between kern I and pearl substance are sometimes the cause of peculiar reflexes.

Natural pearls show very rarely internal cavities but by descending the needle underneath the cavity one can still find division lines between layers whereas the cavity in the cultured pearl distinctly ends at the sharply defined kernel in which no further division lines are to be found.

The divisions of natural pearls are mostly not simply ball shaped as the division line between kernel and covering in the cultured pearl; the division lines of the naturals pearl are mostly toothed in and overlapping. The construction of the pearl is often excentric which makes it advisable to study both ends of the drill channel.

The cultured pearl shows sometimes various layers in the outside covering of the pearl substance, but in a depth
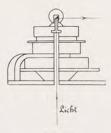
Fig. 54.

Fig. 55.

between 0,2 and 1,5 millimeter sharp divisions between kernel and covering are to be observed under which there are no more division lines. When turning the pearl, the light intensity of the kernel changes according to the position.

On account of the often excentric built of the natural pearl and the excentric position of the kernel in cultured pearls, there may be quite important differences on the two ends of the drill channel

The observer may sometimes be misled by an artificial covering of the drill channel with lacquer or wax like substances with which the drill channel has been smeared out in order to make the examination more difficult. In all cases where the drill channel shows no division lines whatsoever, suspicion is quite obvious and it is necessary to clean and ream the drill channel before the examination with reamer and pearl silk saturated in Benzol or Alcohol.

The drilling of the pearl sometimes results in the splintering out of small cavities in the drill channel which are recognizable by their extending sometimes over the layer borders and by their irregularity. Careless drilling sometimes results in drill grooves which may be parallel to the axis of the drill channel or spirally disposed.

It is important to detect drill splinters in the drill channel as they do not only result in frequent cuttings of the pearl silk but they also cause general discolorations of the pearl substance by rust. Fig. 32 on plate IV shows smoothly polished drill splinters with rust formation on the borders.

For all these cases the reader will find examples in the tables I to IV with the explanation thereto. It is necessary to study these special cases with the tables on hand before examining pearls.

The examination of halfdrilled pearls requires a change in the apparatus. The metal needle is replaced by glass needles with a mirror plane under 45⁰ on the lower end. The observation is done via the needle itself looking through the needle unto the mirror at the end, see Fig. 51.

The pearl is fastened to the apparatus with the hole looking upward and the mirror needle descended into the hole, the mirror directed downward. The way to fasten the pearl to the Cardiometer is shown in Fig. 53. The glass needle which is fastened on to a black round small hardrubber disk, is hung on to a support and the pearl is lifted and des—cended by turning the lower disk of the Cardiometer.

The glass needle also serves another purpose, it is to illuminate the interior of the pearl. For this purpose the needle is fastened to the apparatus with the mirror surface upwards, see Fig. 54, and the illu—mination is done by means of the lamp underneath the Perlometer table. In a natural pearl, Fig. 55, the light ray takes the course around more or less circular layers of the pearl. From the outside one sees a rectangular window filled with diffused light which, with indistinct boarders disappears into the part of the
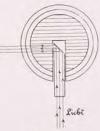
Fig. 56.
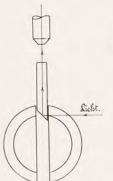
Fig. 57. (See Fig. 51.)

Fig. 58.

pearl which is not illu-
minated.

In the cultured pearl,
however, as seen in
Fig. 56, the light follows
the direction of the
layers of the mother-
of-pearl of the kernel
and produces a dis-
tinctly visible illumina-
ted stripe parallel to
the layers of the kernel.
In Fig 56 the layers
are horizontally depic-
ted in other cases the
layers are in various
different positions.

When the pearl is tur-
ned, this stripe changes its direction and
position. The exit of the light is charac
terized by arrows in these schematic pic-
tures. The length of the arrow symbolises
the intensity of the light. It is obvious
that one can also use these glass needles
with fully drilled pearls, same as metal needles Fig. 57 and 58.

In practice, however, one will always prefer the metal needles for
fully drilled pearls, their handling being considerably simpler.

When first using the glass needles there are various difficulties
which are overcome by longer practice. The glass needle serves very
well for the interior illumination of fully drilled pearls from the drill
channel outward. Cultured pearls then always will show the light stripe
on the outside, whereas
the natural pearls show
a window correspon-
ding to the reflecting
mirror plane of the
glass needle. Fig. 59
shows the way of the
light in a cultured pearl
with layers in an hori-
zontal direction. Fig. 60
the way of the light in
a natural pearl. Fig. 61
should depict the im-
pression when illu-
minating the cultured
pearl from the drill
channel.

In natural pearls one
furthermore also ob-
serves a light effect in
the drill channel. The
lightray coming from
underneath is reflected
by the globular layer of
the pearl substance
struck by the reflected
ray from the needle, so
that the whole layer of
the pearl appears illumi
nated. (Apart from this
the reflected light also
reaches the outside
directly and creates the
lighter window.) In

Fig. 59.

Fig. 60.

Fig. 61.

30
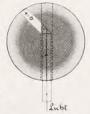
Fig 60 and 62, this manifold reflection in the interior of the layer of the pearl is depicted by an undulated line. If one places the glass needle as shown in Fig. 62 in the lower part of the drill channel and observes the upper part of the drill channel, one can see the displacement of this light window in the drill channel when the needle is moved. The lower position a of the needle corresponds to the upper light spot in the drill channel, the higher position b of the needle to the lower light spot.

Such reflection of the light is only possible in pearls built up by individual layers. In cultured pearls one will therefore only see such reflection in the outside layers, but the phenomena will disappear if the glass needle enters the kernel. In natural pearls without a larger secondary kernel, the phenomena appear as depicted in Fig. 62.

Fig. 62.

In fully drilled pearls as well as in halfdrilled pearls it is possible to measure the thickness of the layers covering the kernel by one hundredth of a millimeter by reading the divisions on the lower disk of the Cardiometer. If one knows the diameter of the pearl one can figure the weight of the whole pearl, the weight of the kernel and the weight of the cover of pearl substance.

In most cases the weigt of the kernel is overestimated considerably as one is apt to forget that the volume and consequently the weight of globes is proportionate to the cube of the radius.

A kernel for instance having half the radius of the whole pearl only weighs one eighth of the total weight. A kernel with a third of the radius of the whole pearl only weighs one twentyseventh of the total weight of the pearl. The volume of the globe is figured according to the following formula:

$$\text{Volume} = \frac{4}{3}\ r^3\ \pi$$

The weight of the pearl is found by the multiplication of the value of the volume with the specific weight of the pearl. The following table gives in grain the value of the weights for the radii from 1 mm to 10 mm.

The table gives the weight in grain for each value of the radius in millimeters and is to be used as follows:

The total diameter of the pearl is first measured with a caliper and half of this diameter noted as R = radius of the pearl. The thickness of the hull is measured with the Cardiometer, and deducted from the radius. This gives the value r for the radius of the kernel. One can make this calculation for cultured pearls as well as for natural pearls, having a so called secondary kernel.

The specific weight of the secondary kernel varies and should be taken as lower than the specific weight of the outside layers. The

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TABLE OF PEARL WEIGHTS

Radius in Millimeter	Weight in Grain	Radius in Millimeter	Weight in Grain
1	0,226		
1,1	0,301	5,6	39,722
1,2	0,391	5,7	41,889
1,3	0,497	5,8	44,132
1,4	0,621	5,9	46,455
1,5	0,763	6,0	48,858
1,6	0,926	6,1	51,341
1,7	1,111	6,2	53,908
1,8	1,319	6,3	56,559
1,9	1,551	6,4	59,295
2,0	1,810	6,5	62,117
2,1	2,095	6,6	65,028
2,2	2,408	6,7	68,030
2,3	2,752	6,8	71,121
2,4	3,127	6,9	74,306
2,5	3,534	7,0	77,584
2,6	3,975	7,1	80,956
2,7	4,452	7,2	84,425
2,8	4,965	7,3	87,992
2,9	5,517	7,4	91,659
3,0	6,107	7,5	95,425
3,1	6,738	7,6	99,292
3,2	7,412	7,7	103,266
3,3	8,129	7,8	107,399
3,4	8,890	7,9	111,522
3,5	9,698	8,0	115,811
3,6	10,553	8,1	120,208
3,7	11,457	8,2	124,716
3,8	12,412	8,3	129,333
3,9	13,418	8,4	134,065
4,0	14,476	8,5	138,910
4,1	15,589	8,6	143,871
4,2	16,758	8,7	148,949
4,3	17,984	8,8	154,142
4,4	19,268	8,9	159,458
4,5	20,612	9,0	164,895
4,6	22,017	9,1	170,452
4,7	23,484	9,2	176,134
4,8	25,015	9,3	181,939
4,9	26,661	9,4	187,873
5,0	28,274	9,5	193,932
5,1	30,005	9,6	200,120
5,2	31,805	9,7	206,441
5,3	33,673	9,8	212,892
5,4	35,616	9,9	219,475
5,5	37,631	10,0	226,195

table is figured on the basis of s = 2,7 for the specific weight of the pearl substance which however is a little too low for the cultured pearl.

One finds from the table the value of the weight corresponding to the value of R and deducts from same the value for r also found in the table. The result corresponds to the weight of the pearl substance covering and it is possible to get a good picture of the quality of the pearl therefrom. The absolute weight of the pearl substance covering is therefore known and the procentual relation to the total weight is easily figured after this formula:

Total weight: weight of the covering = 100 : x.

Whereby x corresponds to the weight of the covering in percentage.

The knowledge of the size of the secondary kernel is important for a good judgement as to the possibility of pealing the pearl.

The higher values of the table which is scaled off in decimals of millimeters can also be used for measurements below 1 mm by shifting the decimal point. It is to be considered thereby that each shift of the decimal point for r corresponds to 3 shifts of the decimal point
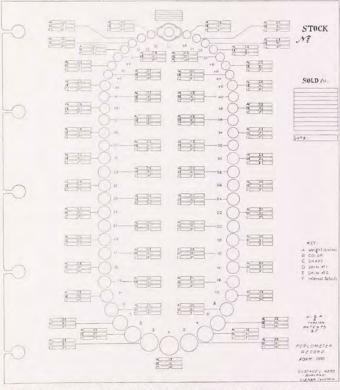
Fig. 63. PEARL IDENTIFICATION TABLE. HERZ MATRIX SYSTEM.
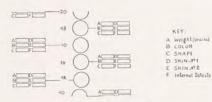
for the weight. It is possible with the aid of this table to get a correct picture of the relations between the total weight of the pearl and the total weight of the covering which relation is essential for the valuation of the pearl.

A PEARL RECORD

If one has examined a lot of pearls and desires to make a record of the results one can to great advantage use the Herz-Matrix System for the identification of pearls. It was impossible heretofore to identify and record the qualities of a pearl sold. For each single pearl the following measurements are made:

> a the weight in grain
> b the colour
> c the shape
> d the measurement of the first measured layer
> e the measurement of the second layer
> f internal faults or peculiarities of the pearl.

The figures for the thickness of the internal layers do not change, no matter what changes are made on the outside of the pearl and are therefore the best means for the identification of a pearl even after a long period. Fig. 63 shows such an identification card which repre-sents a perfect personal document for each lot of pearls or a pearl necklace. The methode has proved very suc-cessful in practice.

KEY:
A Weight (grains)
B COLOR
C SHAPE
D SKIN Nº 1
E SKIN Nº 2
F Internal Defects

Fig. 63 a. Detail.

THE ORIGIN OF PEARLS

In most cases the conversant pearl merchant is able to recognise the origin of a pearl from its appearance. Colour as well as the gloss of a pearl change accord-ing to the kind of mussel or snail from which the pearl hails and according to the country in which the animal

The tables can be purchased from G. L. Herz, I., Burgring No. 1, Vienna.

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lived. The changing appearance of the pearl is also founded physically; the distances between the single lines of the fine surface design of the pearl are much smaller in the Australian pearls than in the Indian pearls. Such examinations can best be made with an instrument called vertical illuminator* illustrated in fig. 64 which permits to enlarge small sections of the surface to a very great extent. The light from the lamp which is fixed into a small
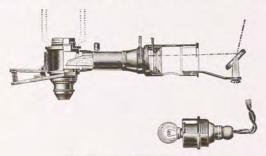
Fig. 64. The vertical illuminater.

piece of tubing strikes a reflecting glassplate and is from there reflected upon the surface of the pearl which is highly illuminated on a small part of the surface and can very well be examined under the microscope. The surface of an Australian pearl is shown in figure 13, the surface of an Indian pearl is shown in figure 25 thereby demonstrating the large differences in the condition of the surface.
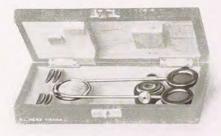
Fig. 65. THE REFRACTEUR.

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* The Vertical Illuminator can be purchased from G. L. Herz, I., Burgring No. 1, Vienna.

Indian pearls are mostly delicately pink to yellowish or pure white.

Australian pearls are mostly pure white with a strong silver white gloss.

Pearls from Venezuela and Panama have very frequently gold jellow tinges.

Pearls from the snail strombus gigas are red, pearls from the animal pinna are brown red, from haliotis are coloured mostly in green shades; black pearls mostly come from the South Sea. The fresh water pearls from american rivers are sometimes beautifully coloured. The fresh water pearls from European rivers mostly furnish yellowish white to reddish yellow pearls in which the prism layers predominate and which also very frequently have a secondary kernel.

The internal construction of the pearl, especially w h e n n o t d r i l l e d, can also be very well studied by means of an instrument called Refracteur as shown in fig. 65 with which one can also very well detect considerable differences in the internal construction of pearls of different origin.

The pearl is preferrably immersed in monobromonaph-talene of the refractive index of 1,66 and placed upon a diaphragm according to its size. The pearl is then observed via one or two special colour filters which make the detection of a mother–of pearl insert easier and surer. The refracteur gives pictures as illustrated on table V part II. The Japonese pearl and the Venezuela pearl have a light border, the Indian pearl shows characteristic varycoloured borders.

4. THE EXAMINATION OF PEARLS
UNDER ULTRA VIOLET RAYS

When the cultured pearls reached the London market in 1921 every effort was made to find a way to distinguish them from the genuine natural product. Mr. Brammal of the Imperial College of Science and Technology was the first to examine the luminescence phenomena of pearls under ultra violet rays; he showed that pearls of different origin showed different luminescence but a difference in the luminescence between natural pearls and cultured pearls could not be detected.

This was to be expected in the first place, because the lumines—cence entirely depends upon the condition of the exterior layers of the pearl, which without doubt are completely alike in natural and cultured pearls.

The luminescence light which the pearls emit is a "cold light". The pearls luminesce in the cool temperature of the room. This lumi—nescence can also be brought about by physical influences other than ultra violet rays.

Utlra violet rays are invisible to the naked eye but they show their influence upon photographic plates. The ultra violet rays are rays of a very small wavelength immediately adjoining the visible violet rays. They can be isolated through filters. Ultra violet rays are created by the arclamp with ironlightcoals or also by a mercury vapor lamp fused of quartz. Both sources of ultra violet rays naturally also contain a great quantity of visible rays and isolating the two is in most cases necessary.

In the year 1921 a special lamp was propagated in London under the name of "Swanson Lamp" for the examination of pearls. The same however was a total failure.

The writer has made a long series of experiments with pearls under the mercury vapor lamp manufactured in Hanau. This lamp undoubt—edly gives the most powerful and pure shortwaved ray but new facts which would make a distinction between natural and cultured pearls possible have not been found. The following gives a table of the re—sults obtained:

1) Shell substances

Object	Luminescence
Mother—of—pearl of the shell of meleagrina margaritifera . .	light blue to dirty white.
Shell warts from meleagrina . .	light blue.
Shell of pinna	velvet brown to dark brown.
Shell of haliotis	vivacious greenish blue.
Balls of the scale of strombus gigas	pink upon the pink surface and whitish yellow upon the inner whitish layers.
Mother—of—pearl ball of the shell of meleagrina	blue, somewhat darker than the pearls.
Japanese half pearls	upper part lightblue, lower part yellowish.

2) Pearls

Object	Luminescence
Oriental Indian Pearls	light blue and greenish.
Australian pearls	light blue.
Brownish pearls (american) average specific weight 2,686 . .	dark brownish, very little luminescence.
Small marine button pearls (australian) aver.–spec. weight 2,662	greenish.

Object	Luminescence
Cultured pearls from the farms of Mikimoto, spec. weight 2,788, 2,760, 2,73, 2,793, 2,75	light blue, greenish, grey green dark brownish.
Pink pearls from strombus gigas	darkish pink.
Black pearls of unknown origin .	Carmine red (lighter spots on the surface appear blue).
Fresh water pearls up to 0,3 gr. specific weight 2,69	mother–of–pearl layers luminesce purely blue the prism layer does not luminesce the pearl there remains carkbrown.

3) Imitations

Object	Luminescence
Glass pearls, massive pearls with irrisating covering	yellow, dirty white, velvety surface.
Black pearls	mouse grey.
White pearls	blueish green.

These observations show that also the pearls of the same country may show different luminescence which evidently corresponds to the age of the pearls.

Freshly taken pearls show a greenish colour which disappears during the drying process. The different behaviour of the pearls from the farms of Mikimoto have possibly the cause therein that the pearls hail from different varieties of the pearl mussel.

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5. THE PEARL COMPASS *)

AN APPARATUS FOR THE EXAMINATION OF UNDRILLED PEARLS

The peculiar behaviour of mother-of-pearl substance in an electromagnetic field may be used with success for the identification of cultured pearls, of course only of those cultured pearls which have an inserted ball of mother-of-pearl. The mother-of-pearl substance consists of very thin parallel plates of arragonite which are situated in more or less parallel layers.
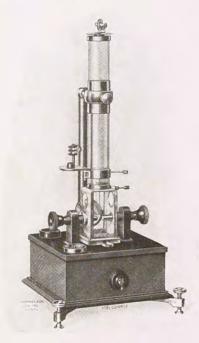
Fig. 66. THE PEARLCOMPASS.
D. R. P., U. S. A. Pat. (other patents pending).

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*) The pearl Compass. Obtain specific information from Gustave L. Herz, I., Burgring 1 (Vienna, Austria).

If a ball of Arragonite is suspended in an electro-magnetic field so that it is easily revolvable, it will place itself automatically in such a position that the crystallographic axis is perpendicular to the lines of force of the electromagnet.

A pearl with such a ball suspended in the electro-magnetic field turns so that the layer direction of the arragonite tablets is parallel to the lines of force. The cultured pearl therefore will when suspended in the magnetic field show a tendency to turn, provided it is not already suspended in a position in which the above mentioned two directions coincide. It is therefore necessary to

Fig. 67. The fastening of the Pearl.

examine each pearl twice in positions which are not just 180° apart.

Natural pearls with concentric and radially symmetrical construction show no tendency to turn in the magnetic field. Irregularities in the internal construction of the pearl however as well as the drillchannel in its position will influence the matter. Foreign substances in the drillchannel as f. i. minute metallic drillsplinters will have a great influence; internal manipulations in the pearl like glueing etc. will also cause certain turnings in the magnetic field. It is therefore necessary to analyze the turning of a pearl in the magnetic field in order to arrive at correct results.

If one makes these experiments with an ordinary electro-magnet, a glassrod, a silkthread for suspension and bees-

wax for the attachment of the pearl to the glass rod, one will find considerable difficulties in the examination.

In the major part of the cases not only the cultured pearls turn in the field but even also the suspension alone, without the pearl shows revolution when the current is switched on. It is therefore necessary to eliminate certain outside influences in order to get correct results, and the apparatus called Pearl Compass fig. 67 shows the embodyment of the latest researches.

The winding around the soft iron core is contained in the wooden box at the bottom of the instrument. From the iron core two extensions reach upward, the ends of which are seen in the illustration, equipped with poleshoes which may be screwed in or out. The glassrod is suspended from above on a silkthread so that the pearl just reaches the space between the poleshoes. This construction lifts the pearl to be examined away from the magnetic influences of the winding and the direct influence of the wire core. Same is exposed purely to the magnetic lines of force between the poleshoes and all irregular influences are excluded.

It is of course to be taken care that the proper glueing substance is used. Same is furnished with the apparatus. The top end of the glassrod on which the pearl hangs is equipped with a black bristle playing on a horizontal scale on which all deviations can be read off. The switching on of the current is recognised by a magnet needle set on top of the case in front, which shows by its rigid position when the current is switched on.

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THE SPECIFIC GRAVITY
OF PEARLS.

6. THE DENSISCOPE

The specific gravity of the pearl gives to a certain extent a clue as to whether one is in front of genuine or cultured pearls. On account of the changing inner construction of the pearl the specific gravity of a genuine pearl fluctuates considerably and lies mostly between 2,30 to 2,78. The Conchyolin is a light organic substance. The prism substance in marine pearls consists of Calcite and Conchyolin and has a specific gravity of 2.67; the Prism Substance in fresh water pearls consists of Arragonite and Conchyolin and has a specific gravity of 2,81. In both kinds of pearls the mother of pearl substance consists of Arragonite and Conchyolin and has a specific gravity of between 2,75 and 2,78. The specific gravity differs according to the amount of the variöus substances in a pearl.

In general one can say that a lower specific gravity indicates a larger content of Conchyolin or Prism Substance, especially in marine pearls.

Highest specific gravity in marine pearls indicates a larger amount of pure pearl substance.

In fresh water pearls the prism substance also has great specific gravity. Larger cavities are extremely rare in genuine pearls so that a lower specific gravity of the whole pearl can be ascribed to them only in rare cases.

Cultured pearls without conchyolin layers around the kernel and without larger cavities or warts show a relatively high specific gravity from 2,75 to 2,78. Their specific gravity sinks however in the case of larger deposits of conchyolin or when larger cavities are present.

If one detects the highest specific gravity in a pearl the same can either be a cultured pearl or a genuine pearl consisting to a great extent of mother of pearl substance. Is the specific gravity of the pearl low, the pearl may be either a cultured pearl with cavities or a genuine pearl with a large amount of conchyolin and prism substance. The presence of a secondary kernel will have the same effect. One can see therefore that the specific gravity of a pearl alone will not give an indication as to its genuineness.

If one however has a larger amount of pearls one can arrive at a correct judgement by establishing their specific weight. It is hardly probable that a lot of 1000 pearls will have the majority of specifically heavy pearls on account of them all consisting of pure mother of pearl substance.

It is much more probable that if in a case of 1000 pearls 950 appear specifically heavy, that is above 2,75, that the whole lot is spurious and consists in the majority of cultured pearls. It is just as unprobable that in a lot of 1000 round even pearls there be 950 pearls with cavities. If one therefore finds in a lot of 1000 pearls 950 with a lower specific gravity than 2,75 one can rightly decide that the whole lot are genuine accidental pearls. When the pearls are irregularly formed such a decision is not permissible.

Practically the border between specifically heavier pearls (mostly cultured pearls) and specifically lighter pearls (mostly genuine pearls) lies at values for the specific gravity between 2,72 to 2,74.

In order to avoid the establishing of the specific gravity of each pearl one can use a liquid of the specific gravity between 2,72 and 2,74. Pearls which float in this liquid have a lower specific gravity and are either genuine pearls or cultured pearls with cavities. Pearls which sink in this liquid have a higher specific gravity and are either cultured pearls without cavities or pearls of pure mother of pearl substance, which are the highest valued natural pearls.

This way permits the quick decision about the general value of a pearl lot or necklace. This is the principle of the Densiscope which can be of great advantage to the jeweler.

Fig. 68 illustrates the Densiscope. It consists of a round glassvessel, approx. 2 in. diameter in its lower part, and about twice the size in its upper part. The upper part bears a circular mounting of pure nickel which, except for an opening on one side, closes the vessel hermetically. The whole vessel may be lifted out from an annular rim; while being held in the rim it may be swung around a horizontal axis.

Two upright columns hold the above mentioned annular rim to an enameled base-plate. The base plate also holds two glass bottles with drop stoppers, one enameled in green, marked "heavy" and one in red, marked "light". The larger bottle contains Bromoform (d = 3), the smaller bottle Monobromo Naphthalene (d = 1,5), both liquids together forming the testing liquid of the apparatus.

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The base plate also contains two round cups, one for the pearls to be examined, the other for those that are examined. A round, hermetically closed cup in front contains Benzol which is used for the cleaning of the pearls, the cleaning of the drill channel being done with a small metal syringe with capillary ending.

All metal parts surrounding the liquid are made of pure nickel, most other metals being affected by the chemicals. A perforated pure nickel spoon serves for fishing out pearls from the glass vessel.

Two round capsules are setting in the front of the base

Fig. 68. HERZ'S DENSISCOPE.

plate, the one holding the above mentioned syringe, the other a set of reamers for the holes with a reamer holder.

One can use various liquids in the Densiscope in order to receive a mixture of the specific gravity between 2,72 to 2,74. The liquids in question are Acethylene Tetrabromide of the specific gravity of 2,97 to 3,00 with the lighter Monobromo Naphthalene or with Benzol.

In a mixture with Benzol the specific gravity changes rapidly on account of the fast evaporation of Benzol. The first mixture is therefore preferrable because it remains constant for a longer time. One can also use a mixture of Monobromo Naphthalene with Bromoform with the specific gravity of 2,88 or a mixture of Bromoform with Benzol.

For Information concerning the Densiscope adress: Gustave L. Herz, I., Burgring 1, Vienna, Austria.

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Monobromo Naphthalene has to be handled very carefully; it easily causes inflammations and catarrhs of the mucuous membranes of the eye.

The specific gravity of the mixture is easily controlled by indicators of which one is floating and the other sinking to the bottom if the mixture is correct. Such indicators are f. i. a calcite crystal and a mother of pearl ball.

After the examination of the pearl lot the pearls have to be washed and dried. The washing is done in Benzol. Pure alcohol is to be totally avoided as it dissolves the Conchyolin substance of the pearl.

The drilling of the pearl eliminates to a great extent the influence of the cavities in cultured pearls. It is necessary to eliminate the air in the drill channel and replace it with liquid which is done with the small syringe found with the Densiscope. The Densiscope will give better conclusions in a lot of undrilled pearls than in a lot of drilled pearls.

THE EXAMINATION OF PEARLS
WITH XRAYS

When pearls are exposed to Xrays over photografic plates, the resulting Xray photos of genuine and cultured pearls do not show enough differences to make distinguishing possible. However, internal cavities around the insert show light stripings if the experiment is made intelligently. One must avoid however to ascribe apparent differences between insert and outside covering to the presence of a mother of pearl kernel. Secondary kernels rich in conchyoline also give a similar picture.

The diffraction and interference phenomena showing on the photographic plate by exposure to Xrays give a better means for distinguishing between cultured pearls and natural pearls.

According to the direction in which the mother of pearl insert is struck by the Xrays, the photographic plate shows interference pictures of changing symmetry so that a definite decision can be formed as to the pearl being genuine or cultured.

Prism substance, radially rayed kernel and mother of pearl insert give totally different pictures under Xrays. Cultured pearls when photographed under various directions of the Xray give different pictures, artificial pearls the same pictures no matter in what direction they are struck by the Xray.

In general the examinations with Xrays demand a special education in that direction, the Xray examination is therefore to be excluded from the laboratory of the jeweler. The optical method described before with the Perlometer proves a simpler and surer way for the discrimination between cultured and genuine pearls.

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Precious Stones

1. GENERAL CONCEPTIONS
OF GEOMETRICAL AND PHYSICAL
CRYSTALLOGRAPHY.

Whosoever desires to occupy himself with the examination of jewels, must be at least primitively conversant with the principles of geometrical and physical crystallography. It is therefore necessary to give a short synopsis of the most indispensable conceptions in this field.

Only very few jewels occur in nature as socalled amorphous bodies, that is they do not exist in a crystalline state. The matter is distributed without rules in these amorphous substances and does not show the throughout regular construction which is peculiar to crystalline substances. The definite molecular structure is entirely wanting and all directions in this mass are sensibly the same. Such amorphous substances are f. i. all Opals.

By far the greatest number of all jewels are found in nature in the shape of crystals, often still with smooth and shining surfaces, often rolled off and rounded off with rounded surfaces and edges.

It can be shown that the various possible crystal forms in the mineral world can be divided in 32 crystal classes according to the conditions of symmetry, and of these 32 classes several again may be combined in so called crystalsystems.

One arrives at the systems in the following way: The crystals show surfaces which already according to their external shape can be recognized as of equal value. The reason for the appearance of faces of equal value in crystals is the following: The crystals have directions in which the molecular forces acting during the growth of the crystals are equal, thereby generating equal faces in these directions.

In order to describe the manifold forms of crystals it is necessary to imagine the establishment of three or more crystallographic axes intersecting in the centre of the crystal and penetrating the crystal faces. Their intersection forms the crystal cross. By choosing these axes, whose directions are often given by the crystal edges, so that faces of equal value form equal sections, it is apparent that for a certain number of these 32 crystal classes the axes have got to be chosen in the same way. This results in 7 distinct crystal systems with the following location and condition of their axes:
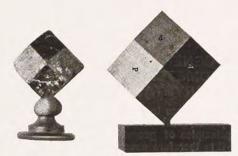
Fig. 1.
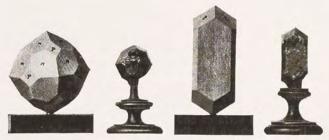
Fig. 2.

Fig. 3.
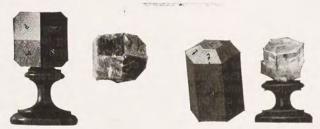
Fig. 4.

Fig. 5.

Fig. 6.

Fig. 7.
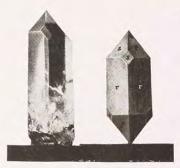
1. The Triclinic System with three obliquely intersecting axes of unequal value,
2. The Monoclinic System with three unequal axes two of which intersect at an oblique angle, the third axis being perpendicular to these two,
3. The Orthorhombic System with three axes of unequal length intersecting at right angles,
4. The Trigonal System with three axes of equal value intersecting under equal angles (rhombohedral edges),
5. The Tetragonal System with three axes, two of which — the horizontal axes — are equal, the third — the vertical axis — longer or shorter,
6. The Hexagonal System with four axes, three of which are equal and in a horizontal plane intersecting at 60 degrees; perpendicular to the plane of the lateral axes is the vertical axis which may be longer or shorter than the other axes.
7. The Regular (cubic) System with three axes of equal length intersecting at right angles.

Fig. 9.

Fig. 8.

Fig. 10.

Fig. 11.

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In part II of the pocketbook the trigonal and hexagonal systems are combined.

The inserted fig. 1 and 2 show two garnet crystals crystallising in the regular system with the pertaining crystal models showing more clearly than the crystals themselves the symmetrical relations.

In the following examples the natural crystals also appear accompanied by the cut woodmodel.

Fig. 3 and 4 show a Zircon crystal viewed from the top and from the side. It is clearly apparent that the two secondary axes are equal between themselves but different from the main axis along-side of which the crystal is developed in a columnar way.

Fig. 5 and 6 show a Rock Crystal from the side and from above. The hexagonal symmetry is clearly apparent in the view from the top.

Fig. 7 depicts the Rock crystal in side view.

Fig. 8 a Tourmaline crystal viewed from the top.

Fig. 9 a Corundum crystal in side view.

Fig. 12.

All 3 last figures, especially fig. 8 show a Trigonal Symmetry in the arrangement of the faces around the lengthwise directions of the crystal. They belong to the trigonal system which may also be combined with the hexagonal system.

Fig. 10 shows an Orthorhombic crystal, a Topaz in which the axis running from the front to the rear is different from the axis extending from the left to the right.
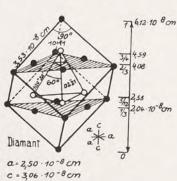
Fig. 11 shows a crystal of Orthoklas, a monoclinic crystal which appears symmetrical according to a plane running from front to rear, one axis runs perpendicular to the plane of symmetry from left to right, the other 2 axes lie in the plane of symmetry and intersect at an oblique angle.

Fig. 12 is a Triclinic crystal of Axinit in which all 3 axes intersect obliquely. It shows the least symmetry of all shown crystals and models.

The symmetry of the crystals manifests itself not only in the faces of the same, but being the result of a lawful internal construction, it manifests itself also in all other physical qualities.

Diamant

$a = 2.50 \cdot 10^{-8}\,cm$
$c = 3.06 \cdot 10^{-8}\,cm$
$a : c = 1 : 1.23$

Fig. 13

Especially judging from the cleavage observable in many minerals one has adopted the view that the crystals consist of groups of atoms which repeat themselves in straight

directions in equal distances thereby furnishing a regular space lattice.

This conception explains all relations of symmetry of the crystals and has been lately fully proven by experiments with Xrays. Ever since the epochal publications of the Physicist Laue who as the first in 1912 showed that Xrays when penetrating a crystalplate showed diffraction and interference phenomena, other methods have been thought out which permit of calculating accurately the internal construction of crystals.

Fig. 13 shows a section of the crystal lattice of the diamond. The diamond consists of carbon and the single atoms of the diamond are arranged as shown in fig. 13. A cube placed on one of its points may be seen, in the corners of which carbon atoms are setting.

Furthermore carbon atoms may be encountered in the faces of the cube and in the interior of the cube the carbon atoms form a pyramid. The distances between the atoms are put at $_{10}-^8$ cm that is the 100 millionth part of a centimeter.

Upon a mm come about 2,2 millions of these cube edge lengths and in a cubic mm of diamond there are about 178 trillions of carbon particles which are disposed in this very regular way.

To date, science has succeeded in exploring the internal structure of a great number of minerals and of jewels, and of each substance the internal structure has a special character peculiar to the substance.

The lawful internal structure of the crystals manifests itself in the physical quality of the same so that one can infer the crystal system from their physical f. i. their optical properties. This is particularly important in ground jewels, their optical examination being entirely harmless to the surface.

It can be shown that the crystals belonging to the regular crystal system permit the light to penetrate and change equally in all directions, whereas crystals belonging to the trigonal, tetragonal and hexagonal systems resolve the light ray into two rays now penetrating the crystal in two different directions.

The regular crystals show single refraction, the trigonal, tetragonal and hexagonal crystals double refraction; however they possess one direction in which the light can pass without being resolved into two rays. This direction coincides with the crystallographic main axis and is called the o p t i c a l a x i s.

The orthorhombic, monoclinic and triclinic crystals also show double refraction but they have two such directions which are called optical axes.

One therefore distinguishes between crystals with o n e optical axis and such with t w o o p t i c a l a x e s. Coloured crystals show whether they are singly or doubly refractive by their colour changing in translucent light according to the direction in which it passes through, a quality which is called P l e o c h r o i s m.

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Crystals with single refraction show the same colour no matter in what direction the light passes through them. Crystals with one optical axis show one colour in all directions perpendicular to the optical axis and another colour in the direction of the optical axis. In crystals with two optical axes one can observe three maximally different colours in three directions perpendicular to one another. They are called Trichroitic. The crystals with one optical axis are Dichroitic. In the intermediate directions mixed colours appear.

By using a Dichroscope*) (Dichroitic lens), consisting of a combination of a piece of Calcspar with a lens, one can observe the pleochroitic colours of coloured crystals alongside each other. When observing crystals with one optical axis via the Dichroscope one can observe one colour only when looking at the crystal in the direction of the optical axis, but two maximally different colours when looking at it at an angle of 90^0 to the optical axis. Crystals with two optical axes show different colours in three different directions. It is necessary to examine in at least two directions perpendicular to one another.

As will be shown later, this quality called Pleochroism is a simple and sure means for distinguishing between highly valued jewels and their cheaper substitutes.

Pleochroism however cannot be observed in all coloured crystals and sometimes the differences in colour are very weak.

The following chapters describe simple methods of examination which each jeweler may carry out himself, methods giving him figures and datas which are necessary to identify the jewels with the aid of the tables in part II of this book.

One of the principal physical data in the tables in part II of this book for the great variety of jewels is the figure for the density or specific gravity of the jewels. The jewels are arranged in the tables according to this figure.

*) THE DICHROSCOPE, Can be obtained from: Gustave L. Herz, I. Burgring 1, Vienna, Austria.

2. THE DETERMINATION OF THE SPECIFIC GRAVITY.

The specific gravity of a mineral is the ratio of its density to that of water at 4^0 C. This relative density may be learned in any case by comparing the ratio of the weight of a certain volume of the given substance to that of an equal volume of water. The specific gravity is best defined as the weight of the body divided by the weight of an equal volume of water, water forming the basis of our metric weight system.

It is therefore necessarry in order to find the specific gravity of a jewel to know the absolute weight of the jewel and then its volume.
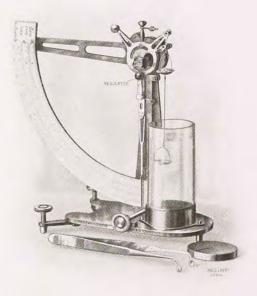
Fig. 14. Newton Scale. made by Gustave L. Herz, Vienna, I. Burgring 1.

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The stone is weighed upon a beam balance, which has a double pan, the lower one of which is submerged in water. The zero point of the scale is so established that the balance beam swings at zero when one of the pans is totally submerged in water.

Fig. 14 shows a special scale built after the system of a letter scale with double pans, the lower one of which submerges in water. By placing the stone upon the upper pan one can read off the absolute weight of the stone. By placing the stone upon the lower pan in the water, one receives a weight smaller than the first by the weight of the water displaced by the stone.

This weight of the water displaced by the stone is equal to the volume of the displaced water, the metric system being based upon the principle of the weight of 1 cm³ of water being 1 Gramm. The figure giving the diminution in weight of the stone therefore also gives the volume of the stone.

The specific gravity then is obtained by dividing the weight of the stone by the volume, the latter being equal to the loss in weight by submerging in water.

Finding the specific gravity of a stone is a very simple procedure with the Newton Scale : First of all the object is weighed by placing the same on the upper pan and reading the actual weight of the object on the scale (A). During this weighing the lower pan serves as damper only. The scale is then arrested and the object placed in the lower pan and the weight of the article in destilled water established (B). A minus B then gives a difference C. The specific weight of the substance is the result of the division of figure A by the loss in weight by immersion in water C.

A : C = S (specific gravity).

A common laboratory scale can be adapted by replacing one pan by a double pan which is equalized by weight on the other beam of the scale. By using a glass of distilled water for the submersion of one pan one can adapt a normal scale for the establishment of the specific gravity.

The specific gravity of crystals is to a certain extent fluctuating owing to the inclusions and the somewhat changeable chemical composition of the same. They are therefore not absolute unchangeable figures which are characteristic for the specific gravity of certain jewels, but a certain difference is possible between many single observations. Col. 1 of the tables in part II of the book gives limits within which these figures vary.

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3. THE DETERMINATION OF THE RE-FRACTIVE INDEX OF A JEWEL.

It is generally known that the lightray is deviated or refracted when it passes from an optically rarer medium into an optically denser medium or vice versa. This can easiest be demonstrated by holding a pencil into a glass filled with water. When viewed from the side the pencil appears to be broken at the point where it reaches the water surface.

Fig. 15,
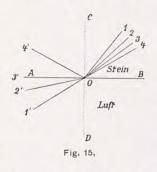
Fig. 15 shows the diagram of various lightrays when entering from air into a stone at a border plane AB and vice versa. In the denser medium the lightray appears with a refraction to the perpendicular, in the drawing the straight line COD, which is also perpendicular upon the deviation plane AB. A ray 1' is also refracted in the stone towards the direction 1, a ray 2' in the direction 2. In the other sense when entering from the denser medium into the rarer (as from stone into the air) a refraction from the perpendicular (COD), can be observed. A ray 1 is refracted into direction 1' and a ray 2 in the direction 2'.

The ray 3 is refracted when entering from the stone into the air just so that it runs alongside the border plane AO. All light however which strikes in the angle region 3 OB upon the border plane will not enter the air but will be totally reflected into the stone, a phenomenon called Total Reflection. The angle of incident CO 3 at which the total reflection begins, is called the critical angle of total reflection and bears a simple mathematical relation to the figures which are stated as indices of refraction in the tables and which express the relation between the light velocities in stone and air.
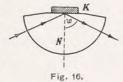
The Column 3 in the tables of part II of the Pocketbook cites the values within which the index of light refraction can vary according to the somewhat changing chemical composition and the colouring of the jewels.

F i. most tourmalines have a light refraction varying between 1,64 and 1,62 but there are also tourmalines in which the light refraction amounts to 1,65. The double refraction that is the largest difference in the distance of the border lines can be seen from col. 4.

THE REFRACTOMETER.

By placing a stone with a plane polished surface upon a hemisphere of glass having a high refractiv index and by letting a lightray play upon the division plane between stone and hemisphere, one can observe, that within a certain angle the light coming from the strongly refractive hemisphere, does not enter the jewel but is totally reflected into the hemisphere as shown in fig. 16.

Fig. 16.

By combining in an instrument whose main part is such a hemisphere of glass having a high refractive index with an obs rvation telescope with a refractive prism according to fig. 17 one can in the field of vision distinctly see the borderline which limits the scope of total reflection. Within the scope all the light is reflected and this part therefore appears lighter, without the scope only a part of the light is reflected, this portion appearing darker.

A scale is built into the observation telescope which gives the index of refraction already calculated corresponding to each angle, so that one can directly read off the index of refraction in the instrument as shown in fig. 17.

The instrument may be placed upon a stationary post or holder or may be used as pocketinstrument as shown in fig. 18.
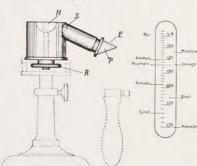
Fig. 17. DR. MICHELS POOKET—REFRAC—TOMETER.

On sate by Gustave L. Herz, Vienna, I. Burgring 1.

By using the refractometer it is necessary to place between stone and surface of the hemisphere a drop of a liquid, which has a higher refractive index than the stone to be examined. For jewels with a lower refractive index one uses Mono-bromo – Naphtalene whose index of refraction $n =$ 1.658 and for je-

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Fig. 18. The Pocket Refractometer *)

wels with higher refractive index one uses the Rohrbach solution viz. Barium Mercury Iodide with an index of refraction $n = 1,77$ until $1,79$ according to the density of this solution. Metholene Iodide with $n = 1,74$ may also be used.

One then observes besides the borderlines of total reflection of the jewels another faint borderline belonging to this intermediate liquid at 1,658 or between 1,77 to 1,79 or at 1,74. This has to be discarded as irrelevant for the index of refraction of the jewel.

One now observes that the borders between the lighter and darker part of the field of vision do not run sharply but appear as coloured broader ribbons. This is caused by the decomposition of the light in its coloured constituents. One therefore mostly builds a colour filter into the instrument or if such is lacking one uses a source of light a natrium (sodium) burner furnishing uniform yellow light.

Independently from this decomposition of the light and the thereby caused broadening of the borders one can with many jewels observe several borderlines caused by the double refraction of these jewels.

THE DOUBLE REFRACTION OF JEWELS.

All jewels which do not crystallize in the regular crystal system or amorphous substances like the Opal are doubly refractive. By passing these jewels the light is decomposed into two parts, which propagate with different velocity and are therefore refracted differently.

We imagine the light to be a vibration of the ether at which the ether particles are put into wavelike vibrations. The plane in which the vibrations occur is called the waveplane of the light and we know that the two parts of ether oscillations created by double refraction are such that their waveplanes are perpendicular upon one another. The optical relations are variable in doubly refractive jewels according to the direction in which the light passes the jewel and in which the parts generated by double refraction vibrate.

In short, the optical qualities of jewels with double refraction are dependent upon the direction of the light.

Contrary to this, the optical relations in jewels crystal—lizing in the regular system or in amorphous jewels are independent of the direction of the light. The light passes such substances in all directions with the same velocity and is not decomposed into parts with variously strong refraction. They are simply refracted. These substances are called substances with single refraction.

But also in doubly refractive minerals there are directions in which single refraction is prevalent. In substances which crystallize in Trigonal, Tetragonal and Hexagonal systems, light which passes in the direction of the crystallographic main axis is refracted singly. Such a direction in which in spite of doubly refractive bodies

*) On sale by G. L. Herz, Vienna, I. Burgring 1.

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simple light refraction is to be observed, we call the optical axis and we call the substances which belong to the named three systems, sub—stances with one optical axis. The substances crystallizing in the Orthorhombic, Monocline and Tricline system have two directions in which single refraction is to be observed (with certain deviations) and are called optically biaxial substances.

On the other hand one can observe anomale double refraction or tensial double refraction in singly refractive substances but they show up differently from the normal double refraction.

In the Column 2 of the tables in part II of the Pocket book the crystal systems are given in the following letters:

r = regular   rh = orthorhombic
h = hexagonal and trigonal   m = monocline
t = tetragonal   tr = tricline

Amorphus substances are designated with an a. The single and double refraction by the letters s and d, r and a are always coupled with s, whereas h, t, rh, m, tr appear always combined with d as can be inferred from the above statement.

It is therefore to be ascribed to double refraction when in spite of using light of a single colour several borders appear when examining doubly refractive jewels for establishing the index of refraction. These borders may be shifted by revolving the hemisphere which in most cases is possible (in the here described instrument by a nut on the bottom).

By noting the figures of the stationary and shifting borderlines one receives the values which in column 3 of the tables in Part II are called indices of refraction. Minerals with single refraction only show one borderline.

In order to get good results the following rules should be observed : One selects in the stone to be examined a plane larger surface disregarding smaller or uneven surfaces. This surface is placed upon the plane upper part of the hemisphere after moistening the same with a drop of Monobromo Naphtalene or Baryum Mercury Iodide.

Care has to be taken against injuring this soft glass surface. If the stone is out of its setting one covers it with the metal cap of the instrument and then lifts the instrument to the eye so that the plane surface of the hemisphere remains horizontal. One then looks towards a source of diffused light like an incandescent lamp shielded with a ground glass or against the diffused sky. If necessary one has to place a ground glass before the opening of the instrument.

The telescope is then adjusted until one sees the scale of the instrument sharply and then one looks for the division between the lighter and the darker part of the field of vision. If one only finds one border at n — 1,658 it is obvious that the index of refraction of the stone lies a b o v e the figure. It is then necessary to repeat the observation by using a drop of Baryum Mercury Iodide after cleaning the plane surface of the hemisphere with a soft rag.

The Rohrbach solution or Baryum Mercury Iodide is best kept in a small wellclosed bottle and applied to the hemisphere with a glass—rod. The soluton diminishes its index of refraction when standing a longer time. In a concentrated state the borderline of total reflection for this liquid is at 1,77 to 1,79.

The hemisphere is almost always rotatably mounted and a favourable point of observation found by rotating the same during observation.

Only very few jewels have a higher light refraction then Baryum Mercury Iodide as f. i. the zircon or the diamond.

One can also examine jewels in a setting provided the jewel has one large plane surface exposed, permitting the placing of the jewel upon the hemisphere.

4. OPTICAL INSTRUMENTS AND METHODS.

The microscopical examination of jewels.
(Double refraction, Pleochroism, Inclusions).

a) The Microscope:

The universal instrument for the examination of jewels which should in the first place be popular with jewelers is the Microscope. That is, a Microscope which is specifically adapted for mineralogical examinations; an instrument of this kind replaces a number of other apparatuses and is especially useful for the examination of jewels.

Fig. 19

Fig. 19 shows such an instrument which we will describe hereafter. The object which we desire to examine is placed into a small glass container and immersed in a liquid whose index of refraction is not too much different from the index of the object to be examined. Container and object are placed upon the table C. The immersion of the object makes it more transparent and eliminates the disturbing reflexes. The light necessary for the observation is furnished by the mirror placed underneath the microscope table.

The lighting apparatus also contains an Iris Diaphragm built in, which permits of excluding the border rays by closing the Diaphragm to some extent.

This is for instance very important when one is looking for the augmentation stripes in synthetic jewels. The object is looked at via the ocular and objective lens combined in the tube. The object may be moved sideways by means of a sliding table. The large adjustment screw at the side of the tube and the micrometerscrew of the tube is moved up and down so that various depths of the object may be scrutinized. The whole jewel may be explored in the interior from top to bottom and all inclusions, defects, etc. located.

Especially the exact study of the inclusions and the distribution of colour with in the stone

give us definite indications as to the genuineness or spuriousness of a stone.

For the examinations of stones we also need several additions to the microscope, first of all there ought to be a device in the lighting apparatus furnishing so called polarized light.

The ordinary light continuously changes its direction of vibration. Light which only vibrates in one direction is called polarized light. We will later see in which way polarized light is aiding us in the examination of jewels; we only desire here to describe the device which furnishes us such polarized light.

The holder called P in the drawing contains a prism of clear transparent calcite (Iceland or double spar) consisting of two parts which are ground and cemented together and called the Nicol Prism or in short the Nicol; the ordinary light coming from the mirror is doubly refracted in this prism; the one kind of light waves is eliminated by total reflection, so that from the prism only light emanates consisting of waves vibrating in one plane.

Such light is called polarized light.

It is possible to obtain polarized light in various ways, and the construction of the Nicol varies. We call the whole device furnishing polarized light the polarizer. The plane in which the polarized light vibrates we will call the vibration plane of the polarizer.

In the tube there is a second such prism designated by the letter N which permits that light to emanate only which vibrates in a certain other plane. This prism is called the analyzer. It is usually built into the tube in such a way, that its vibration plane is exactly perpendicular to the vibration plane of the polarizer, when same is pointed to a certain mark.

The figure also shows another prism of this kind at A which at the present moment is to be discarded as well as the lens at B in the tube.

The mineralogical microscope must have a revolvable table, bearing a division on the circumference so that the degree of turning can be read off with a nonius. The turnability of the table makes it necessary that the objective be centrable. This centering is done with the aid of two screws marked Ce under 90⁰ to one another. This permits of bringing into coincidence the optical axis of the microscope with the revolving centre of the table. One concentrates sharply upon a point which is in coincidence with the crossing point of the haircross built into the ocular and observes now the circle which this point describes when the table is turned. The centre of the circle is then brought into coincidence with the haircross centre by turning the centering screws Ce.

b) DETECTING DOUBLE REFRACTION.

We can now determine whether a stone is doubly refractive or not.

When vibration planes of polarizer and analyzer are crossed under 90⁰, the observation field appears darkened. We call this position shortly as crossed Nicols. The light now emanating from the polarizer is not permitted to pass the analyzer. We first exclude the analyzer and project all the light upon the visionfield with the mirror. The analyzer is now inserted and we see whether the field is darkened. If this is not the case the polarizer is turned until the field darkens. This position of the polarizer is usually indicated by a mark in the setting. The light which now comes from the polarizer is not permitted to pass the analyzer.

If we however insert into the path of the light a jewel with double refraction, the following occurs: The lightray in a stone with double refraction is decomposed into two rays which are differently deviated in the stone and whose vibration planes are perpendicular to one ano—

ther. If now the stone is so placed upon the microscope table that the two vibration directions are parallel to those of the polarizer and analyzer there is nothing changed in the above described circumstances and the field of vision remains dark. If one however revolves table and stone a little, then the two parts of the lightray created by double refraction are joined by the analyzer. They are brought into interference and give an interference colour and the field of vision clears up.

Every time when the vibration directions of the stone are parallel with the vibration planes of polarizer and analyzer, the vision field remains dark, in the intermediate position it is cleared up. In the course of a full turn of 360' the vision field clears up and darkens four times. This is a sure sign of a jewel having double refraction.

A stone with single refraction does not have the faculty to lighten up the vision field because he has no preferred vibration directions, but permits the light to pass equally in all directions. It is necessary however to place the stone upon a second facet not under 180° from the first and examine the stone again with crossed Nicols in order to be able to definitely say that the stone has single refraction. The stones with double refraction have, as previously stated, also certain directions in which the light is refracted singly.

Fig. 20.

This examination f. i. is an excellent means of detecting coloured glasses which always show single refraction and discriminating them from the stones which they are to falsify:

it is thereby easy to discriminate between green glasses and the genuine emerald.

Glasses however also sometimes show phenomena similar to double refraction, due to certain tensions in the glass, but this "tension refraction" is easily recognizable as such.

Minerals crystallizing in the regular (cubic) system (spinell, garnet etc.) are easily distinguishable from similar minerals of other crystal systems. The minerals

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crystallizing in the cubic system show single refraction, the latter double refraction. Ruby and Spinell are thereby easily distinguishable.

The tension double refraction or anomale double refraction is thereby characterised that the extinguishing occurs spotwise, certain parts extinguishing before the other. The uniform extinguishing other—wise observed does not occur in double refraction by tension.

A good illustration of a substance showing such anomale double refraction by tension is fig. 20. It depicts a synthetic Spinell which contains more aluminate as it should according to its formula. Same is here photographed under crossed Nicols with weak enlargement. It clearly shows the spotwise extinguishing of parts of the field.

This anomale double refraction by tension is very characteristic of most synthetic Spinells.

In jewels which consist of twin crystals the single parts of the twin crystals belong to different individuals and one finds under crossed Nicols that certain parts extinguish and others not, especially the twin border can repeat itself several times and be accompanied by variegated ribbons. It is easy to distinguish this phenomenon from the appearance of double refraction by tension.

———

c) THE PLEOCHROISM.

The mineralogical microscope finds a second wide field of application in determining the Pleochroism of a jewel. Coloured jewels with double refraction show different colours when looked upon in different directions. If we desire to see these colours consecutively we must have polarized light. After excluding the analyzer we turn the table of the microscope whereby the different colours appear one after another, with the greatest difference between themselves in the two vibration directions.

Glasses and minerals crystallizing after the cubic crystal system are easily distinguishable thereby from the minerals crystallizing in the other systems. Glasses and minerals crystallizing in the cubic system are n e v e r p l e o c h r o i t i c. It is necessary to examine the jewel in several directions, because as we have seen before there are directions in which double refraction and pleochroism are lacking.

As an example: Spinell is not pleochroitic whereas the ruby of the same colour shows strong pleochroism in the colours yellowish red and deep red. Only in the direction of the main axis the ruby shows no pleochroism.

Instead of crossed Nicols it is possible to get along with one Polarizer set turnable on top of the ocular lens of the microscope. This polarizer being revolvable, the microscope table can remain fixed. This arrangement however only permits the examination of the pleochroism of coloured and doubly refractive jewels.

By observing a coloured stone like an emerald or a ruby with the naked eye one can see the change in colour by looking through the stone in various directions. By looking via an emerald in the direction of the crystallographic main axis the stone appears d a r k g r e e n; by looking in a direction perpendicular to the main axis, the stone appears b l u e g r e e n.

A ruby appears d a r k r e d; p u r e r e d when looked upon in the direction of the main axis and y e l l o w i s h r e d when looked at in a direction perpendicular to the main axis.

By making this observation with polarized light the colour differences are still more clearly to be observed, f. i. by examining an emerald or a ruby over the polarizer of the microscope. The absorptions for the various vibration directions appear differently.

For instance by observing a plate of emerald cut parallel to the main axis and observed in a direction perpendicular to the main axis, a b l u e g r e e n and a d a r k g r e e n shade may be seen consecutively whereas by observing the same plate in ordinary light one sees a colourmixture of the two.

THE DICHROSCOPE:

The phenomena seen in the microscope consecutively can be seen alongside each other in the Dichroscope. The Dichroscope is a combination of a lens with a piece of calcite both contained in a tube. By looking through the lens one sees two little squares. The square opening on the end of the Dichroscope appears doubled by the calcite crystal. The vibration directions of the two pictures are perpendicular to one another.

By holding an emerald before the opening of the Dichroscope so that one looks at it under 90⁰ to the main axis, one cam see alongside each other the two dark green and blue green shades which one has seen consecutively in the microscope over the polarizer. The one colourshade corresponds to the colourshade in a position to the microscope in which the light vibrates parallel to the main axis, the other colourshade to the position in which the light vibrates under 90⁰ to the main axis.

The two colours in the Dichroscope squares change continuously when turning either jewel or Dichroscope, and the largest difference between the two colourshades is seen when the direction of the main axis is parallel to one pair of the sides of the squares in the Dichroscope.

When observing pleochroism in the Dichroscope it is necessary to examine the stones in positions which are not exactly 180⁰ apart from one another by turning the stone or the dichroscope. There will be found special directions in which doubly refractory bodies show no double refraction and therefore no pleochroism.

Oneaxial crystals show the greatest differences when cut in plates and observed perpendicular to the main axis of the crystal. Plates cut under 90⁰ to the main axis and observed parallel to the main axis show no pleochroism. Crystals with two axes show in three directions perpendicular upon one another the largest differences.

The largest colour differences are rendered upon the two tables VI and VII and explained in part II of the Pocketbook in the tables for the various colourgroups of jewels.

In these tables the tints seen by natural daylight are depicted alongside of the tints observed over a ground glass or over a daylight filter under artificial light. Both show sometimes great differences.

The Dichroscope can be obtained from G. L. Herz, Vienna, I. Burgring 1.

d) THE EXAMINATION OF INCLUSIONS.

The microscope renders extremely valuable service for the examination of inclusions of jewels. In the following remarks concerning inclusions, the facts of purely scientific interest are eliminated and only those descriptions rendered, which are of practical interest to the jeweler.

One can examine the inclusions either directly in the microscope or project the picture of the same upon a ground glass and photograph them with a camera. Fig. 21*) shows a simple arrangement by

Fig. 21.

which the picture may be observed through the tube on the side, whereas at the same time the observation may be micro-photographed in the camera set above.

In part II, on tables XI to XXVIII there are rendered a series of micro—photographs which largely illustrate this section concerning inclusions. The cases depicted there are typical cases described and explained in the reading matter adjoining the tables and it is advisable for the jeweler to study these tables carefully.

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*) For information concerning the microcamera address: Gustave L. Herz, Vienna, I. Burgring 1.

GENERAL REMARKS CONCERNING
INCLUSIONS.

Inclusions in jewels are generated during the growth of the jewel, whereby foreign substances have been absorbed, cavities and often even negative crystals with crystal surfaces formed. The cavity within the crystals may partly or fully be filled with liquid, absorbed during the growth, or sometimes filtered into the cavity later Solid substances may have been secreted later when the temperature sank and solutions were decomposed.

The inclusions may be distributed irregularly in the stone but they may also mirror the symmetry of the stone in their shape as well as in their distribution. Inclusions of crystallized solid substances often show the crystal shapes pertaining to these substances, but the including material also directs these crystals according to its own crystallizing rules. These crystals then appear lawfully oriented according to the including material.

Liquid inclusions often show the shape of negative crystals, i. e. of crystal surfaces of the including substance arranged to the orderly rules of symmetry of the including material. Negative crystals are shown in illustrations on tables XXI and the lower illustration of table XIX. The cavities may also be empty or filled with gas though with regular demarcations according to crystallographic rules.

The inclusions in a crystalbody may be quite irregularly disposed, same as the colouring. Zones free of inclusions may change with zones full of inclusions, same as lighter zones alternate with darker sections.

The composition of the inclusions varies considerably, the cited examples showing great variations. In most cases the borderline of the inclusions will already characterise the same either as crystallized substances, liquids or gases.

Crystalline inclusions have in most cases delicate borderlines, especially when the light refraction of the material does not deviate very greatly from the light refraction of the surrounding material. By raising and lowering the microscope tube a short distance, the light borderline on the edge of the crystal seems to wander. When raising the microscope tube the light borderline of the inclusion seems to encroach upon the inclusion, if the inclusion has the higher light refraction. If, when lifting the microscope tube the borderline seems to shift to the

outside, then the surrounding substance has the higher light refraction.

Fig. 22 shows an inclusion of a crystalline substance presumably calcspar in a Colombian emerald. The microscope is so adjusted that the light borderline runs in the interior of the small tabletlike crystals. The borders are delicately visible. The crystals themselves extremely thin ; they are oriented between themselves and against the surrounding substance. Inclusions of substances with very strongly varying index of

Fig. 22.

refraction show the borderlines considerably stronger. The manifestations of their own double refraction are distinctly perceptible in the right positions.

Liquid inclusions show mostly broader, darker borders. In the proper position the free space of the inclusion is perceptible alongside of these dark borders.

Fig. 23 shows such darkly bordered liquid inclusions of various shapes. Very many liquid inclusions show a totally irregular shape, they appear hoselike, wormshaped, droplike. whereby in the latter case the single drops are extending to long dotted lines, running more or less parallel. Very many liquid inclusions show balanceflies (Libellae) i. e. very movable gas bubbles floating on top of the liquid, which in each and every case clearly designate the inclusion as a liquid one. Such balanceflies are shown in the table XXI. Liquid inclusions may finally also show crystallized portions as shown in the lower illustration of table XXII.

Gas inclusions show a considerably stronger border. The reason for the darkness of the border of the gas inclusions is the total re—

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Fig. 23.

flection as well as manifold deviations and refractions of the light. The upper illustration of table XXVIII shows a typical gasbubble in a glass. The whole bubble sometimes appears totally dark and untransparent.

Fig. 24 shows a liquid inclusion surrounded by a layer of vapor, in a Topaz from Schneckenstein. It shows the typical broad dark surrounding wall, caused by the vapor. The illustration shows a small amount of one liquid surrounded by a vaporwall and in the fine ends of the figure a second liquid without this surrounding.

Fig. 24.

INCLUSIONS IN GENUINE NATURAL CRYSTALS.

A) CRYSTALLINE INCLUSIONS.

(Inclusions of solid substances, Individualized inclusions.)

Examples of such inclusions are found on tables IX to XIII in part II of this book.

Fig. 25 shows rutile needles especially characteristic for the rubies of Birma; such rutile needles may also be observed in sapphires from
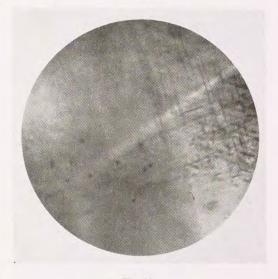
Fig. 25.

Ceylon. In the latter case they are often found in conjunction with liquid inclusions. The rutile needles are oriented in the stone and appear mostly nontransparent on account of their high light refraction inspite of great thinness.

Fig. 26 shows a scale of mica in a ruby, strongly enlarged.

Fig. 27 shows skeletonlike exudations of opaque (nontransparent) substances in a Siam ruby. One is sometimes tempted to confound these skeletonlike exudations with inclusions as shown in table XXVI, in a synthetic ruby.

Genuine natural stones are characterized by a distribution of the inclusions and of the colouring matter in zones, which are parallel to the crystal faces of the stone

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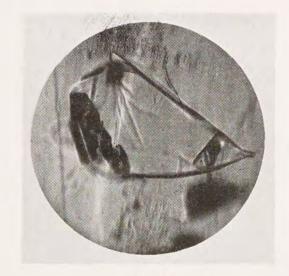
Fig. 26.

Fig. 27.

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and sometimes in certain positions appear as zones bordered by sharp lines as shown in fig. 28, showing the zonar distribution of the colouring matter in an emerald.
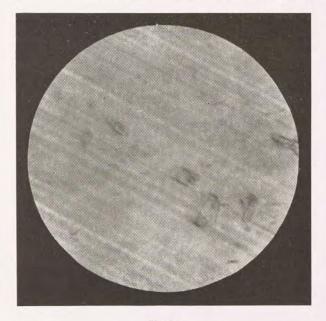
Fig. 28.

Inclusions as depicted on table XII stand on the border between crystalline and liquid inclusions. They are minute skins of a solidified isotrope substance of which one cannot see whether it had this shape at the time when the crystal grew and formed its shape or whether it grew to this condition afterwards. It is also possible to think of a later intrusion of such substances, which afterwards shaped into rosettelike formations as depicted on table XII.

These skinlike flat formations are mostly combined with cracks in the stone which either have been existing primarily, giving cause to the intrusion of these substances, or have been generated after the formation of the stone through the inhomogenity of the matter. A part of these cracks is sometimes filled with air which then appear untransparent as shown in the lower illustration of table XXIV.

B) LIQUID INCLUSIONS.

Tables from XIII to XXIII contain examples of various inclusions. Liquid inclusions with or without gasbubbles, crystalline exudations in liquids with gasbubbles and one or two liquids in arbitrary shapes and finally the so called negative crystals.

If the liquid fills the cavity fully, there appear formations of the kind shown in fig. 29 in a ruby. The single sometimes extended thin liquid filled channels, are combined to a "vane" and run more or less parallel. Similar liquid inclusions are shown in figure 30 in a Ceylon ruby.

The manifold exterior shape of the vane is not only shown in fig. 31 and 32 both in sapphires, but also in table XIV, XV, XVI, XVII. In all these cases the dropshaped, hoseshaped, wormshaped liquid inclusions are combined to sharply defined vanes.

Fig. 33 illustrates liquid inclusions in a tourmaline in which the inclusions mostly show a more irregular disorderly course than in the Corundums. Liquid inclusions showing the type of negative crystals are illustrated on table XXI. The lower picture shows very distinctly the round almost globelike balancefly which appears when the liquid almost fills the cavity of the stone. This relatively small bubble may also adapt itself to the shape of the inclusion as shown in table XXII.

The lower picture of this table shows the type of a liquid inclusion with a gasbubble and the crystalline exudation in the shape of a cube. The existence of such movable balanceflies or such crystalline exudations excludes all doubt about the fact that a liquid fills the cavity.

Fig. 29.

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Fig. 30.

Fig. 31.

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Fig. 32.

Fig. 33.

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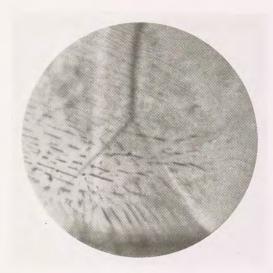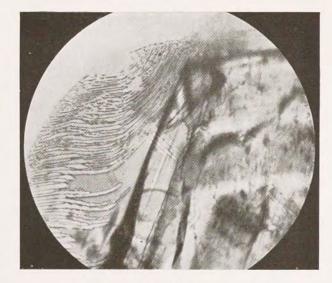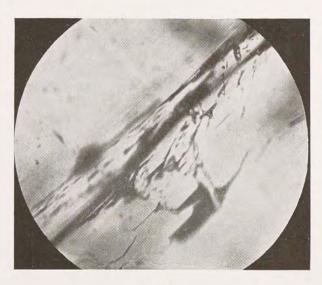
Sometimes there are two solid substances next to a liquid and a libella as shown in fig. 34a depicting an inclusion in a Columbian Emerald. In the liquid filling the hook—formed cavity lie two rounded off cubes (probably NaCL) betwenn them a calkspar crystal. The end is pointed upwards, the pointed end being filled with a gasbubble.

Fig. 34 a.

The balanceflies may not only be movable but may also be made to disappear by heating. One succeeds in this especially easily when the inclusion consists of liquid carbonic acid which gasifies at the critical temperature of about 31^0 C. One can observe an increase in liquid and a diminishing of the gasbubble or vice versa, a gasifying of the liquid and the increase of the bubble. At the critical temperature a sudden conversion of all liquid into gas occurs. Pollution of the liquid may cause the critical temperature to be below 31^0 C.

If the quantity of liquid diminishes, the liquid may take the shape of a drop surrounded by a border of vapor against the walls of the enclosure as shown in fig. 34 in a Topaz. Here is a less expansible

Fig. 34.

liquid, probably water which fills the extending ends of the inclusions and alongside of it a second more expansible liquid, probably carbonic acid in the shape of drops filling the broader part of the inclusion and surrounded by a hull of vapor of carbonic acid gas, separating liquid and walls of inclusions. Such inclusions are called inclusions of two n o n m i x a b l e l i q u i d s; the liquid carbonic acid in this case does not reach the wall of the inclusion.

Fig. 35 shows a different type of inclusion consisting of two non-mixable liquids. These are cavities in which the edge directions running parallel through the whole stone show that the cavities are partly well bordered negative crystals filled with the same two nonmixable liquids as shown in the type of fig. 34. Here the bordering of the two liquids adapts itself in many parts to the borders of the cavities.

The liquid inclusions illustrated in fig. 36 in a smoky quartz consist either of water with liquid carbonic acid in the shape of a bubble or of water containing carbonic acid with a bubble of carbonic acid gas on top.

Fig. 37 represents a somewhat different type of an inclusion with a double balancefly or more exactly with two nonmixable liquids. This case shows water, liquid carbonic acid and carbonic acid gas. The liquid carbonic acid has here the shape of a bubble (balancefly) in the water According to the relation of liquid carbonic acid to carbonic acid gas, the liquid carbonic acid takes the shape of a drop surrounded by carbonic acid gas edged between the liquid and the border surfaces of the inclusion and the water as in fig. 35. Through heating, the borders are completely removed and even the heat generated by the photographing causes the borders to move. In doubtful cases one can detect the borders through warming up the jewel.

The inclusions with several liquids may sometimes show various fillings as shown in fig. 38. The cavity is oblong, widens in the upper end and runs into a point on the lower extremity. The cavity is filled with a liquid which at about the centre shows two solid substances next to two large gasbubbles which snuggle on to the two small crystals. The upper crystal is calkspar, the lower probably NaCL.

In the lower part of the cavity the second liquid is imbedded in the first liquid (filling the whole cavity) in the shape of an oblong drop. In the second liquid, which is not mixable with the first liquid, there is suspended the drop of a third liquid, which is likewise not mixable with the second. This inclusion therefore shows the interesting case of t h r e e n o n m i x a b l e l i q u i d s alongside with crystalline inclusions.

Inclusions of a solidified liquid glass are very rare in jewels. They sometimes occur in Feldspar or Olivin. This glass inclusion has sometimes the shape of a negative crystal also showing one or more gasbubbles which here however are completely unmovable and cannot be made to disappear by heating.

The liquid inclusions may contain liquids which have been absorbed primarily during the crystallization of the stone. On the other hand there are cases where infiltration into cavities through cracks and crevisses has taken place. Specially interesting is the case where liquids have filtered in through cracks. The liquids proceed in dendritic treelike branched out shapes and in proper positions can be recognized as small liquidfilled veins in the otherwise partly airfilled crack. In other positions such "s e c o n d a r y i n c l u s i o n s" may appear totally nontransparent and as skeleton shaped crystallizations of a nontransparent substance, similar to the formations depicted in table XXVI. By revolving the object one can however detect the true character of the inclusion, whereas the skeletons in a synthetic ruby remain nontransparent in all positions. Liquid veins appear transparent in some positions.

Fig. 35.

Fig. 36.

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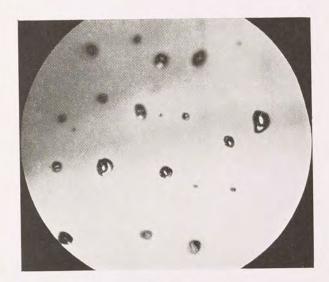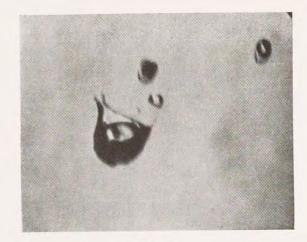
Fig. 37.
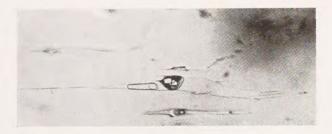
Fig. 38.

Crystalline oriented inclusions as well as regular zonar arrangement of the lighter and darker layers which are at crystallographic angles between each other, also all liquid inclusions are absolute characteristics of genuine jewels.

INCLUSIONS IN SYNTHETIC ARTIFICIAL JEWELS.

Synthetic jewels have appeared upon the market during the past 25 years. In the 70th of last century the so-called Fremy Rubies appeared, which however owing to their small tabletlike shape were unuseable neither for jewel purposes nor in the watch making. These first so called "rubis scientifiques" were the first synthetic rubies made and have entirely disappeared from the market at present. The "Rubis de Genève" were other artificial rubies fabbricated in the last decennaries of the past century from the remnants in the grinding of genuine rubies by fusing them together.

These stones were the only ones rightfully called "reconstituées", reconstructed rubies, an expression which does not fit the artificial rubies and jewels of today.

The artificial jewels on the market today are produced by the process invented by A. Verneuil. This process consists principally in the following: A small rod of burned clay is heated by an oxyhydrogen gasblowpipe whose stream is directed upon the clay post, while a fine powder of the exact chemical composition of the jewel to be produced is blown upon the heated rod. The melted powder is deposited upon the rod and while the rod is rotated it grows in the course of a few hours into a pear-shaped formation, setting with a thin stem upon the clayrod, the diameter increasing upwards. This formation is a regular crystal though it may not show it in its outer form. While the outside shape is round the inner composition is the regular construction of a crystal following the crystallographic rules of the material.

The apparatus furnishing artificial Corundums is schematically illustrated in fig. 39. The aluminum oxyde powder is deposited in the box P, which has a perforated bottom. The box is vibrated through an electrical hammer which causes the powder to drop from the box. Above the box, oxygen is inducted at O, the tube, pointed on the bottom in which oxygen and powder are moved to the point, is surrounded by a second tuce which is furnished with hydrogen at H. At a point of the inner tube were oxygen and hy-
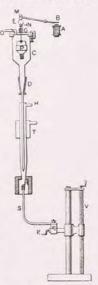
Fig. 39.

drogen come together, the very hot blowpipe flame is generated. The descending powder is melted in the heat of the blowpipe flame and deposited upon the clayrod R, which by a regulating arrangement K and V may be lifted, descended and moved sideways according to wish.

According to the colouring additions to the aluminum oxyde powder the generated pearshaped formation is a ruby crystal or a sapphire crystal or any other desired stone. The substance however cannot deny having been created in an oven within a short space of time. The molten pear absorbs gasbubbles, the mass is not completely uniform owing to the uneven access of the powdered substance. It is of course endeavoured to receive a very intimate mixture of the powdered materials especially with the colouring substances. Small variations however are unavoidable so that augmentation layers and differences in the colouring of the substance are discernable.

Fig. 40 shows the melted peardrop setting upon the clayrod,

Fig. 40.

Fig. 41.

fig. 41 a drop taken from the rod. Unavoidably the melted drops are brittle and inclined to show cracks and crevisses because they have to be cooled off rather rapidly.

Fig. 42.

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The colouring addition for the ruby had been found very quickly. One receives a beautiful colour by the addition of up to $2\frac{1}{2}\%$ chromeoxyde. Iron salts must be carefully avoided as they turn the colour to brown.

Fig. 42 shows the augmentation striping in artificial corundums. The layers are weakly or stronger curved, never completely straight. This curvature is a distinct sign of the stone being artificial and it can always be found, provided the stone is revolved under the microscope. Fig. 42 also shows coarse gasbubbles.

Rubies grow these stripes very narrow, blue sapphires further apart. Green sapphires have mostly narrow stripings. In the ruby these stripings rarely take the washed out appearance as shown in fig. 43.
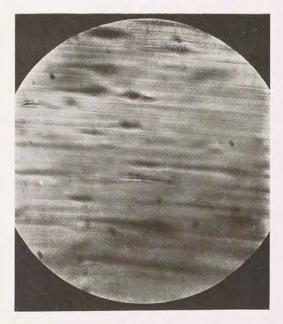
Fig. 43.

If one does not find the augmentation stripes in one position one has to turn the stone with a tweezer and place the stone on an other facet. Fig. 43a shows a glass vessel which permits of fastening the stone in the liquid so that it may be turned under observation.

One must not be discouraged if the augmen—

IMMERSIONS NAPF nach RIEDL u. HERZ
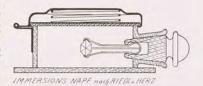
Fig. 43a.

tation lines are not immediately distinctly visible and a closing of the Iris Diaphragm in the microscope will sometimes make them spring into appearance suddenly.

Fig. 44 shows fine gasbubbles.

Fig. 44.

The modern products excel by very fine minute bubbles. It is impossible to confound these bubbles with liquid inclusions of which fig. 45 gives a counter example. This bubble is filled with liquid carbonic acid surrounded by a border of carbonic acid gas and filled with water in the pointed ends (conditions in a quartz).

Further examples are shown in tables XXIV, XXV, XXVI, XXVII: Special attention is called to the characteristic cracks which appear in series. Similar cracks may also appear in genuine stones through faulty grinding but they always constitute a grave momentum of suspicion if they appear in heaps. It is always necessary to examine such a stone most carefully.

Fig. 45.

It was considerably more difficult to produce the blue variety, the sapphire, artificially.

The usually efficacious cobaltsalts did not produce results. Only after adding to the mixture magnesia or lime salts one received a crystalline blue product which however was not a corundum but a

spinell. These blue spinells which with red spinells were produced on a large scale have been completely supplanted by the artificial sapphires which Verneuil produced in 1910. He used as a colouring agent $1^1/_2 \%$ iron oxydul oxyde and $^1/_2 \%$ titanic acid and received thereby a beautiful blue colour completely alike to the blue colour of the natural sapphire.

Since then one has also learned to produce alongside of the red and blue corundums all possible varieties and colourings. Colourless stones, pink, violet, orangered, green stones, are the most popular. Especially also an alexandritelike variety appearing green in natural light and winered in artificial light is very popular. All these peculiarly coloured varieties of the corundum are called synthetic or artificial sapphires with an adjective defining their colour.

Alongside of the corundum one can also produce spinells in manifold colours of which especially the pale blue, the aquamarine coloured stones, spinells in the colour of blue zircons or darkgreen spinells with a quality to change to red in artificial light, are mentioned. The melted drops of the spinell show frequently clearly expressed crystal

Fig. 46.

surfaces as shown in fig. 46. Cube or octahedron faces are often seen on the drops.

The Synthetic Spinells have often a composition not exactly conforming to the intended formula. They mostly show an excess in aluminate; they very often show the anomale double refraction by tension especially under crossed Nicols. (See fig. 20).

The tension double refraction is characteristic of the Synthetic Spinells.

The pleochroism and colour change of many varieties of synthetic corundums are printed on page 54 and 55 of part II of this book.

INCLUSIONS IN GLASSES.

It has often occurred that during the attempt to produce synthetic jewels, fused masses have been obtained which though showing the exact desired chemical composition, do not show the inner crystallo—graphic and other physical qualities of the jewels and which substances therefore have to be classed as glasses.

Even already the old Romans knew recipes for coloured glasses with some similarity to coloured jewels. The middle ages produced lead glasses with great success as substitutes for the diamond. All the glasses have always one quality by which they can easily be distinguished from the jewels, that is their l o w h a r d n e s s.

By adding Thallium to the colourless glassmass one receives a glass which has a strong colour dispersing quality; but all endeavours to increase the hardness of the glass have remained futile. Only blue and green glasses have been produced in the max. hardness of 6¹/₂.

One has also tried to produce inclusions artificially in the glass which would make the glass look similar to the jewel. These artifices however do not stand up under microscopic examination.

Fig. 46a shows a vane of gasbubbles in a green glass and as counter examples in fig. 47 and 48 genuine liquid inclusions in sapphires; the first glance will immediately show the difference bet—ween these figures.

Fig. 46 a.

Fig. 47.

Fig. 48.

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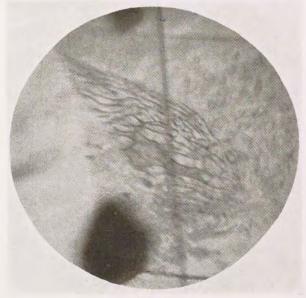
Fig. 49.

Fig. 49 shows gasbubbles in a green glass, which had been stretched in a half molten state, thereby also stretching the otherwise round gasbubbles.

Fig. 50 shows a cavity in a topaz partly filled with liquid and with gas, clearly demonstrating the difference agai st fig. 49 in the border—line and the filling. These inclusions in the topaz also appear crystallo—graphically oriented The streaks typical for glasses are shown in the upper illustration on table XXVIII.

INCLUSIONS IN DOUBLETTES.

Already the Romans knew how to falsify jewels by making doublettes or "mixtes". In order to increase the weight of the stone which considerably increases its value, one sometimes combines two parts of genuine materials as diamonds or emeralds, so that two surfaces are per-fectly fitted and glued together. Doublettes in which all genuine materials are used are called genuine doublettes, others in which only the upper part is genuine material, which is combined with colouring matter or glass are called half genuine doublettes.

Both processes are usually resorted to, not only to in-crease the weight but also to improve the colouring of a genuine piece of material.

Pale emeralds or aquamarines or sometimes even quartz are used for the process in which a thin green tablet

is inserted between two parts; a pale genuine upper part is often combined with a highly coloured lower part of glass. The common red garnet is very often used for the manufacture of doublettes in which the colour of the lower part, blue or green, usually completely overbalances the red colour of the garnet, whereby a very good mixed colour is achieved, which may cause the inexperienced to confound this doublette with the precious sapphire of Cashmir.

In rarer cases the upper part of a thin genuine stone is combined with a cupped out lower part of glass filled with a coloured liquid.

In most cases doublettes are glued together but it also happens that the genuine garnet is embedded in hot melted glass of which it cannot be separated so easily. The regular gluedtogether doublette can be separated by immersion in hot water or alcohol, a procedure which does not give results in the case of melted in doublettes.

No doublette is so well made that it cannot be detected under microscopic examination. Especially impurities

Fig. 50.

on the dividing surface and the different character of inclusions in the genuine and glass part, give definite clues to the character of the doublette. In many cases the immersion of the doublette shows a distinct difference of the two composite parts in their colouring.
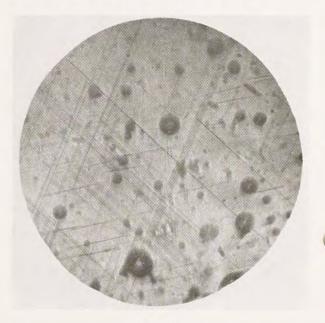
Fig. 51.

Microscopic examination shows impurities on the dividing surface as well as the unavoidable gasbubbles on the same. Plate XXVIII shows on the lower picture the upper part of a garnet doublette in the nearest proximity of the dividing surface.

Fig. 51 shows a half genuine doublette under the microscope.

THE ARTIFICIAL COLOURING OF GENUINE JEWELS.

A wide group of jewels is changed in its colouring by artificial means.

Agates or Opals are often saturated with colours because these materials absorb colouring matters easily.

Common Jasper can be transformed into German Lapis by depositing Prussian blue in the same. This product is not genuinely coloured and is also called "Neunkirchner Lapis".

Other stones cannot be coloured by depositing colouring matters but they are influenced by certain kinds of rays or by changes in temperature.

Some Blue Sapphires are coloured yellow under radium rays. Pink Kunzite becomes light green. Both colourings however disappear again under the influence of ultra-violet rays which are also contained in the sunrays.

Light Brown Zircon becomes colourless through heating but it is thereby also considerably enhanced in its gloss and then called "Matura Diamond" in the trade.

The usual Red Brown Zircon receives a beautiful blue colour through heating.

Gold Brown Topaz becomes rose pink when heated. There are of course a lot of other colorations to be achieved through rays or temperature. However the sometimes talked about wonderful improvements in jewels by radium or Xrays are considerably exaggerated.

5. THE EXAMINATION OF JEWELS WITH THE DETECTOSCOPE ON THE BASIS OF THE ABSORPTION OF LIGHT.

It is difficult to exactly describe the colour of jewels. The trade knows several colour scales, the old one by Radde and the scale by W. Ostwald. Still it will be difficult to classify the colour of a transparent jewel, same being influenced by the gloss of the stone, the polishing, the ground surfaces, the light dispersion and the changing absorption of the light in the jewel, as well as the influence of the inclusions.

One has therefore tried to designate the colour changes in jewels spectroscopically. Each Pocket Spectroscope embodies a scale which gives the wavelength pertaining to the colours of the spectral ribbon. By looking at the sky with such a pocket spectroscope one can see the coloured ribbons and therein the figures of the scale. In the coloured ribbon there also appear faint dark lines which however are not strong enough to divide the ribbon.

By holding a coloured jewel in front of the narrow opening of the spectroscope one can see that this stone either weakens or brings to disappearance certain portions of the spectrum. By noting these places in which a weakening or disappearance of the light has occurred one receives an exact specification of the colour of the stone by the use of its spectrum. One will find by comparing in this way stones of apparently the same colour that they have not the same spectrum, they are not spectroscopically equal.

However the spectroscopical examination of jewels is still rather complicated so that same has not found favour in the eyes of the practical jeweler. The writer in collaboration with G. Riedl has replaced the spectroscopic examination of jewels by their examination over colour filters.

In principle this makes use of the fact that jewels appearing in the same colour may still have considerable differences in their spectrum.

For instance the red portion of the spectrum of an emerald appears in a different position than the red portion of the spectrum of all green glasses. If one now uses the colour filter so that the red portion of the spectrum of an emerald still passes through, whereas the red portion of the spectrum of green glasses is annihilated, it necessarily follows that emerald and green glass must appear in different colours when looked upon via these filters.

The same occurs, when the filter is placed upon a source of light and stone or glasses regarded above the filter. The filter permits only that part of the red spectrum portion to pass through, which appears in the emerald, but does not permit that part of the red to pass through which appears in the spectrum of the glasses. The effect is that the red in the glasses is totally suppressed. The emerald appears bright red, the green glasses dark blue.

By examining the spectrum of the green jewels usually found on the market one can detect characteristic differences, which permit the construction of filters over which the particular green jewels show characteristic colours. One filter does not suffice, because over one filter several green stones appear in the same colour, however the examination over different filters shows such differences, that with these filters all green stones may be classified according to their variety.

These filters are so chosen, that especially the emerald immediately stands out prominently and can at once be detected. Falsifications of the emerald are today more frequent than ever before owing to the high price of the good stones and sure means of recognizing the genuine stone are important.

THE DETECTOSCOPE.

Fig. 52 shows the combination of two filter disks with a source of light in a handy apparatus. The filter—

Fig. 52. THE DETECTOSCOPE. TABLE TYPE.
PATENTED.

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disk A contains five filters. The disk B three filters. These disks may be inserted into the apparatus at will. A magnifying lens H and a Dichroscope D are also provided as well as a stoneholder T.

The Detectoscope consists of a cast table plate supported by a substantial casting. The table holds in its centre a circular glass plate. The lamp is situated below the table and the filter disks A or B slid in between lamp and table from underneath. The disks are revolvable around the centre and permit the consecutive insertion of the filters between the light and the Detectoscope table.

The magnifying lens as well as the Dichroscope may be inserted into a special holder and used for the examination of the object which is either placed upon the glass disk or fastened with beeswax upon the objectholder T.

The instrument also is made in a pocket edition as illustrated in fig. 54 which is operated by dry cells.

Green stones are all examined over filterdisk A.

Fig. 53. THE DETECTOSCOPE. POCKET TYPE.

Page 19 in part II of this book with table VIII and reading matter thereto explains the observations to be made with the Detectoscope. As stated before, filterdisk A is mainly used for the detection of the emerald from among any amount of other green stones, the manifold substitutions of the emerald being the greatest danger to the jeweler.

The examination for pleochroism, inclusions etc. in green stones may also be done as explained in the next chapter for the other co—loured stones.

Red, blue, yellow and brown jewels do not show so far reaching differences in their spectroscopical behaviour that a distinction between the different varieties could be achieved with the aid of the colour filters. Disk B for

these stones therefore only contains a luminescence filter, a daylight filter and a ground glass.

The examinations for inclusions and pleochroism are made over the groundglass.

Red stones are examined over the luminescence filter.

Rubies with the exception of very dark brown red Siam rubies show distinct luminescence over the green filter, that is they appear to glow and to send out red light though they only have the temperature of the room.

The light Spinells show luminescence whereas the Dark Spinells or Garnets, Zircons or Tourmalines show no luminescence. The different luminescence phenomena are cited in the table on page 21 in part II of this book and on pages 102—111 of this volume.

The following chapters deal with the examination of coloured stones with the magnifying lens and the Dichroscope.

Blue, yellow and brown stones can, as stated before, not be examined with colourfilters. They have to be examined with magnifying glass and Dichroscope.

The distinction between artificial jewels and genuine jewels must be made with the magnifying glass or with the microscope. Especially the inclusions make a complete identification of the stones possible as previously explained in the chapter concerning inclusions and illustrated on tables IX to XXVIII in part II of this book.

The Pleochroism as means of identification:

Coloured jewels with double refraction appear in different colours according to the direction in which the light passes through them. Coloured jewels with single refraction, or glasses show no difference, no matter in what direction they are penetrated by the light. The Dichroscope permits the comparison of these colours in two little squares side by side. It is thereby possible to detect even very slight differences in colouring. It is necessary to examine the stones in at least two positions which are not 180° apart. The phenomena observed in the examination with a Dichroscope are described in the previous pages of the first part and on the tables VI and VII and pages 15 to 19 of part II of this book. The characteristic pleochroitic colourshades for the separate varieties of jewels of the same colour are cited in Column 5 of the identification tables of part II.

The way to proceed with the examination of a stone is preferrably as follows:

1) Green stones are examined over the first colorfilters.

In order to discriminate for instance between the pleochroitic tourmaline and a nonpleochroitic glass the Dichroscope may be used to advantage.

2) Red stones are examined over the green luminescence filter. Thereby the rubies and many spinells are forming one group, the zircons, garnets, some spinells and glass the second group.

Discrimination between Ruby and Spinell is done with the Dichroscope as well as the separation of Zircon and Garnet and Coloured Glass.

The decision concerning Rubies and Spinells, whether they are genuine or artificial is done with the magnifying lens or the microscope. Glasses are detected by the absence of pleochroism, by gasbubbles and the characteristic streaks and folds.

3) All other coloured stones are analyzed by their Pleochroism and then divided in genuine and synthetic stones by examination with the magnifying lens or the microscope. Especially sapphires are produced today in all imaginable colour shadings.

7. LUMINESCENCE PHENOMENA IN JEWELS UNDER CATHODE RAYS, XRAYS AND ULTRAVIOLET RAYS.

Many jewels as well as pearls show the peculiarity to emit light under ordinary temperature under the influence of certain rays. One says they luminesce, and designates the light which they emit thereby as luminescence light. Ordinarily one distinguishes in the luminescence of substances according to the lenght of the gleaming between Phosphorescence in which the substance gleams longer than the physical cause of the same, and Fluorescence in which the gleaming is confined to the time of the physical influence. Phosphorescence and Fluorescence however merge frequently and in the following explanations the Phosphorescence is being designated as an afterglow.

Physical influences which are causing luminescence are f. i. certain lightrays and the so called ultraviolet rays, rays with a small wavelength following the still perceptible violet rays. Especially great effects are received with Cathode rays and I am describing hereafter a small apparatus which permits the examination of substances with Cathode rays.

The physicist Hittorf discovered that in an evacuated glass tube with two melted-in electrodes certain electrical discharge phenomena can be observed when the wires are connected to the secondary winding of an induction coil. The negative electrode, preferably equipped with a tin disk, emits certain rays which cause the opposite wall of the glasstube to glow. The glass luminesces. This bundle of rays emitted from the negative electrode, the Cathode, is influenced by a magnet and the rays are called Cathode Rays.

Examinations have shown that this bundle of Cathode Rays consists of minute electrically charged particles called electrones which are propulsed from the cathode with a speed of between 60.000 and 100.000 kilometers per second.

If these Cathode Rays strike a solid body f. i. a third obliquely posed electrode, called the anticathode, they are causing electro magnetic oscillations by their impact.

(We are also imagining the light to consist of electro magnetic vibrations, but it has wavelengths which are approx. 10.000 times larger than these oscillations emitted from the Cathode.)

The physicist Conrad Röntgen first found these short waved oscillations emitted from the Anti Cathode and they are called after him Röntgen-Rays or Xrays. Cathode rays as well as Xrays are causing luminescence phenomena in many jewels.

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THE VACUUM RAYONNEUR.

A new compact apparatus for the examination of lu-
minescence phenomena of jewels in cathode and Xrays.

Usually the execution of these experiments was hinder-
ed by the large and very expensive apparatusses neces-
sary to generate Cathode and Xrays.

In the following lines I am describing in fig. 55 a
simple and inexpensive apparatus for the purpose. As
source of current a dry battery is used. A small induc-
tion coil is built into the left upper corner of the wooden
case and the tube in which Cathode and Xrays are gen-
erated is in a separated righthand upper corner of the
case. The tube is evacuated with a mercury airpump,
which is operated through the lifting and descending of
the level vessel marked Hg. The whole apparatus is
contained in a wooden box $8:15:19^{1}/_{2}$.

Fig. 55. VACUUM RAYONNEUR,

The schematic drawing Fig. 56 shows the functioning of the pump. All connections are made by glass upon glass. The Vacuum Rayonneur consists of the following parts:

1. the tube in which the articles are examined
2. the barometer (vacuum—meter)
3. an air dryer
4. the level—bottle filled with mercury
5. the mercury air pump.

When the levelbottle filled with mercury is lifted, the rising mercury surface closes valve 1, whereby tube, barometer and dryer are shut off. The centre part of the airpump is considerably widened and the air therein is expelled via valves 2 and 3 by further rising of the mercury. The level
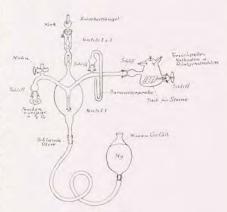
Fig. 56.

vessel is lifted so high that both valves 2 and 3 are finally under mercury, but should not be lifted higher than until the mercury reaches the upper cork in which the pipe leading to the safety globe is inserted.

When the levelbottle is descended the valves 2 and 3 shut off the centre part of the mercury pump and by descending the levelbottle further, a vacuum is created therein. Finally valve 1 is opened when the mercury sinks below this valve and the annexes of the airpump i. e. the tube, the barometer and the dryer emit their air into the evacuated centrepart of the pump.

Through several times lifting and descending the levelbottle, the air in the tube is more and more rarified and after 7 to 8 liftings such a vacuum is created, that by switching on the induction coil Cathode Rays or Xrays may be generated in the tube. The induction coil is switched on by a pushbutton on the right hand, outside the case. There are two possibilities for the connection of the tube to the wires coming from the induction coil, thereby either generating Cathode or Xrays.

The battery furnishing the current is set into the wooden box in the left lower corner. The insertion of the battery is done so that the shorter polend points upward the longer polend downward. This results in the forward pole being the negative and the rear pole the positive end of the tube.

Röntgen-Strahlen.   Kathoden-Strahlen.

Fig. 57.

By making connections according to fig. 57 left hand side, the cathode K 2 emits Cathode rays upon the anti cathode A K which in itself sends out Xrays which strike the table or the bottom of the tube. Cathode rays are obtained when the spiral spring is connected between A K and K L and the connections are made as shown on the right hand side of fig. 57.

One can therefore without having to evacuate again examine the same object under Xrays and under Cathode rays.

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PRACTICAL ADVICE FOR THE USE OF THE APPARATUS.

The first two liftings of the levelbottle should be done very slowly, rash or sudden movements are endangering the valves. The level bottle should only be lifted so far that the two upper valves 2 and 3 are totally submerged in mercury. This is the case when the level of the mercury is just below the cork of the safety globe. If mercury enters the safety globe however it can be emptied by lifting the rubber stopper. The second lifting of the levelbottle usually results in the barometer descending from 70 to 40, the third lifting usually brings it on to 30 and the seventh or eighth lifting usually brings both arms of the barometer to the same level. At the fifth lifting one can see a distinct light around the Cathode when switching on the current and a violet bunch of light rays its emitted from the surroundings of the cathode. The seventd lifting already gives different phenomena and the bottom of the tube begins to fluoresce green. The eighth or at the most the ninth lifting gives a good vacuum in which the luminescence phenomena are to be observed excellently.

It is an absolute necessity for the good functioning of the apparatus that all ground glass connections as well as the petcock are closing tightly, especially also the petcock above the dryer. If one does not get good results after the ninth lifting it is necessary to go over all the ground glass connections which in order to fit tightly must be carefully greased in.

The grease to be used is a mixture of beeswax and vaseline. Some-times air also comes in via the upper valves which results in the dripping of the mercury, when the levelbottle is descended. The cause of this may be a poor seat of the valve. Should it be impossible to get the valve to work properly, it is necessary to let the air into the apparatus and to lift the valves out. The upper valve is gripped with an iron wire twisted to a hook and the whole combination taken out. It is totally prohibited to use anything but iron wire, as copper would immediately amalgamate with the mercury.

If the lower valve 1 does not work properly a soft knocking on the bottom of the wooden case will usually release it.

The examination of the luminescence phenomena is done via a small door on the side of the apparatus. The vacuum descends when the apparatus is left standing for a long time but 1 or 2 liftings of the level vessel will restore the previous vacuum.

During the observation the level vessel is placed so high that the mercury level closes the lower valve.

After the observation the level vessel is descended so far that the lower valve 1 can be opened very carefully and slowly. If one notices a lifting of the mercury in the left tube of the barometer one usually waits another 30 seconds and then slowly only opens the petcock fully. The rising of the mercury in the barometer must occur very slowly. When the apparatus is filled with air the levelbottle can be replaced in the place provided for it in the lower right hand corner of the box.

If one desires to interrupt observations to be taken up later on, it is advisable to place the levelbottle so deep that the lower valve 1 remains open. Then all danger for the apparatus is eliminated Otherwise by placing the levelbottle into the wooden box an untight seat of the valve 1 might cause the mercury to mount into the dryer. It is there-fore always necessary to first ascertain the good seat of valve 1.

The ground in stopper of the observation tube holds a metal table upon which the parts to be examined are placed. It is of course also possible to place the articles to be examined upon the bottom of the tube. The objects to be examined must be carefully cleaned first with alcohol and afterwards with ether, but care must be taken that all the

alcohol and ether are completely evaporated, before the article is placed into the tube.

Special care is also necessary with articles having cracks and crevisses. Sometimes the wiping off of the articles with a dry cloth does best service.

The dryer is filled with Phosphor Pentoxyde, the surface of which is apt to become dry and must be loosened up every once in a while. If it has absorbed too much moisture it must be renewed.

The phenomena observed during the influence of Cathode and Xrays upon jewels in many cases permit an exact and quick decision as to the character and genuinety of the jewels. In most cases one will use Cathode rays in preference to the Xrays.

REMARKS FOR THE PRACTICAL USE OF THE VACUUM RAYONNEUR.

The case is most practically to be set upon a table.

Open the case by unlocking and removing the door.

Fill level vessel with chemically pure mercury, approx 3,5 kilos = 7 lbs.

Set level vessel so deep that mercury disappears.

Open petcock carefully, first a trifle to admit air into the apparatus. This is to be done as a precaution when the apparatus is used for the first time, but it should always be done before using, as a sudden rush of air into the formerly established vacuum would damage the apparatus.

Take out Cathode tube, remove ground-in glass stopper L and put material to be examined on table T.

The material must be carefully cleaned and dried. The cleaning is best done with Benzol and some absorbant cotton, but the material must be perfectly dry under all circumstances.

Replace plug L with table into the cathode tube.

Connect wires on A and K for Cathode rays.

Combine A and X together to one wire and K to the other wire for Xrays.

Then close petcock D.

Begin to pump by lifting level vessel up slowly.

A vacuum is usually established after 8 to 9 liftings.

The manifold phenomena observable with this apparatus and their employment for the identification of jewels are shown on pages 65 to 68 of part II as well as on the following pages.

A. COLOURLESS STONES.

Name	Luminescence under:	
	Cathode Rays	X Rays
Diamond	sky blue or yellow green	same as under cathode rays but weaker
Sapphire natural . . .	red violet	same as under cathode rays but weaker
Sapphire synthetic . .	more violet red	same as under cathode rays but weaker
Topaz	weak blue to yellow	yellowish to very faint
Zircon	in low vacuum yellowish in high vacuum white	same as under cathode rays but weaker
Beryllium	very weak reddish	no luminescence
Tourmaline	very weak reddish	very weak luminescence
Rock Crystal	very weak blueish	no luminescence

B. RED STONES.

Name	Colour	Luminescence under:	
		Cathode Rays	X Rays
Ruby natural	in all shades of red except red violet	vivacious red, responds easily; afterglow	vivacious red responds easily, short afterglow
Ruby synthetic . . .	all shades of red	vivacious red responds easily; strong afterglow	vivacious red responds easily, strong afterglow
Spinell	pure red, same as Birma Ruby	red, responds weakly	same as under cathode rays
Spinell	brown red, Garnet colour	no luminescence	no luminescence
Kunzite	pink	strongly orange yellow, strong afterglow	same as under cathode rays but weaker

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RED STONES CONTINUED.

Name	Colour	Luminescence under:	
		Cathode Rays	X Rays
Almandine	pink	no luminescence	no luminescence
Topaz	pink	no luminescence	no luminescence
Zircon	dark red	in low vacuum yellowish, in high vacuum blue	appears opaque frequent deviations
Zircon	light red	appears opaque, sometimes with coloured spots, divia- tions are frequent	opaque frequent deviations
Beryllium	pink	new red, distinct diffe- rence between this stone and the Ruby of equal colour; afterglow	new red, weak
Tourmaline	red	no luminescence	no luminescence
Rose Quartz	pink	blue; afterglow	—

C. YELLOW STONES
(also brown yellow stones).

Name	Colour	Luminescence under:	
		Cathode Rays	X Rays
Sapphire natural from Ceylon	light yellow	salmon red	weak red yellow
Sapphire natural from Australia	gold yellow	dark red	weak red
Sapphire synthetic . . .	light yellow	blue red	violet
Sapphire synthetic . . .	Padparadschah, red orange	red violet	violet
Chrysoberyll	delicate yellow-green	dirty yellow-green	no luminescence
Chrysoberyll	honey yellow	no luminescence	no luminescence

YELLOW STONES CONTINUED.

| Name | Colour | Luminescence under: | |
		Cathode Rays	X Rays
Gold Beryll	light yellow	dark yellow	no luminescence
Gold Beryll	gold yellow, dark	brown red	no luminescence
Heliodor from South West Africa	greenish yellow	blue violet, intense pink to reddish yellow	no luminescence
Heliodor from Madagascar	greenish yellow	no luminescence	no luminescence
Heliodor from Brasil . .	greenish yellow	no luminescence	no luminescence
Topaz	lighter and darker yellow	blue luminescence	hardly any response
Olivine	yellow greenish	no luminescence	no luminescence
Tourmaline.	light yellow to dark yellow	no luminescence	no luminescence
Zircon	yellowish green to honey yellow	blue to white or yellow	same but weaker than under cathode rays

D. GREEN STONES.

| Name | Colour | Luminescence under: | |
		Cathode Rays	X Rays
Corundum natural	dark green	no luminescence	no luminescence
Corundum synthetic . . .	green	dark orange; no afterglow	no luminescence
Corundum, synthetic Alexandrite	grey-green to winered	sombre red to orange yellow, sometimes pink; no afterglow	no luminescence
Alexandrite natural .	delicate green sometimes dirty green a/c inclusions	red	no luminescence
Demantoid	light green	no luminescence	no luminescence

GREEN STONES CONTINUED.

Name	Colour	Luminescence under:	
		Cathode Rays	X Rays
Hiddenite	green	brown orange	no luminescence
Spinell	green	dark green	no luminescence
Emerald	green	dark red	in high vacuum faint red
Tourmaline	green	no luminescence	no luminescence
Chrysolith	yellow green	no luminescence	no luminescence
Zircon	light green	weak blue	very weakly green
Zircon	brown green	no luminescence	no luminescence
Green Glass	green	yellow green	no luminescence
		(behaviour changes according to composition)	

E. BLUE STONES.

Name	Colour	Luminescence under:	
		Cathode Rays	X Rays
Sapphire synthetic . . .	dark or lightblue	light blue with violet tints sometimes light reddish	opaque, appears like enamel dirty blue or dirty red
Sapphire genuine from Montana	light blue	wine red	no luminescence
Sapphire natural from Australia	green blue	very weak blue or none	no luminescence
Sapphire natural from Birma	dark blue	dark winered or green-blue	no luminescence

BLUE STONES CONTINUED.

Name	Colour	Luminescence under:	
		Cathode Rays	X Rays
Sapphire natural from Ceylon	light blue	vivacious red	red; very weak
Spinell synthetic . . .	dark blue	new red	red violet; weak
Spinell natural	dark blue	dark green	no luminescence
Topaz	light blue	light blue; strong after-glow	weak blue
Zircon	blue	in high vacuum light blue, in low vacuum yellowish blue; very intense; strong afterglow	—
Aquamarine	delicate blue green	no luminescence	no luminescence
Tourmaline	blue green and light blue	no luminescence	ro luminescence

F. VIOLET STONES.

| Name | Colour | Luminescence under: | |
		Cathode Rays	X Rays
Sapphire	red violet	weak response weaker than Birmaruby	weak red
Kunzite	delicate violet	very strong orange yellow; strong afterglow	same as under cathode rays but weaker
Almandine	red violet	no luminescence	no luminescence
Spinell	red violet	no luminescence	no luminescence
Spinell	amethyst colour	faint light green	no luminescence
Amethyst	light or dark	yellow to brownish	ochre yellow

The phenomena cited in the tables may sometimes be changed through uncommon admixtures in the specimens to such an extent that they appear extraordinary. For instance Heliodor from South West Africa luminesces very strongly whereas Heliodor from Brasil and Madagascar does not show luminescence at all. This luminescence is brought about by contents of Uranium which also in certain cases of the Topaz produces strong luminescence phenomena.

In general it is to be stated that the luminescence alone must not be the basis of a definite decision in doubtful cases. Exceptions are cases like the Kunzite which have such a characteristic unique luminescence that it can be recognized by these means alone.

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THE HARDNESS OF JEWELS.

If one speaks of the hardness of jewels one usually thinks of the hardness when scratching. These observations were deposited in several characteristic steps in the well known scale of Mohs.

Mohs's scale consists of ten minerals arranged in the order of increasing hardness, as follows:

1.	Talc	6.	Feldspar
2.	Gypsum	7.	Quartz
3.	Calcite	8.	Topaz
4.	Fluorite	9.	Corundum
5.	Apatite	10.	Diamond

It would be false to imagine that the differences between the several steps of the Mohs scale are equal. In the contrary, the differences between the several grades of the Mohs scale show great variety as shown in the lower table.

The determination of the scratching hardness with comparing minerals is a very raw examination indeed, which only in very few cases aspires to a satisfying exactness. One mostly employs thereto plates of minerals of the Mohs scale and also chips of these minerals which are held in pencillike holders. One tries to carve the plates with the stone to be examined and vice versa tries to carve the stone with the chips. In most cases it is necessary to beware from too strong exertions because the jewels to be axamined may easily be damaged. This, and because the results of the examination not always permit of establishing the correct degree of hardness the whole procedure has no great importance in ascertaining the hardness of jewels.

If for instance the surface of the stone to be examined is not sufficiently even, it is possible to detach particles of the harder body by means of the softer body and the result received is wrong. Similar difficulties occur when the surfaces are polished.

The scratching hardness is furthermore different on different crystal surfaces or even on one and the same crystal surface according to the direction in which the examination is carried on. In certain minerals the hardness even appears to be different when they are carved in the same direction but in a different sense.

These differences in the hardness are in very close conjunction with the inner built of the crystals and also show a certain connection with the cleavage of the minerals.

The figures of the Mohs scale therefore only give average values and they also have the fault that the scalings off of the hardness between the single members of the scale are extraordinarily different as can be ascertained by other methods.

By various grinding experiments to ascertain the relative hardness of the members of the Mohs scale the following differences have been found:

Mineral	Mohs Scale	Resistence ascertained by grinding after Holmquist	Resistence ascertained by grinding after Rosival
Corundum	9	5260	10873
Topaz	8	813, 633	1570, 926
Quartz	7	1000, 900, 840	1000, 852, 819
Adular	6	316, 478, 493	192, 234, 373

Where there are several numbers cited they correspond to the hardness on various surfaces. The hardness of the diamond results as about 90 times as large as that of the Corundum. If one designates the hardness of the Corundum with 1000 the hardness for the diamond should be 90.000.

One sees from these numbers that actually the distances between the single members of the scale are extraordinarily different and that even the differences in hardness of the various surfaces are considerable. The examination of the mineral with chips or plates of the proving minerals are therefore a very raw method which is also sometimes dangerous for the stone whose hardness is to be proven.

This method therefore is to be employed only when all other examining methods fail.

Important and conclusive is mostly only the axamination with a good hardened steel point or a steel file to which one ascribes the hardness 7. This surely is a means of immediately detecting glasses whereas only a small number of jewels show a hardness below 7.

———

THE LOCATING OF THE TRUE POSITION OF A FLAW IN A GEM.

By Professor Paul F. Kerr, Columbia University,
New York.

When a beam of light on passing through air strikes the facet of a diamond exactly at right angles, it continues to travel in the same direction through the stone but suffers a loss of velocity. The ratio between the velocity of light in air and the velocity in the gem can be expressed by a constant called the index of refraction. The value of the index of refraction in the case of the diamond is approximately 2.4 referred to the index of refraction of air as equal to 1.

The relation which exists is reciprocal, that is, the greater the index of refraction, the less the velocity. The index of refraction may be determined indirectly, by the measurement of the apparent displacement of an image within a gem.

A flaw provides just such an image, and the distance of apparent displacement may be used in calculating the index of refraction. If the true distance from a given facet is known and the apparent distance measured, the first value divided by the latter equals the index of refraction.

It is conversely true that when the index of refraction is known, the apparent displacement may be used to calculate the true position of a flaw.

The principle is illustrated in figure 58, which represents a cross section of a brilliant cut diamond. An imperfection is located at the point T near the culet of the stone. If observed, hovewer, through the table facet along the line of O, the point T is not seen in its true position, but to the eye appears at A.

FIG. 58.
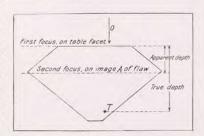
Diagram illustrating the relation between the true position of a flaw (T) and the apparent position (A) observed in the direction indicated by the arrow (O).

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If the distance of the apparent image from the table facet is A, and the true distance of the flaw from the same facet is T, then the index of refraction n is related to T and A according to the equation:

$$n = T/A \text{ or } T = nA$$

Thus, if the value of n is known, the problem of locating the true position of a flaw resolves itself simply into the measurement of the distance A.

The distance A may be determined in a number of ways: the simplest, however, and probably the most practical, in view of the accuracy attained, employs the microscope as a measuring instrument for vertical distances.

The method is as follows: first, the gem is placed in a proper position with the facet under observation at right angles to the axis of the microscope; second, the perpendicular distance is then measured from the facet to the image of the flaw. The latter is accomplished by lowering the microscopic objective and reading the distances recorded on the dials by the adjustment screws (Fig. 59). This is accomplished by bringing the microscope to a focus, first on the top of the facet, and taking a reading; then focusing on the image and reading the dial again. The difference between the two readings gives the apparent depth of the flaw. This distance multiplied by the index of refraction equals the true depth of the flaw.

For example let, us suppose that in a flawed diamond the distance from the facet to a flaw is 1.2 millimeters. Since the index of refraction of the diamond is 2.4, the true distance of the flaw from the facet would be 1.2 x 2.4, or 2.88 millimeters.

The diagram Fig. 59 previously referred to, shows a gem stone mouted on the stage of a microscope on the under side of a glass slide. The stone may be measured on top of the slide just as easily, but the table
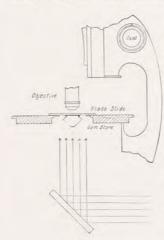
Fig. 59

A cross section of a microscope stage showing a gem stone in position for locating a flaw. Vertical distances are measured by raising and lowering the objective, meanwhile reading the adjustment dials.

provides a much better facet for mounting than the culet. The stone, therefore, is mounted with the table upward attached to the lower side of the slide. The stone is observed through the glass of the slide, but the sides of the latter need cause no confusion if the observer is careful to focus the microscope on the table facet of the gem and not on the glass. A small ink mark on the table is of assistance in locating the surface of the facet in the microscopic field.

SUMMARY

The true position of a flaw in a gem with reference to a given facet may be accurately determined. This is accomplished by measuring the apparent depth of the flaw along a line at right angles to the facet and multiplying the figure thus obtained by the index of refraction of the gem in question. The apparent distance may be conveniently measured with a microscope and the resulting measurement substituted in the equation:

$$n = T/A$$

where,

$n =$ Index of refraction
$T =$ True depth of flaw
$A =$ Apparent depth of flaw

———

Appendix

THE GEMOSCOPE
Patents in all countries of the world
A UNIVERSAL APPARATUS FOR THE EXAMINATION OF
PEARLS
and
PRECIOUS STONES

Fig. 60.

The Gemoscope is the only apparatus in the world permitting the examination of all Jewels, Pearls as well as Precious stones.

This new apparatus constitutes without doubt the greatest advancement in this art and enables through its completenes and its reduced price every jeweler to examine the material which he purchases and sells.

There is no determination concerning pearls and very few concerning precious stones which the jeweler cannot make with the Gemoscope.

The Gemoscope is exquisitely built and consists of a baseplate of bronze with two cups for the jewels to be examined.

The optical part consists of a magnificent microscope and an exquisite condensor, the latter built in under the microscope table. The condensor collects all the lightrays comig from the mirror, also underneath the table, and throws them through the opening in the table of the apparatus. The light is generated in an incandescent lamp of 40 Watt, which may be connected to the next lampsocket. Two lens–systems are provided, one for the examination of precious stones, the other for the pearls.

The table also carries a disk with a serie of colourfilters, all carefully prepared and permitting the examination of jewels under filtered coloured light, which creates phenomena permitting valuable discriminations.

A cardiometer sets on a table which is revolvable around the mainpost of the instrument and which can be swung in and out of the way. It is swung in when pearls are examined and swung out of the way when not in use.

The Gemoscope is so constructed that the microscope which forms part of the same can be entirely removed. The instrument is than adapted for the examination of jewels with the filters and with the Dichroscope, which is also furnished with the apparatus.

With the microscope removed, the instrument completely replaces the previously described Detectoscope.

The Gemoscope can be furnished with the microscope or without the same.

THE EXAMINATION OF PEARLS

with the

GEMOSCOPE

The Gemoscope is the only apparatus in the world which permits the quick and sure examination of all pearls wether drilled or undrilled.

Undrilled pearls are set upon a suitable opening of a diaphragm, which is fastened revolvably to the upper surface of the instrument table, and the collected lightrays are shot through the pearl. In nine cases out of ten, the cultured pearl is recognised by the telltale dark stripes in a certain position of the pearl to the direction of the lightrays.

Drilled pearls are explored through a mirror introduced into the drillchannel, and the internal structure of the pearl is carefully studied by the attentiv examination of the picture in the mirror, which presents itself in a greatly enlarged state via the microscope.

The cultured pearl is immediately recognized by the sharp divisionline between the mother of pearl insert and the outside pearlsubstance.

The examination of the genuine pearl is also very useful by the detection of internal cracks, discolourations and spurious manipulations of the previous owner.

THE EXAMINATION of PRECIOUS STONES

Fig. 61.

THE GEMOSCOPE COMPLETELY
REPLACES THE PREVIOUSLY DESCRIBED DETECTOSCOPE.

The examination as to wether a stone is natural or synthetic is done with the microscope of the Gemoscope, by looking at the jewel immersed in a highly refractive liquid, in translucent light.

The synthetic jewel is immediately recognized by the characteristic airbubbles in the same.

The natural jewel shows Gods own fingerprints in the liquid or crystalline inclusions in the same.

For the examination of jewels the light from the condensor is made to pass a series of coloured light filters inserted at will into the path of the light and converging upon a circular glass set into the apparatus table. The colours of the filters are as follows:

1 dirty yellow
2 red purple
3 blue tinted red
4 pale blue
5 green
6 clear glass

These filters are set into a revolvable disk and numbered 1—6.

The recognition of a genuine emerald from the multitude of very similar green jewels, which in common practice in the trade, pass as genuine emeralds, is done by means of the colourfilters of the Gemoscope. The characteristic colours of the genuine emerald in the coloured filtered light of the Gemoscope, permit an instantanous discrimination and an immediate classification of the jewel.

The study of the Pleochroism of jewels is done with the Dichroscope, which also forms part of the Gemoscope and is inserted in a holder of the same.

THERE IS NO COLOURED JEWEL THAT CANNOT IMMEDIATELY BE CLASSIFIED WITH THE GEMOSCOPE.

THE PRICE OF THIS INSTRUMENT IS LOW OWING TO MASSPRODUCTION.

—

THE

SELECTOR

A NEW PATENTED POCKETINSTRUMENT FOR
THE CLASSIFICATION

OF

PRECIOUS STONES

The SELECTOR is a new valuable addition to the equipment of the Jeweler. It is a small pocketinstrument which is indispensable to the Jeweler or gemdealer, as it serves him for the immediate discrimination between synthetic and genuine jewels, between the genuine emerald and its many substitutes, and also enables him to correctly classify any white or colored stone.

The Selector consists of:

        A Lens magnifying 12 times (L)
        A Dichroscopic lens (D)
        2 Colorfilters (F_1 & F_2)
        1 Groundglass (M)
and an Objectholder (G)

Magnifying glass and dichroscope fit alternately into a holder B. Three more holders are united with the first by a bolt around which they swing.

F_1 and F_2 are the colorfilters. A concave glass fits over the filters and holds down loose stones to be examined. The groundglass is held in holder M, which also permits the mounting of the objectholder G, which is so constructed that it will hold any jewel mounted or unmounted above the groundglass.

To discriminate between a genuine and a synthetic jewel, the object is clamped into the objectholder and examined through the magnifying glass slid into the holder B.

The whole apparatus is then held against the eye and turned towards a lighted window or an incandescent lamp. The characteristic inclusions of the genuine jewel are thus easily observed and a quick decision made.

The Emerald is immediately distinguished from among any amount of other green stones, glass or doublettes by examining same over the filters F_1 and F_2.

Over Filter 1: The genuine emerald appears dirty yellow
(dirty yellow)
The brazilian emerald with a reddish tint

Thicker paler stones appear delicately yellow green in center

Tourmalines, glasses and other imitations appear olivegreen

Green garnet, green zircon and all other green corundums appear reddish

Over Filter 2: The genuine emerald appears dark lilac
(red purple)
colored with a reddish tint

All Tourmalines, glasses and other imitations appear blue

Green garnet, green zircon and all green corundums appear red purple

A common pocket searchlight may to great advantage be used by holding the milkglass or colorfilter over the lighted bulb, whereby the examination is greatly facilitated.

The Dichroscope forming part of this equipment is used to determine wether a stone is singly or doubly refractive. Colored stones with double refraction show different colors when examined in different directions, a quality which is called Pleochroism.

This quality determined, it is easy to discriminate between a ruby and a red topaz or spinel, or between a sapphire and a blue zircon or blue spinel or topaz. These decisions are ordinarily not made by the jeweler and he is apt to buy or sell stones of lesser value instead of the genuine article.

In doubly refractive jewels the 2 squares of the Dichroscope show different colors. Here are a few of the colorphenomena:

RED STONES

Name	Pleochroism
Ruby	yellow red—bluish red
Spinel	none
Topaz	reddish blue—yellowred
Kunzite	lilac—pink
Tourmaline	pure red—yellow—red

BLUE STONES

Name	Pleochroism
Zircon	steelblue—fleshcolor
Sapphire	darkblue—lightblue
Spinel	none
Topaz	blue—yellow
Tourmaline	lightblue—darkblue

GREEN STONES

Name	Pleochroism
Emerald	bluegreen—yellowgreen
Hiddenite	blue—yellowgreen
Diamond	none
Alexandrite	raspberryred—orange—green
Sapphire	green—brownishgreen

The above list is only a small summary of the colorphenomena, a complete list of which can be found in Dr. Michels Pocketbook for Jewelers.
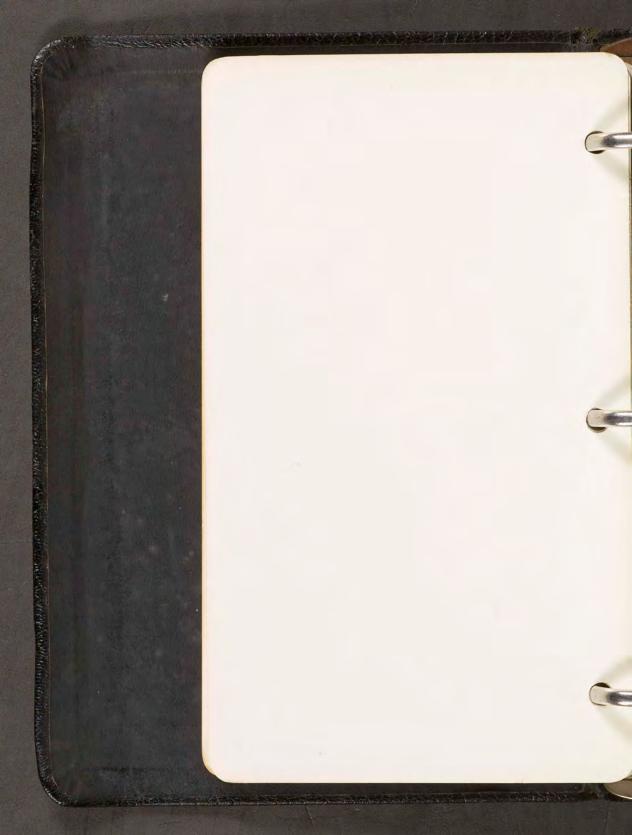
The SELECTOR is a small pocketinstrument and is of inestimable value to the jeweler. It comes in a small velvetlined wooden box and its price is low and within reach of every man in the trade.

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THE QUARTZ GLASS MERCURY VAPOR LAMP, FOR THE EXAMINATION OF JEWELS UNDER ULTRAVIOLET RAYS.

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Fig. 62.

Ultraviolet rays are causing luminescence phenomena in jewels similar to those caused by cathode or Xrays. The most practical apparatus for this purpose is the one made in Hanau. The source of light is a quartzglass mercury lamp which furnishes a light very rich in ultra-violet rays, rays whose wavelength is smaller than the shortest waved light.

A proper filter eliminates the visible portion of the rays almost totally so that an object placed under the lamp is almost entirely struck by waves whose length is between, 0,0004 and 0,0003.

The light is switched on by tilting the lamp body. The incandescent mercury vapors furnish then raybundles ex-

tremely rich in shortwaved rays. There are two types made, one for direct current and one for alternating current. The lamp may be directly connected to the next lamp socket.

It is advisable to use for the observation of the luminescence phenomena coloured filters in the colours red, yellow, green and blue under which the luminescence light appears in different colours more distinctly. The phenomena are classified in the table page 66 to 68 of part II of this book.

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For information concerning apparatus fig. 62 address: Gustave L. Herz, I. Burg-
ring No. 1, Vienna, Austria.

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FOREHEAD LENSES "POLYPHEM"

(CYCLOP)

Trade mark registered   Patents pending!

Fig. 63.

An excellent method for the Preliminary Examination of Pearls and Jewels is the one with Herz' Forehead-Lens "Polyphem". The ordinary magnifying glass which is usually pressed into the orbit cannot be made with greater magnifying than $4-6\times$, on account of its weight becoming too great to hold.

The inventor has succeeded in combining even lens-sets with an enlargement up to $18\times$ with an elastic head strap, so that the lenses can be brought into the best possible position in front of the eye. The lenses can be readily and quickly exchanged, even though the strap remains in its place.

BOTH THE OBSERVERS HANDS ARE FREE to hold and to turn the object into the best position for the observation.

The forehead band is adjustable to any size of forehead by pressing a button in or out of several holes. The strap is made of white opaque Gallalith and is once and for all adjusted to the head-size of the user. In large workshops or offices several forehead straps may be used in connection with one lens-set.

Any of the four lens-systems may be slid into the holder sleeve which is movable in two ball joints, so that

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Fig. 64.

any desired position may be taken before the eye, or the sleeve pushed upward when not in use.

The lens-systems are made of carefully selected rock-crystal, furnishing achromatic pictures free of coloured borders.

The lens-systems are selected to magnify $6\times$, $8\times$, $12\times$ or $18\times$ at the option of the user.

The forehead lens-set "Polyphem" (Cyclop) is furnished in a fine velvet lined case, holding strap and lenses dustproof and should not be missing from any jeweler's salesroom or workshop.

It is also used to great advantage by watchmakers, gold and silver smiths, engravers, draftsmen, etc.

The following combinations are furnished:

Polyphem with 4 lenssets: $6\times$, $8\times$, $12\times$ and $18\times$.
Polyphem with 3 lenssets: $6\times$, $8\times$, $12\times$.
Polyphem with 2 lenssets: $6\times$, $12\times$.
Polyphem with 1 lenssets: $8\times$.

You may have your own choice of enlargements.

Extra-straps to a set of more than one lens are also furnished.

Address all orders and inquiries to Gustave L. Herz, Vienna, I. Burgring 1, Austria.

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J.J. Peek
1342 Carlotta
Berkeley 3, Cal

THE BRILLANTOSCOPE
by Prof. Johnsen, University of Berlin, Inventor

Fig. 65.

The value of a stone depends almost entirely upon its brillancy and colourdispersement, which in turn depend to a great extent upon the correctness of the cut and the kind of cut applied to the jewel.

The jewel, be it a Diamond or any other kind of colourless or coloured gem will not divulge at a glance mistakes that have been made in the cutting. This instrument shows them greatly magnified.

THE CONSTRUCTION:

The Brillantoscope is an electrical apparatus which may be connected to the next lampsocket. It is very easily handled.

The Brillantoscope consists of a metalhousing on 4 legs, with two vertical extensions rising from the top of the housing and bearing on their upper ends globular cups of ground milkglass with a ground glass covering unto which the jewel is placed. Incandescent lamps in the interior send their lightrays through a system of achromatic lenses and prisms into the upper milkglass halfglobes and through them into the jewels which again reflect these rays to the surface of the glass—globes.

These appear more or less lightspotted and colored, according to the faculty of the jewel to disperse the light properly.

The illustration shows the effect of a ring set with a Diamond (left side) of 1 Carat as against the effect of a Sapphire of 4 Carat (right side) cut as a diamond. The difference is immediately apparent.

The apparatus measures approx: 12×17 and 22 in height.

Two or more Diamonds can be compared with each other, white Topas, Zircon, White Sapphire readily separated trom Diamonds and the Quality of Diamonds judged and classified as to their quality of light dispersion as well as the quality of their cutting.
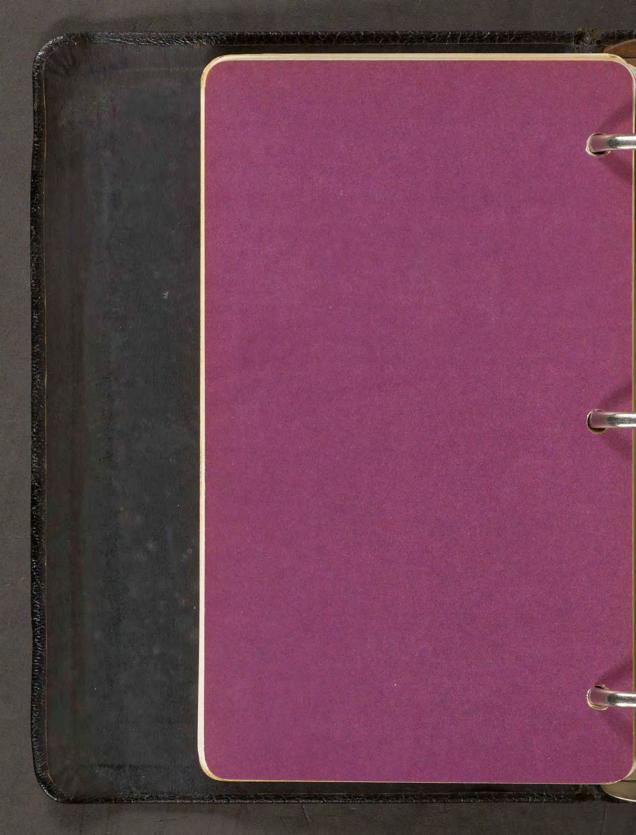
Another exceedingly valuable use of the Brillantoscope is the enhancement of the beauty of a jewel, be it a ring, bracelet, brooch or stickpin, TO A COSTUMER by placing it on the Brillantoscope. It is the best jewelery Salesman imaginable.

The Brillantoscope is furnished with complete instructions.

State Voltage used when ordering.

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Direct all orders and inquiries to:

GUSTAVE L. HERZ C. E.
VIENNA, I. Burgring 1

The

Pocket-Book

for

Jewelers

Lapidaries

Gem & Pearl

Dealers

BY

DR. HERMANN MICHEL

VIENNA

PART II

PLATES & TABLES

1928

Pearls

THE
EXAMINATION
of the
INTERNAL STRUCTURE
of
GENUINE
&
CULTURED

PEARLS
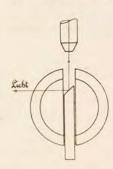
THE
EXAMINATION OF THE DRILLHOLE
OF FULLY DRILLED PEARLS BY
MEANS OF A MIRROR
(THE PERLOMETER)

GENERAL INTRODUCTION:

The mirror finished end of a thin metalneedle is introduced into the drillhole of the pearl and the image appearing in the mirror observed under the microscope while strong lightrays from the outside penetrate the pearlsubstance illuminating the interior. A very thorough examination of the interior and of the whole internal construction of the pearl is thereby possible.

The end of the needle is ground off under 45⁰ and highly polished to a perfect mirrorfinish. The image on the mirror appears as a brillantly illuminated ellipse. The lower part of the ellipse, the one nearer to the Observer corresponds with the upper part of the drillchannel in the following colorplates.

This holds good for all observations made with the Perlometer equipped with Binocular Tube and with Stereo. The Monocular tube shows the picture reversed.

The Microscope should be so adjusted that the whole image in the mirror appears perfectly sharp.

It is necessary to adjust the lenses of the Microscope to the image in the mirror and not to t e mirrorsurface itself as one is at first tempted to do. The image in the mirror appears just as far behind the mirror as the actual distance of the object in front of the mirror.

The picture shows lines going across. These lines correspond with the division lines of the more or less globular zones of the pearl substance of which the pearl is built up. These lines vary in curvature according to the shape of the drillhole, which is not always round, but sometimes poorly drilled and oval.

The position of the lamp exerts an influence upon the shape of these lines, which according to the direction of

the light rays may appear straight or slightly convex or concave. The images in the color plates show these lines in the same curvature throughout in order to avoid irritation.

As a rule it is necessary to examine both sides of the drilled channel, because neither genuine nor cultured pearls are built as exactly symmetrical globes but show many irregularities and the inserted ball of a cultured pearl may be located one–sidedly in the pearl substance secreted by the animal, even though the pearl may be entirely round on the outside.

Before beginning with the examination of the pearl it is advisable to clean the drillhole of the pearl by running a silk thread through the same, which has been soaked in Benzol on one end. The dry part of the thread is used to dry the dampness out of the drillhole by running the pearl over the dry portion of the silk thread. It may be necessary to remove dirt from the hole with a reamer before washing with Benzol

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PLATE I

WHAT THE ILLUSTRATIONS SHOW:

Fig. 1 Cultured Pearl with a thin covering of pearl substance.	**Fig. 2** Cultured Pearl with thicker covering of pearl substance, direction of light rays under 90 degrees to the layers of the mother—of—pearl insert.
Fig. 3 Cultured Pearl in a position where the light rays penetrate parallel to the layers of the mother—of—pearl kernel.	**Fig. 4** Cultured Pearl with light re—flexes on the surface, dividing insert and pearl substance.
Fig. 5 Cultured Pearl with light—re—flexes on the border between cover and insert.	**Fig. 6** Cultured Pearl with a zone of prism—substance, covering the insert, followed by the globular deposits of pearl substance.
Fig. 7 Cultured Pearl showing a Con—chyolin deposit on the division line, also showing curved zoning lines in the pearl sub—stance.	**Fig. 8** Cultured Pearl. Nipple shaped deposit of Conchyolin over the insert.

PLATE II

WHAT THE ILLUSTRATIONS SHOW:

Fig. 9 Cultured Pearl. Strong Conchyolin deposit on wide surface.	**Fig. 10** Cultured Pearl. Conchyolin deposit between kernel and prism zone of the covering.
Fig. 11 Cultured Pearl. Sharp division line between insert and pearl substance. Conchyolin deposit within the pearl substance.	**Fig. 12** Cultured Pearl. Empty area between insert and pearl substance.
Fig. 13 Cultured Pearl. Wedge like cavity above the insert and Conchyolin deposits in the same.	**Fig. 14** Cultured Pearl. Wide cavity above the insert with Conchyolin deposits.
Fig. 15 Cultured Pearl. Nipple shaped cavity between the kernel and a zone of prism substance.	**Fig. 16** Cavity in the pearl substance, blasted out by broken drill.

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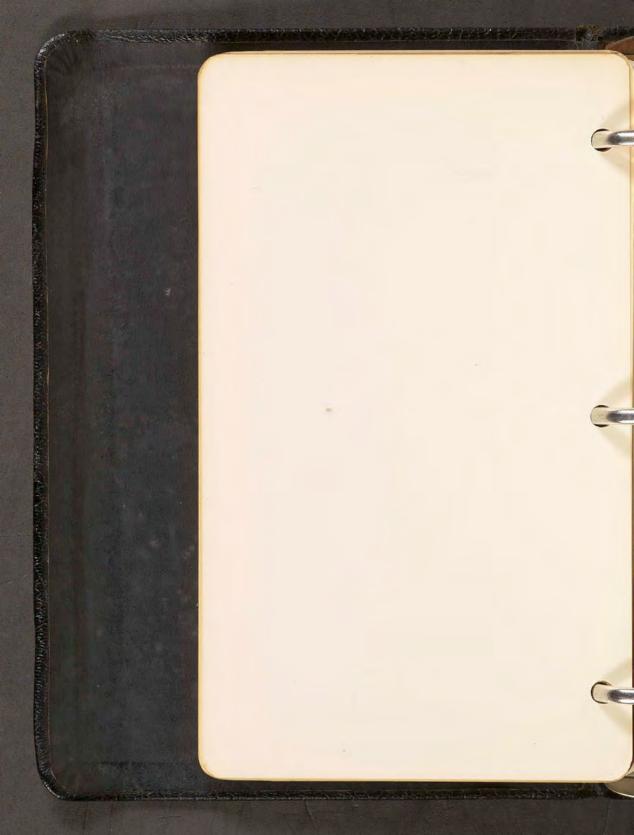
PLATE III
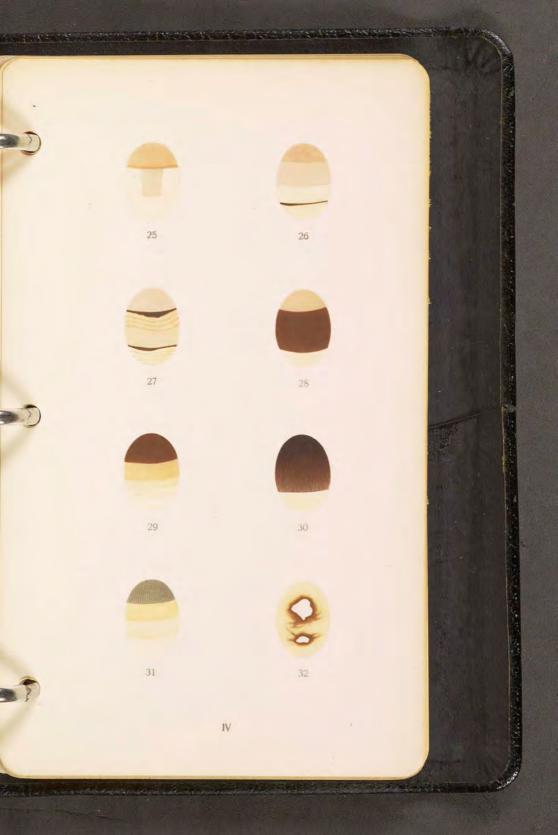
WHAT THE ILLUSTRATIONS SHOW:

Fig. 17 Genuine Pearl. Upper border line of the drillhole.	Fig. 18 Genuine Pearl. Several zone divisions, showing differently coloured layers.
Fig. 19 Genuine Pearl. Showing characteristic toothing of the division lines.	Fig. 20 Genuine Pearl. Showing characteristic toothing of the division lines.
Fig. 21 Genuine Pearl. Showing edge of an internal crack.	Fig. 22 Genuine Pearl. Internal crack.
Fig. 23 Genuine Pearl. A System of coarse internal cracks.	Fig. 24 Genuine Pearl. A System of coarse internal cracks.

PLATE IV

WHAT THE ILLUSTRATIONS SHOW:

Fig. 25	Fig. 26
Genuine Pearl. Odd crack.	Genuine Pearl. Diverse layers. Conchyolin deposit between two layers.
Fig. 27	Fig. 28
Genuine Pearl. Repeated Conchyolin deposits between layers.	Genuine Pearl. Wide belt of Conchyolin — coloured pearl substance.
Fig. 29	Fig. 30
Genuine Pearl. Internal layers rich in Conchyolin.	Genuine Pearl. Prism — zone in Conchyolin — coloured interior.
Fig. 31	Fig. 32
Genuine Pearl, with a zone of prism substance near the surface.	Genuine Pearl. Rusted drill — splinters in the interior of the pearl.

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27   28

29   30

31   32

IV

LEGEND TO TABLE I & II

PART I: CULTURED PEARLS

Pearls obtained by inserting a ball of mother—of—pearl or a similar sub—
stance into the body of the living oyster.

Fig. 1. Cultured Pearl with a thin covering of pearl substance. (0,15 mm)

By using a larger sized mirror needle it is possible to get the whole thickness of the layers of pearl substance upon the mirror, as in this case. The lower part of fig. 1 corresponds to the upper part of the pearl and the lowest of the three sections, the white part in the oval corresponds to the brillantly illuminated mirror, which protrudes above the pearl. Then comes the whole width of the pearl substance (0,15 mm in this case), then a sharp border line and the beginning of the mother—of—pearl insert, showing grey in this picture.

Cultured pearls usually show only a thin skin of pearl substance covering the inserted ball, ranging in thickness from 1/64th to 1/32th of an inch. 3/64th occurs rarely and is considered the maximum thickness up to today.

Fig. 2. Cultured Pearl with a thicker covering of pearl substance, light rays under 90 degrees to the layers of the insert:

In these cases it is necessary to descend the mirror deeper into the drillhole of the pearl, until the border between the yellow pearl substance and the grey mother-of-pearl insert is reached.

By revolving the pearl around the mirror needle it is possible to see a darkening and lightening up of the grey kernel, which depends upon the direction in which the parallel layers of the mother—of—pearl in the insert (kernel) are struck by the light rays. This is seen most clearly in the case when the pearl is drilled parallel to the layers of the insert. There is no change perceptible at all when the layers appear pierced under 90 degrees. Fig. 2 shows the situation where the light rays penetrate under 90 degrees to the layers of the insert.

Fig. 3. Cultured pearl in a position where the light rays penetrate parallel to the layers of the insert:

Fig. 1—3 are characterized by the smooth and sharp division line between insert and covering. The covering of the insert is sometimes intersected by division lines showing its globular structure. These lines frequently show irregularities similar to the ones, shown on table III, fig. 19 & 20, always however in cultured pearls a sharp and smooth division line between insert and covering can be found, dividing grey matter from yellow or brownish

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coloured pearl substance, when descending deeper into the drillhole with the mirror.

It is advisable to revolve the pearl fully around the mirror needle and follow up the division line to avoid mistakes. By descending the mirror deeper into the channel no more division lines in the grey substance are observable. This is the main characteristic of the cultured pearl.

The insert is built up homogeniously, except for the parallel layers of mother-of-pearl, which however are not so clearly observable in most cases.

By descending the mirror deeper and deeper into the drillhole, the image presented is mostly a homogenious, more or less dark grey field.

The main characteristics of the cultured pearl are therefore:

1) The homogenious grey colour following the passage of the sharp division line.
2) The absence of border lines within the substance of the insert (no globular strata).
3) The change in light intensity when the pearl is rotated.
4) The smooth sharp division line between the insert and the covering of the pearl.

One of these characteristics alone however as for instance a sharp line between the layers is not sufficient to form a correct opinion. It is always necessary to penetrate deeper into the pearl and to observe the structure of the suspected insert. Only when the following observations show the other characteristics above mentioned, the pearl is to be condemned as "cultured".

Internal cracks in genuine pearls (See legend 21—24, table III) present a picture, similar to a cultivated pearl. This shows the importance of following the division line all around the drilled hole.

Even a change in light intensity can possibly be brought about by cracks in the interior of the genuine pearl, the surface of the crack serving as light reflector and giving different light intensity according to the direction in which the light rays strike the crack surface, sometimes accompanied also by changes in colour.

In rare cases an insert is found in cultured pearls, consisting of artificially coloured dark grey or black mother-of-pearl. This in most cases is answered by the animal by a strong deposit of Conchyolin on the surface of the insert (see legend fig. 2, 7 and 8). This mostly results in a cultured pearl of grey colour. The image of the insert in the mirror appears considerably darker in these cases compared to the ordinary mother of pearl.

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Fig. 4. Cultured pearl showing light reflexes on the surface, dividing insert and covering:

The sharp division line between insert and cover is accompanied by a second dark line (compare also fig. 5).

Fig. 5. Cultured pearl showing light reflexes on the border between insert and covering:

Here the sharp division line is followed by a dark zone, gradually thinning out into the yellowish coloured pearl substance.

These phenomena in fig. 4 and 5 are to be ascribed partly to the uneven secretion of pearl substance in the immediate proximity of the border between insert and covering. The sharp smooth division line between insert and pearl substance however is always clearly perceptible.

Fig. 6. Cultured pearl with a zone of prism substance covering the insert, followed by the globular deposits of pearl substance:

The pearl oyster secretes either prismatic pearl substance or the substance usually deposited in globular strata. Zones of prism substance therefore also occur in genuine pearls, the oyster having the faculty to deposit either kind of pearl substance. This is however very rare.

The upper part of the illustrations shows the grey mother of pearl insert followed by a zone of radially striped prism substance and thereafter by the outer covering of yellow pearl substance at the lower part of the picture corresponding with the covering ot the insert.

The oyster therefore first covered the insert with radially striped prism substance and then with the globularly zoned pearl substance.

Fig. 7. Cultured pearl with Conchyolin deposit, also showing structural more or less globular lines in the outer shell of pearl substance:

It is found very often that the insert is covered first of all with Conchyolin before the pearl substance is deposited. The picture shows the dark brown substance adjoining the sharp division line, consisting of repeatedly secreted thin deposits of Conchyolin. These deposits often show on the outside of the pearl through the pearl substance, appearing as dark spots.

Fig. 8. Cultured pearl showing a nippel shaped deposit of Conchyolin over one spot of the surface of the insert:

Before being introduced into the oyster the insert is covered by the hand of the operator with a thin bag made out of the soft substance of the pearl sac of another

oyster and the bag tied up. These wart like nippel shaped eruptions occur mostly when the pearl sac-covering does not fit tightly over the insert. The nippel shaped eruption consists partly of Conchyolin and partly of a mixture of prism substance and Conchyolin. This often shows on the outside of the pearl as a wart like unevenness. Pearl substance covering this part of the pearl frequently shows the zone structural lines indicated in the picture 7, resulting from repeatedly ocurring thin deposits of onchyolin.

In cultured pearls, whose covering of pearl substance is very thin, these deposits show as darker spots on the outside of the pearl.

Fig. 9. ultured pearl with wide spread Conchyolin deposit over the insert:

This deposit sometimes appears as a brown stripe over the whole circumference of the border line.

Fig. 10. Cultured pearl. Conchyolin deposit over the insert, followed by a zone of prism substance (compare fig. 6).

Fig. 11. Cultured pearl with smooth border line between insert and cover and Conchyolin deposit within the covering:

These Conchyolin deposits are sometimes found beyond the kernel and mostly appear as grey-brown or violet-grey flat areas, often clearly observable through the covering of the pearl.

Fig. 12. Cultured pearl with narrow empty area between mother-of-pearl insert and covering of pearl substance:

The covering sometimes does not envelop the insert tightly, but leaves thin cleavages between. One sees the sharp border line of the inserted ball and can look in between the ball and the covering, seeing the more or less irregular ending of the empty space, when the ocular tube of the Microscope is adjusted to the depth of the space. It is characteristic of the empty space that one can look deeper into it by descending the Microscope tube. The colour of the empty space changes according to the position of the lamp and the direction of the light-rays striking the layers of the insert.

Fig. 12 shows the empty space as a white narrow zone but it may also appear darker yellow than the covering. Characteristic for the cleavage and for the emptiness of the space is that one can follow it up and look into it by descending the ocular tube of the Microscope.

Fig. 13. Cultured pearl with wide cleavage above the kernel and Conchyolin deposits within the cavity:

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These cavities are sometimes not entirely empty, but filled with a brown loose material, consisting principally of Conchyolin. The mass does not fill the cavity completely (as for instance the nipple in fig. 8 is filled), but leaves the interior of the space open. This hollow space does not always extend over the whole surface of the kernel. Fig. 13 shows the beginning of the opening.

Fig. 14. Cultured Pearl showing wide part of the cavity filled loosely with Conchyolin. (See also fig. 13):

The cavities are sometimes extending over the whole field of observation and are sometimes wartlike as in fig. 15.

Fig. 15. Cultured Pearl. Picture shows a nipple like developed hollow space, loosely filled with Conchyolin, between the insert and the prism zone of pearl substance.

Fig. 16. Wide empty space which may occur in any place of the drillhole of the pearl and is due entirely to the action of the drill. This may happen in genuine as well as in cultured pearls and has only to do with the carelessness of the driller, the incorrect speed of the drill and possibly its poor quality.

These cavities should not be taken for the cavities described in fig. 13, 14 & 15. Their location is not always on the border line between two zones but may occur anywhere and be located in the midst of a zone or extend over several zones.

The previously described cavities show no further interior zoning lines, whereas in these latter cavities, especially when or curing in genuine accidental pearls, zoning lines of the pearl substance may be observed (See Table IV, fig. 27)

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GENUINE ACCIDENTAL PEARLS

Fig. 17. Upper border of the drillhole of a Genuine Pearl.

This picture corresponds perfectly with the picture of a cultured pearl in the same position of the mirror. The lower part of the oval shows a white grayish space, corresponding with that part of the mirror which has not as yet descended into the drillhole and protrudes over and above the pearl. It appears brillantly lighted, which is indicated by the silver–gray colour in the picture. The yellow top–part of the picture represents the part of the mirror already descending into the drillhole and lit up through the pearl substance.

Fig. 18. Genuine Pearl.

See the consecutive globular stratä of pearl substance in various tints and shades of brown. Cultured pearls are usually covered with a thin cover of pearl substance only, not exceeding ($1\frac{1}{2}$ mm $\frac{1}{16}$ of an inch) and varying in thickness between 0,4—0,7 mm ($\frac{1}{32}$—$\frac{1}{16}$ of an inch). It is rare to find more than one globular zone of pearl substance in this thin covering of a cultured pearl.

Conditions are quite different with genuine accidental pearls, where the spherical zones can be followed up to the center of the pearl. Division line follows division line when the mirror descends into the interior of the pearl. The colour is mostly a reddish yellow which grows richer in tint towards the center. There is no change in the light intensity when the pearl is revolved around the mirror needle, except in the case of internal cracks. (Compare fig. 21—24.)

Fig. 19 & 20: Genuine Pearl showing ragged lines as zone divisions.

This toothing together of spherical zones of pearl substance is one of the most definite characteristics of the genuine pearl and never occurs in the insert of a cultured pearl and very rarely in its covering. These complicated, ragged interlacing border lines occur in great variety and are usually combined with differently coloured zones. The zones are not smoothly spherical but are wedging into each other. Higher levels are toothed together with lower situated strata with sometimes abrupt changes of colour and irregular construction.

Fig. 21. Genuine Pearl showing edge of internal crack:

These cracks are sometimes found running parallel to the structural lines for a certain distance, then changing their direction abruptly, which characterizes them as cracks

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with certainty, excluding the possibility of taking them as
division lines between layers. Whereas the picture in
fig. 21 could possibly be taken as showing a structural
line, the picture 22 which is the continuation of picture 21
decidedly points to a crack. In many cases, lines indi-
cating a crack disappear abruptly when the pearl is re-
volved around the needle. The explanation is that the
drillhole has just caught an edge of the crack which is
extending into the pearl away from the drillhole.

It is always necessary to turn the pearl around and
examine the other end of the drillhole also, especially
when there is any doubt about the actual existence of a
crack. Structural lines namely appear in similar distances
from the ends of the drillhole whereas cracklines do not
as a rule appear duplicated on both sides of the drill-
hole.

Fig. 22. Genuine Pearl with internal crack:

As above mentioned this illustration shows the con-
tinuation of the crack illustrated in the foregoing picture.
It also shows the irregular light effects accompanying
internal cracks, the crack surfaces acting as reflectors.
When the pearl is moved around the mirror needle,
whole portions of the pearl appear suddenly lit up and
then again darkened in an irregular way, accompanied by
changes of colouring. This is to be distinctly held apart
from a similar phenomenon observable during the exam-
ination of a cultured pearl. The parallel layers of the
inserted ball of mother-of-pearl substance create a similar
effect of changing light and dark when the pearl is
revolved around the needle, but this lighting up and
darkening takes place gradually and the lightest position is
separated from the darkest position by exactly 90 degrees.

Fig. 23 & 24: Genuine Pearl showing a system of
    coarse internal cracks:

Internal cracks occur in an entirely irregular way, taking
an irregular course. One spot shows sometimes several
cracks at a time, being the cause of remarkable effects.
The appearance of one and the same spot of the drill-
hole changes abruptly when the position of the illuminat-
ing lamp of the Perlometer is changed. One part of the
cracklines may disappear entirely, other lines may appear
suddenly.

Fig. 23 & 24 show the same spot of the drillhole
under different directions of the light rays. The gray colour
of the pictures has been chosen to show only the change-
able distribution of light and dark and the grey colour has
nothing to do with the actual colouring of the interior
of the pearl.

Fig. 25: Genuine Pearl with odd cracks:

Two cracklines are shown, which run almost perpendicular to the zoning line and end with a line almost parallel to the zoning line. The cracked off plugshaped part of the pearl also shows a different colour from the surrounding pearl substance, which is due to light reflexes.

Fig. 26: Genuine Pearl with various zone division lines. Conchyolin deposits within the pearl substance:

Conchyolin deposits may occur at any stage of the process of secretion of the pearl substance, and are found quite often in genuine pearls. They however appear also frequently on the border between the insert and the pearl substance of cultured pearls.

Fig. 27: Genuine Pearl with repeated Conchyolin deposits:

These deposits of Conchyolin may appear on different border surfaces of the spherical strata of the pearl substance. Heavier deposits change with fine films of Conchyolin, which here appear as thin faint lines when cut through by the drill and reflected by the mirror.

Conchyolin deposits may also appear combined with cavities, either empty or filled loosely with Conchyolin. These cleavages are not so frequent with the genuine pearls as with cultured pearls. A variety of cavities may appear in one and the same pearl in different strata.

Fig. 28: Genuine Pearl with a wide belt of conchyolin coloured pearl substance:

Conchyolin deposits may also occur in wide zones in a pearl. In cases where these deposits are located near the surface of the pearl they tend to give the pearl a lead-grey appearance, even though they may not be so deeply tinted. In cases where heavy belts of darkly tinted pearl substance occur near the surface, the pearl is called a „BLUE PEARL" although the appearance is rather more grey than blue.

The Conchyolin deposit may be followed towards the center of the pearl by strata of regular reddish yellow pearl substance. Some abnormal physiological process accompanied by a heavier secretion of colour substance within the oyster is evidently the cause of this phenomenon.

Fig. 29: Genuine Pearl with interior rich in Conchyolin:

It is a common occurance to find a dark brown center in the interior of genuine pearls, which is followed by lighter zones towards the outside of the pearl, as shown in this picture.

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Fig. 30: Genuine Pearl with zone of prism substance on the outside part of the conchyolin-coloured interior:

In rare cases it is possible to observe faint radial lines in the outer part of the dark conchyolin-coloured interior zone of a pearl. The oyster has deposited prismatically crystallized matter together with Conchyolin. The dark zones of genuine pearls are very frequently consisting of this prism substance, but it is rarely observable as such, owing to the dark colouring of the Conchyolin.

Fig. 31: Genuine Pearl with a zone of prism substance near the surface:

This zone of prism substance contains also Conchyolin when occurring nearer the outer surface of the pearl. It seems that the same amount of colouring matter had to be distributed over a greater area, thus resulting in a fainter colour. In these cases the radial stripes are clearer perceptible because they are not overshadowed by too much Conchyolin as in fig. 30.
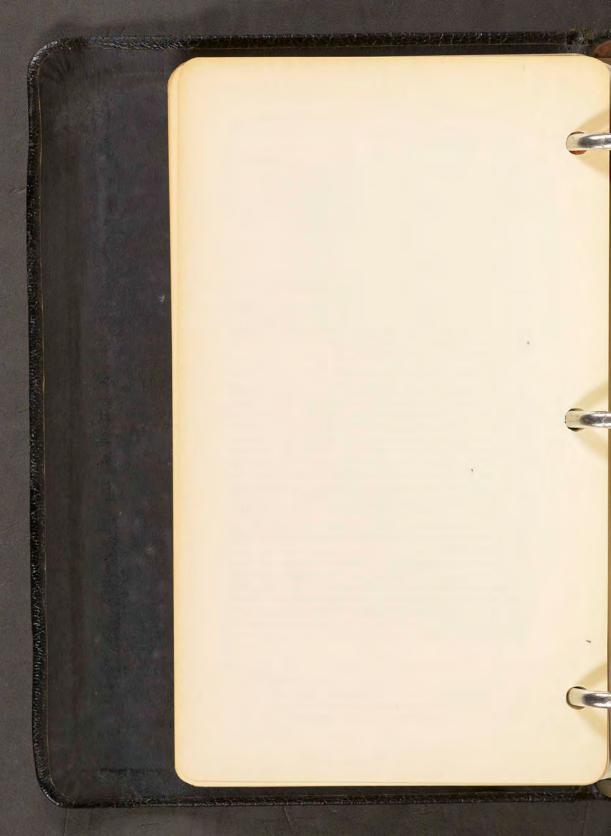
Fig. 32: Rusting drill splinters in the drillhole:

It may happen in genuine as well as in cultured pearls that particles of the fine drill break off during the drill-ingprocess and remain imbedded in the wall of the drill-hole. The drilling being continued and also the friction of the silk thread when the pearl is strung, polish these splinters to a high gloss and they appear as irregular brillantly lighted spots in the drillhole (white spots in the picture).

The other surfaces and the edges of the steel particles get rusty through the moisture of the pearl and frequently discolour the adjoining parts of pearl substance, extending their influence often to the further sections of the pearl.

Another disagreeable effect of these drill splinters is the repeated cutting of the string of a necklace by these sharp steel edges.

Abnormal discolorations in a pearl combined with repeated breakage of the string are indicating a situation as above described. The confirmation of this diagnosis is mostly found by examining the pearl with the Perlometer, showing a situation similar to the one illustrated in fig. 32.

THE
EXAMINATION
OF
PEARLS
IN
TRANSLUCENT LIGHT

———

An often employed preliminary examination of Pearls is the one in translucent Light over a diaphragma of suitable size (set into the Perlometer table). The results are more satisfying when the reflexes from the outside layers of pearlsubstance are eliminated by submerging the pearl in a liquid of a refractive index similar to the one of the pearl substance. (Aragonite). The process of submersion is best done in the "REFRACTEUR", a small metal cup with glass bottom and diaphragms, changeable according to the size of the pearl.

This imbedding of the pearl in a liquid of the same refractory quality as the pearl substance results in the exterior strata of the pearl appearing more translucent on account of the suppression of the reflexes from the pearl surface (total reflexion). (See further explanation in text of Pocket–book.)

The liquids mostly used for the purpose are Mono–Bromo–Naphtalin with an index of refraction $n = 1,658$ and Benzol with an index $n = 1,501$. When using Mono–Bromo–Naphtalin it is necessary to wash with Benzol afterwards and dry the washed out pearl completely in order to avoid damage. It is also recommended to run a dry silk thread through the pearl in order to dry out the drillhole. It is imperative to use Benzol chemically pure.

LEGEND TO PLATE V

THE ILLUSTRATIONS:

Fig. 1: Japanese ultured Pearl submerged in liquid and subjected to strong light rays:
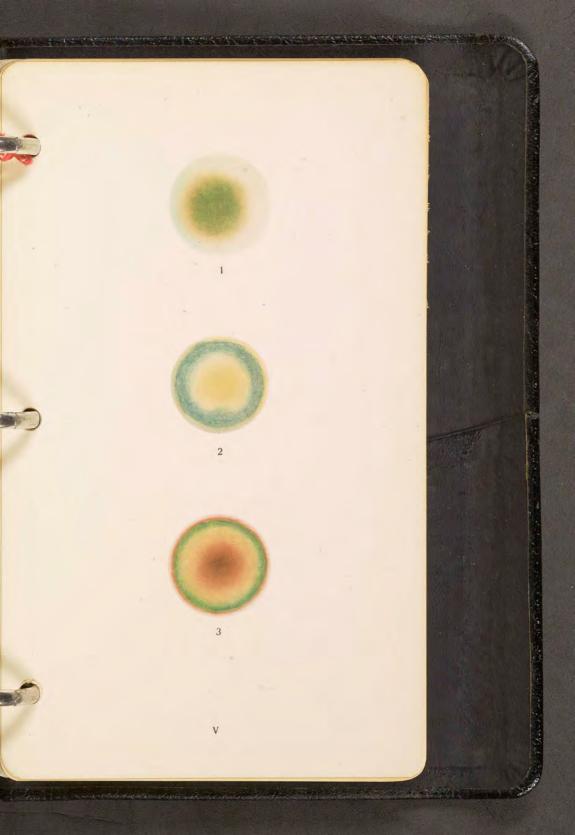
In this case the light rays strike the pearl under 90 degrees to the layers of the mother of pearl insert. The insert shows as an almost uniform round greenish spot in the center of the picture. The outer spherical covering of pearl substance appears lighter in whitish or pale greenish colour. By turning the pearl around with a glass rod one can frequently see the striping coming from the parallel layers of the insert and also a change in light intensity according to the direction of the light rays in relation to the position of the layers of the insert. (See information on pages following.)

Fig. 2: Venezuela Pearl submerged in liquid and subjected to strong light rays:

The center part of the pearl appears rather light, in many cases followed by a grey green annular zone, coloured by Conchyolin deposits in the outer layers of the pearl. When a pearl of this kind is cut in half, pocket like cavities are found in the outer layers, which cavities are filled with a brown substance. When the pearl is turned around with a glass rod, no change in light intensity is perceptible, nor is there a striping in the center to be seen. (See text on following pages.)

Fig. 3: Genuine Oriental Pearl, submerged in liquid and subjected to strong light rays:

The pearl is built up of almost pure pearl substance. Characteristic is the yellow reddish colour in the center and the varicoloured zones around it and near the surface. (For further information see later pages.) Revolving the pearl has no effect upon the light intensity.

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V

A

THE

PLEOCHROISM

OF

COLOURED

STONES

LEGEND TO
COLOURPLATES VI & VII

14

INTRODUCTION:

PLEOCHROISM is the quality of transparent colored substances to appear in different colours when examined under polarized light. These examinations are made either with the Microscope equipped with a Polarizator or more frequently with a simple Dichroscope, and the colours observed which appear when the jewel is held against a source of light.

In the Microscope with a Polarizator the different colours of Pleochroitic stones are observed one after the other by revolving the Microscope table or the Polarizator 90° around.

The Dichroscope when looking through it, divides the field of vision into two squares appearing alongside each other which are differently coloured when pleochroitic stones are examined. The simplest way to examine jewels for Pleochroism is therefore with the Dichroscope which may be used to advantage in conjunction with the Detectoscope.

These two plates VI & VII show the Pleochroism of the most important and most frequently used coloured jewels.

The tints and shades of coloured stones are so manifold that a complete reddition of the whole great variety of these colours, either in natural daylight or in polarized light of all the colortints appearing in the Dichroscope would be entirely out of question.

Different shades of colour and their different intensities as they appear in jewels, produce different colour shades under polarized light; a faintly coloured jewel will of course produce fainter differences of colour in the Dichroscope and vice versa.

It is to be observed that there are directions in which pleochroitic stones show no Pleochroism. It is therefore necessary to make observations in two directions, always differing from one another more or less than 180 degrees, in order to definitely decide upon the absence of Pleochroism, which is characteristic for amorphous jewels and jewels crystallized in the regular (tesseral) system of crystallization.

The colour shades change according to the direction in which the light passes through and only in certain definitie directions the strongest differences in the colour shades are obtainable, which in turn have been reproduced in the colour tables.

Substances crystallizing in the trigonal, tetragonal and hexagonal system show in specific directions only the two colors most widely differentiated. Substances crystallizing in rhombohedral, monoclinic and triclinic systems

generally show three directions in which the colourtints appear which are the most different from one another. See table VII. Alexandrite and Cordierite (Iolite).

THE LIGHT USED FOR THE EXAMINATION IS ALSO OF GREAT INFLUENCE.

In order to make the following statements generally useful, it was necessary to give the colours in ordinary dayligth, as well as in artificial light, in the latter case by the interposition of a daylight filter (Filterdisk B, No. 8) or a ground glass (Filterdisk B, No. 7).

In the following tables, the letters: N, T and M have the following meaning:

N means observations made in natural daylight,

T means observations made in artificial light over the daylight filter (with the Detectoscope),

M means observations made in artificial light, over the ground glass (with the Detectoscope) (See text).

A great many coloured jewels show the same colour-shades in artificial light as in daylight, but another large variety shows quite important differences. The differences are reproduced separately.

Stones of especially great sensitiveness also change their colour when the daylight filter is interposed as against the colour in regular daylight. For instance: The Genuine Alexandrite, the Corundum of Alexandrite-colour and some Ceylon Sapphires, also called "Blue Alexandrites".

Less sensitive stones show only more or less different colours between observations in daylight and observations in artificial light over the ground glass of the Detectoscope.

Generally, the artificial light in conjunction with the ground glass only tends to deepen the colour shades by a yellow reddish tint, coming from the colour of the incandescent lamp in the Detectoscope.

Natural daylight is not understood to be direct, glaring sunlight, but natural daylight means the diffuse reflected light of the overcast sky. By looking into direct sunlight or into the blue sky or into light reflected from a wall painted yellow for instance, observations deviating from the colours in the tables VI and VII would be obtained. These deviations may be quite important, especially with the delicate faint tints.

As an example, by observing a Kunzite via the Dichroscope, the one square is almost colourless and only richly coloured Kunzites produce a faint pink colouring. By looking at the overcast sky through a Kunzite, held in front of the Dichroscope, the one square of the Dichros-

cope appears blue-gray and by examining the same stone over the ground glass in artificial light, the same square appears light yellow with a reddish tint instead of colorless. (Compare fig. 8 & 10, Table VIII.)
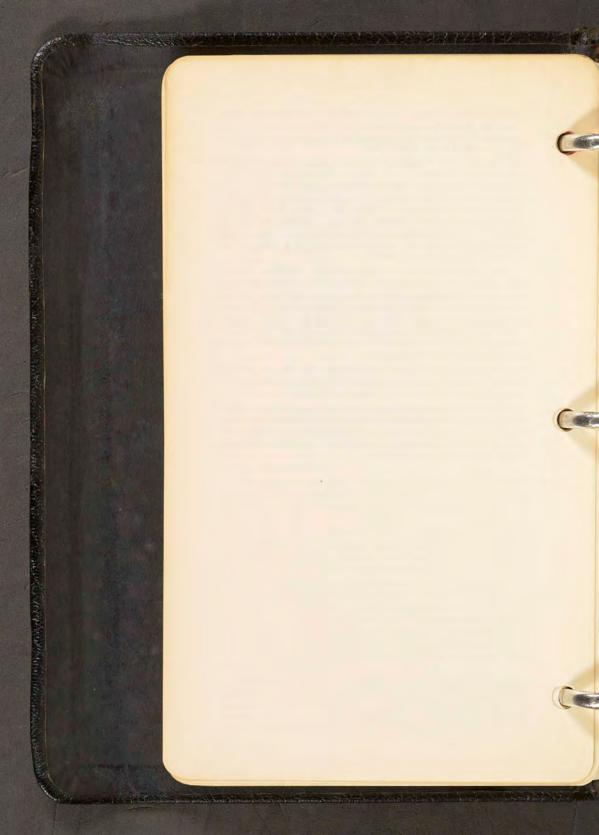
Whereas the Pleochroism of a Kunzite is registered as: lilac — delicate pink, these colours in most cases in practice will be overshadowed by the colour of the background viz the colour of the illuminated groundglass. Similar are the cases of: Pink Beryl and Pink Topaz, whose colours also appear strongly influenced by the colour of the background. The tables give the actual colours of the stones, the colourplates the colours influenced by the background.

The light used for the observations therefore greatly influences the Pleochroic Colours of the precious stones. Furthermore stones of a great multitude of colourshades and colour intensities range under the same names, so that colour tables VI & VII are meant only to reproduce correctly the general character of the colour tints and are to be taken as such in the regular practice of Mineralogist and Jeweler.

Colour reproductions furthermore can only give the colours to be regarded in reflected daylight, though the examinations are made in translucent light.

The colour reproductions are entirely unique in their exquisiteness, representing as they do the latest development of the fine art of colour reproduction and being the result of a complicated eightcolour process extending over more then nine months.

1   2   3

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7   8   9

10   11   12

13   14   15

16   17   18

19   20   21

22   23   24

VI

No. 1. Burmaruby. N = T = M (the phenomena are the same whether observed in day—light or over the day—light filter or in artificial light).

No. 4. Synthetic Ruby: N = T = M.

No. 7. Synthetic Pink Ruby. N = T

No. 10. Kunzite. N = T. In artificial light, over the ground glass M. The lilac pink Kunzite shows almost the same colours as the synthetic pink Ruby under Nr. 8. (See text following concerning the influences of the light.)

No. 13. Pink Topas. N = T. In artificial light over the ground glass M both tints appear more alike and stronger reddishly tinted. (See later text.)

No. 16. Reddish Brown Tourmaline. N = T. M (in artificial light over the ground glass), the paler shade (right) becomes stronger red.

No. 19. Emerald from Colombia. N = T = M.

No. 22. Darkgreen Tourmaline* (brownish green) N = T. M – green as well as browngreen appear stronger yellow. (The tint on the right square should be more brown. Appears too grey in the colourtable.)

No. 2. Siam–Ruby. N = T = M.

No. 5. Synthetic Purple Sapphire. (Dark blue Ruby with reddish tint.) N = T.

No. 8. The same stone over ground glass. M.

No. 11. Pink Beryl. (Morganite) N = T. In the artificial light over the ground glass M. the two colour tint are almost equalized and appear yellowish red. Compare later text.

No. 14. Burnt Yellow Brown Quartz. So-called Spanish Gold-topas. N = T = M.

No. 17. Greenish Brown Tourmaline* N = T. Very dark Tourmalines of all colourshades, sometimes almost completely obscure one of the squares of the Dichroscope. M (in artificial light over the ground glass). Red–brown appears on one side and yellowish brown on the other side. The green tint vanishes almost entirely.

No. 20. Emerald from Brazil, N = T = M.

No. 23. Darkgreen Tourmaline* clear green stone. N = T. M – both tints appear more yellowish over the ground glass.

* Very dark Tourmalines of all colour shades, sometimes almost completely obscure one of the squares of the Dichroscope.

No. 3. Siam–Ruby. N = T = M. Variety deviating from Nr. 2 by the stronger yellowish colouring. The yellowish colouring of Nr. 2 und 3 as against Nr. 1 is characteristic for the Siam–Ruby.

No. 6. The same stone over ground glass. M.

No. 9. Synthetic Orange-coloured Sapphire. (So-called Padparadshah) N – T = M.

No. 12. Red Tourmaline. N = T. The artificial light over the ground glass M equalized the colours and makes the tints more yellowish red.

No. 15. Redbrown Topas. N = T. M (in artificial light over the ground glass). The blueish tint (left) disappears and becomes clear red, the other tint (right) becomes yellowish red.

No. 18. Chrysolith. N = T = M.

No. 21. Hiddenite (Sometimes called Lithion Emerald) N = T. M (in artificial light over the ground glass. Brillantly green on one side and almost clear strong yellow on the other).

No. 24. Bluegreen Tourmaline* N = T. M – both tints appear brownish green and yellowish green.

No. 25. Green Genuine Sapphire. N = T. M. (in artificial light over the ground glass of the Detectoscope) both tints more yellowish to brownish.

No. 28. Alexandrite in natural day light N.

No. 30. Synthetic Sapphire of Alexandrite—like Appearance. N. (in day light).

No. 33. Blue Burma Sapphire the same stone over ground glass M. Not all Sapphires from Burma show such strong differences between colouring in natural and in artificial light.

No. 36. Ceylon Sapphire the same stone in artificial light over the ground glass M: Not all Ceylon Sapphires show such change of colour, some remain clear blue (same as synthetic stones) (Ceyloncolour 40), some stones show this change of colour only over the ground glass M and not over the day light filter T.

No. 39. Synthetic Sapphire same stone in artificial light over the ground glass M.

No. 42. Dark Aquamarine (clear blue) N = T. M: over the ground glass in artificial light the paleblue tint disappears and that right square appears clearly yellow in the colour of the lightbulb.

No. 45. Dark Purple Amethyst (reddish purple) N = T, M: in artificial light over the groundglass it appears dark yellowred (left) and light yellow—reddish.

No. 26. Green Synthetic Sapphire. N = T.

No. 31. The same stone in artificial light. T. M: The ground glass somewhat enhances the red colour in both squares of the Dichroscope. Quite lately Swizzerland produces a new synthetic Sapphire of Alexandrite colour which shows a Dichroism very nearly alike to the genuine Alexandrite. N. In natural day light it shows bluegreen to yellowgreen with reddish tints to reddish—yellow. M: In artificial light it shows vividly raspberry red and greyblue to blue. The stones produced up to now lacked the red tints in natural day light and the green tints in artificial light which seems to have been overcome by a Swiss factory. Another new Swiss variety shows already in natural daylight without Dichroscope green and red tints alongside each other. In artificial light with the Dichroscope the green tint is missing.

No. 34. Ceylon Sapphire in natural day light. N. The colour of the blue (left) is mostly perfectly clear blue. The colour of the other square is pale greenish blue.

No. 37. Sapphires from Australia. N = T. Over the ground glass M in artificial light the blue appears dirtier and the green more with a yellow tinge.

No. 40. Synthetic Sapphires. Ceyloncolour. N = T = M.

No. 43. Blue Zircon of Siam. N = T. M. In artificial light over the groundglass the blue tint appears dirtier (left), the dirty flesh—coloured tint (right) distinctly yellowreddish.

No. 27. Green Synthetic Sapphire. The same stone in artificial light over ground glass M. The dirty bluegreen (left) has become fainter yellowish green and the yellowgreen (right) has become more brownish yellow.

No. 29. Alexandrite same stone in artificial light. T = M. The Alexandrite crystallizes very frequently in twinform so that often practically only two distinctly different colourshades are observable with the Dichroscope, instead of three. The day light filter shows the bluegreen pure, the ground glass a little more yellwish green. The raspberry red tint appears stronger clear red over the ground glass.

No. 32. Blue Burma—Sapphire. N = T.

No. 35. The same Ceylon Sapphire over the day light filter T. This complete change of colour is characteristic of the Ceylon Sapphire, which appears red—lilac in artificial light. These stones are frequently called "Blue Alexandrites".

No. 38. Synthetic Sapphire (Imitating East—Indian stones) N = T.

No. 41. Blue Tourmaline. (Indigolith) N = T. M: Over the ground glass in artificial light the darkblue shade becomes more ink-coloured, the lightblue shade pales away and the right square appears almost clear yellow in the colour of the artificial light.

No. 44. Cyanite (Disthen) N = T = M. Appears almost like the genuine Sapphire.

No. 46. Cordierite (Water—sapphire) N = T. M: in artificial light over the groundglass the first tints appear more yellow, the other colours are tinted more red to bluered and greyviolet. As for the colours in the two squares following the first blue square, the shades in the center mostly contains more blue and the grey colour more yellow tint.

25 26 27

28 29

30 31 32

33 34 35

36 37 38

39 40 41

42 43 44

45 46

VII

Filter 1 der Scheibe A

1

2

3

Filter 2 der Scheibe A

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Filter 3 der Scheibe A

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Filter 4 der Scheibe A

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Filter 5 der Scheibe A

17

18

VIII

B

COLOUR
&
LUMINESCENCE PHENOMENA
IN
COLOURED JEWELS

OBSERVATIONS IN FILTERED LIGHT

EXAMINATIONS OVER THE FILTERDISK
of the
DETECTOSCOPE

ANNOTATIONS: The HIDDENITE or LITHION EMERALD, a light green sometimes yellowish or olivegreen rare jewel, appears in the same colours as the Emerald over filters 1 & 3. Over filter 4 it appears even in thick specimens or when put on edge in the colour of the filter, viz. pale blue but with a tinge of yellowish red. Hiddenite appears grassgreen over Filter 5.

The YELLOWGREEN CHRYSOLITH shows colours similar to the Corundum, but over filter 1 it appears more yellowgreen without the red tinge. Over filter 5 it shows yellow brownish. The yellowgreen Chrysolith is easily recognized by the trade, that is why a separate filter over which it appears blue—green and distinctly different from Emerald and Corundum, has been left off.

The NATURAL DARK GREEN ALEXANDRITE (Chrysoberill) appears raspberry red in artificial light, viz. over filter 5.

The GREEN SYNTHETIC CORUNDUM (Synthetic Alexandrite) is recognized by its characteristic grey—green colour in the translucent light. In reflected light it appears reddishly tinted, especially on edges.

RE: BRAZILIAN EMERALD: Stones have recently appeared on the market as Brazilian Emeralds, which have been the subject of discussions owing to their strange appearance. (Showing a faint yellow tinge.) They are however recognizable as genuine Emeralds, showing the same colour effects as other Emeralds, especially as small specimens or on the thin edges of larger stones. Heavier stones appear also discoloured in the center, same as indicated in the table above.
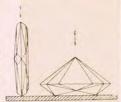
No of the Filter	Color of the Filter	EMERALDS from: Habachtal, Norway, Ural, Egypt, East-Indies, North Carolina, Peru Muso (Colombia)	Brazilian EMERALDS
		APPEARANCE IN FILTERED LIGHT	
1	Dirty yellow	Dirty yellow, same as filter but more reddish tint	Thin stones distinctly reddish, Thicker paler stones delicately yellow-green in center.
2	Red purple	Dark lilaccolored and deepgreen Emeralds appear more reddish.	Thin stones red purple (same as filter). Thicker paler stones are blueish in the center.
3	Bluetinted red	Light Emeralds appear in the color of the filter. Dark Emeralds appear more reddish.	Appear in the color of the filter. Thick heavy Brazilians are rather blueish in the centerpart.
4	Pale blue	Light Emeralds appear light blue (color of the filter). Thick stones, or thin stones put on edge appear green. Dark Emeralds appear green with yellow tinge.	Thin Brazilian Emeralds appear pale blue. Thick heavy stones or thin stones put on edge appear delicately blueish in the center.
5	White light of the in candescent Lamp. (ground glass)	Green	Thin stones almost white. Thick stones or thin stones over the edge green.

TOURMALINES, TECLA IMITATIONS, GLASS-IMITATIONS in varicolored tints, green bluegreen to yollowgreen.	GREEN GARNET GREEN ZiRCON NATURAL GREEN CORUNDUM SYNTHETIC GREEN CORUNDUM	
APPEARANCE IN FILTERED LIGHT		
Olive green	dirty yellow with reddish tint	Examine Stones in several positions flat & over the edge
Blue	red purple	
Distinctly blue	GREEN GARNET appears brilliantly red over this filter. ZIRCON & GREEN CORUNDUM (genuine & synthetic) appear in the color of the filter but more red	
Blue to greenish blue	GREEN GARNET dirty yellow to yellowish red. ZIRCON appears purple especailly when put on edge. GENUINE GREEN CORUNDUM dirty purple. SYNTHETIC GREEN CORUNDUM pale blue, very faint.	
Green in various tints	NATURAL GREEN CORUNDUM appears olivegreen with yellow tinge. SYNTHETIC GREEN CORUNDUM light yellowgreen.	

RED JEWELS

Name of Stone	Colour of Stone over Green Luminescence Filter	Luminescence
RUBY genuine natural		
from Siam	Darkblue with red tinge	dark red
from Burma	Lightblue with red tinge	strong light red
RUBY synthetic		
colour: clean red	Blue to bluegrey	strong red
colour: yellow red	Colour of filter, edges salmon pink	weaker red
colour: purple	dark blue	weaker red
SPINEL:		
colour: lightred	Colour of filter, on the edges salmon pink	red
colour: dark brownred	Greygreen	no luminescence
GARNET:		
colour: brown	Olive brown	no luminescence
colour: lilac	Greygreen	no luminescence
ZIRCON red	Olivegreen—browngreen	no luminescence
GLASS red	Colour of filter to salmon pink	no luminescence
TOURMALINE red	Colour of filter	no luminescence

Phenomena are enhanced by using THE HANDFILTER

LEGEND TO TABLE VIII

FILTER 1 OF FILTERDISK A		
1. Colour of the filter.	2. Colour in which the Emerald appears over this filter. Similar colours are shown by: Green Garnet, green Zircon & Green Corundum.	3. Colour in which Glassimitations, Doublettes, Tecla-imitations and Tourmalines appear.
FILTER 2 OF FILTERDISK A		
4. Colour of the filter.	5. Colour in which the Emerald appears over this filter. Similar colours are shown by: Green Garnet, Zircon and Corundum.	6. Coulour in which Glassimitations, Doublettes, Tecla-imitations & Tourmalines appear over this filter.
FILTER 3 OF FILTERDISK A		
7. Colour of the filter.	8. Colour in which Emeralds appear over this filter. Similar colours are shown by: Zircon & Corundum.	9. Colour in which Green Garnet appears over this filter.
10. Colour in which glassimitations, Doublettes and Tourmalines appear over this filter.		
FILTER 4 OF FILTERDISK A		
11. Colour of the filter.	12. Colour of Green Zircon over this filter.	13. Colour of Genuine Green Sapphire over this filter.
14. Colour of Synthetic Sapphire over this filter.	15. Colour of Emerald over this filter.	16. Colour of Green Garnet over this filter.
FILTER 5 OF FILTERDISK A (ground glass)		
17. Colour of natural Green Sapphire over this ground-glass.	18. Colour of most synthetic Green Sapphires over the ground glass in artificial light.	

C

THE

EXAMINATION OF THE INTERIOR

—

ENCLOSURES

ZONE STRUCTURES

AUGMENTATION STRIAE

CRACKS

IMPERFECTIONS

THE EXAMINATION

OF

ENCLOSURES

(INCLUSIONS)

GENERAL INTRODUCTION

It is not sufficient to examine a jewel with a magnifying glass, no matter how strong, in order to decide upon its genuineness but recourse must be had to the microscope. The magnifying glass permits only the general superficial examination of the jewel and the detection of the coarsest enclosures and impurities, but more delicately constituted enclosures are not perceptible with the magnifying glass.

Correct judgement as to the genuineness and value of precious stones and as to their origin can therefore only be based upon an exact examination of the enclosures under a suitable microscope.

When putting a stone resting on a thin plate glass upon the microscope table the following observations will be made: Besides the disturbing reflexes from the cut surfaces of the jewel, the appearance of wide dark completely opaque borders alongside the contours of the crystal leave only a small centerpart of the jewel available for the examination. The stronger refractive the substance the stronger and more apparent are these phenomena which are caused by the total light reflection from the steeply facetted surfaces of the stone.

In order to eliminate or at least strongly diminish these disturbing reflexes it is necessary to immerse the jewel in a liquid of as nearly as possible the same refractive index as the jewel itself. The closer the coincidence of the refractive indices of stone and liquid the less total reflection there will be and the more the dark borders of the crystal are due to vanish.

In most cases it is sufficient to take Mono Bromo Naphtaline of the refractive index $n = 1.658$ for the immersion of the stone.

Extreme caution must be taken in handling Mono Bromo Naphtaline the liquid tending to inflame the mucuous membranes of eye nose or mouth if one were careless enough to touch them with fingers wet with this liquid. After the examination the stone should be cleaned with Benzol and wiped dry afterwards.

The Mono Bromo Naphtaline is poured into an immersion cup, — a flatbottomed round glassvessel with a low border – and the jewel embedded in the liquid. It is in most cases quite imperative to examine the jewel under different angles by setting it upon different ones of its facets with a tweezer. It is sometimes found convenient to fasten the gem with beeswax to a thin glassrod and turn rod and gem around during the examination.

Should the borders of the enclosures fail to show up clearly and distinctly it will in most cases suffice to shut off the border light rays from the illuminating apparatus by decreasing the diameter of the shutter. Especially the augmentation stripes in synthetic stones spring into view when the lightcone is diminished in diameter by shutting off the border light rays.

The following plates are Microphotographs and illustrate the various types of characteristic enclosures in Natural Genuine as well as in Synthetic Artificial Stones. The detailed explanations will be found in the legends to these illustrations, the general remarks thereto in the foregoing text of the Pocket–Book.

The following is a brief Summary of these explanations describing the Different Kinds of Enclosures, characteristic of jewelery stones:

1. C r y s t a l l i n e E n c l o s u r e s or Enclosures of solid Substances in general, which take themselves the shape of entirely independant crystals. These enclosures are sometimes found embedded in the jewel in a position conforming to the law of crystallization of the surrounding substance. It is as if during the formation of the crystal the enclosures had been turned into certain directions according to the law of crystallisation of the embedding substance. An Enclosure in such a position is hereinafter called an "Oriented Enclosure".

The edges and borders of these also socalled „Individualized Enclosures" are mostly more delicately formed than in the ordinary enclosures because the differences between the respective qualities of light refraction are comparatively small.

Larger differences in the refractive qualities between embedded crystal and surrounding jewel substance are found very rarely in such enclosures.

What is sometimes observed, however, are Enclosures of non transparent substances as for instance Crystal skeletons of Magnetite, Iron–Titanium or Hematite in thicker tablets.

2. L i q u i d E n c l o s u r e s. Liquid Enclosures are mostly found arranged as "Vanes" as the jeweller calls these formations. Singly occurring liquid enclosures are

rare. They are mostly found in flat formations, sometimes in well–contoured sections within which the enclosures appear more or less oriented towards one another as well as in relation to the surrounding substance. Liquid Enclosures in most cases show wider borders than crystalline Enclosures.

Liquid Enclosures may also appear in "Negative Crystals" (Minus Crystals) namely in cavities within the jewel which owe their shape to the crystalline structure of the surrounding substance.

These cavities have remained open within the mineral at the lime the crystal had "grown", their flat sides against the surrounding crystal substance being regular crystal surfaces.

Cavities, however, may also take altogether irregular shapes and be completely or partly filled with liquid. Had the amount of liquid not sufficed to fill the cavity completely, they remained partly filled and the room left had been taken up by a balancefly (gas bubble) floating on top of the liquid in various positions, depending upon the relative proportion of cavity and liquid.

There are liquid enclosures in which the liquid substance does not wet the surrounding walls, the liquid being completely enveloped by gas. They are cases of socalled "Liquids not wetting the wall". This phenomenon is frequently found in Topaz. The balancefly however is in ordinary cases a gas bubble floating in the liquid.

Two different nonmixable liquids may also be found alongside each other within the cavity. They are most easily detected in cases where the two liquids have different refractive qualities, in most cases it is water alongside of liquid carbonic acid. The water fills the parts towards the borders and the lappets, the carbonic acid the inner parts of the cavity. The liquid carbonic acid often encloses a bubble of carbonic acid gas. The relative position of these three elements may change according to the volume of the respective parts (see foregoing text in Pocket–Book).

A perceptible change takes place within the enclosure in case the same is subjected to heat. The liquid carbonic acid may completely evaporate resulting in a large gas bubble floating on top of the water. When the jewel is cooled off again to 31° Centigrade or below, the carbonic acid liquifies again and the enclosure appears again filled with water, liquid carbonic acid and carbonic acid gas.

Balanceflies or gasbubbles always appear heaviliy bordered and sometimes moveable, when observed under the microscope.

Liquid inclosures may also contain Crystalline extra-versions, frequently appearing as cubes.

The borders of the liquid enclosures vary in widths according to the shape of the cavity and the light refraction of the liquid. Various parts of one and the same Liquid Vane may therefore appear lighter or darker according to the direction in which it is observed, darker when seen from the narrow side and lighter when the flat side is under observation.

3. Enclosures of Gas show strong wide dark borders produced by total reflection and the refraction of the lightrays on the walls of the gas filled cavities. They sometimes make the whole gas bubble appear untransparent.

Gas Enclosures may have different shapes. They may be globular or extended and pointed on the ends; in liquids the gas bubbles often conform to the shape of a part of the cavity.

Genuine natural stones never show gas enclosures or gas bubbles unaccompanied by liquids. Gasbubbles appearing in a stone without liquid are a sure sign of the stone being Synthetic.

Gas Enclosures or gas bubbles alone are never found in natural jewels but in these cases always appear combined with liquids.

Synthetic stones, however, have no liquid enclosures but always show some gas enclosures. These gas enclosures appear often in heaps or nests or congregated in the augmentation zones and may have any kind of a size.

Microscopic examinations should also comprise the detection of other conditions in the interior of a jewel.

Cracks, Fractures extending to the surface may appear in a stone. They may sometimes be filled partly or entirely with air and then appear glossy and irisating. The microscopic examination shows these cracks as partly dark on account of the total reflection of the light on the crack surfaces. Cracks not filled with air show off as irregular lines.

The fissibility of natural jewels sometimes manifests itself by the appearance of parallel fissures. The ground facets and the edges of the facets appear under the microscope as unclear and washed out lines and only very rarely as sharp lines. In cases where the embedding liquid is of similarly high light refraction as the stone it is necessary to reduce the light cone in order to see the facetedges clearly

It is advisable to look first for the facets on the top of the stone, than search the interior of the stone downward until the facets on the lower surface are found. This is the only way to be sure to have explored the whole interior of the stone.

Often appearing small air bubbles on the surface of the stone embedded in the liquid are not to be mistaken for enclosures, — they disappear when the stone is moved — neither are impurities of the embedding liquid to be taken as being located in the interior of the stone.

The colouring matter of a stone or the enclosures may be arranged according to crystal surfaces or they may appear as irregular formations thus furnishing important points for the stones identification.

In artificial synthetic stones more or less curved lines and stripes appear which conform to the augmentation strata with which the synthetic stone is built up. The synthetic stone is an agglomeration of melted drops upon a rotating clay cylinder. Drop after drop being blown against the rotating clay plug form curved augmentation layers which appear as curved stripes in the cut stone, more or less curved according to the size of the resulting pearshaped drop, from which they have been cut. Smaller drops produce stronger curved strata than larger drops. (Striations)

Natural stones also have zone structures which often appear oriented according to several crystalline plains. They also sometimes have stripes of different colour but these are always straight bordered and appear running under regular angles, governed by the crystalline structure of the variety.

NATURAL GENUINE JEWELS therefore show one or several of the following characteristics:

Regularly oriented Crystalline Enclosures.

Liquid Enclosures with or without balancefly with sometimes Crystalline Exudations in the liquid,

Straight Zone Structure, sometimes intersecting under regular angles,

The appearance of negative crystals, mostly filled with liquid with or without gasbubble.

SYNTHETIC, ARTIFICIAL STONES show one or several of the following characteristics:

Gas Bubbles.

Curved Stripes of Augmentation. (Striae)

Heaps of Fissures in the interior of the stone or starting from the facet edges or from internal cracks.

GLASSES show the following characteristics:
Gas Bubbles in conjunction with irregular softly curved lines in the glass, clearly visible, when the shutter is reduced in size.
Glasses show no Pleochroism.

DOUBLETTES show these characteristics:
Besides the often broken out edges on the border (Rondiste) also the irregularity in the behaviour under optical observation, (compare foregoing text in Pocket-Book).
The surface alongside which the two materials are pasted together invariably shows impurities and gas bubbles.
Doublettes consisting of a genuine top part will of course also show characteristics of the genuine jewel mixed up with the characteristic signs of the glass. The presence of indications for genuine stones and for artificial stones is therefore characteristic for Doublettes.

The following plates give all important typical examples of the characteristics of genuine and artificial jewels. Less important cases are mentioned in the foregoing text of the Pocket-Book.

A SERIES OF PLATES.

— MICROPHOTOGRAPHS —

depicting the

MOST CHARACTERISTIC

ENCLOSURES

IMPURITIES & DEFECTS

OF

PRECIOUS STONES

&

THE CHARACTERISTICS of their

IMITATIONS
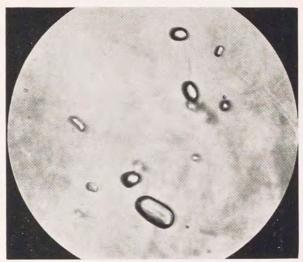
a CRYSTALLIZED ENCLOSURES IN
A GARNET. Such enclosures are found
in many garnets. The border lines of the
individual enclosures are partly sharp,
being formed by crystal surfaces. These
enclosures are highly double refractive
dichroic but the refractive index is
smaller than that of the garnet. They
presumably are particles of Augite and
Augite stems.

Microphotograph enlarging 130 ✕

b CRYSTALLIZED ENCLOSURES IN
A GARNET. Needles probably of Augite
intersect the Garnet in all directions of
the edges of the planes of the Dode–
kahedron and often produce a certain
glimmer of light, following the crystalline
directions. The small tablets visible on
the right are also embedded following
the crystalline structure, they show double
refraction and have a somewhat higher
refractive index than the garnet.

Microphotograph enlarging 120 ✕

Crystallized Enclosures　　　　　　　　　**Garnet**
Inclusions crystallisés　　　　　　　　　　*Grenat*
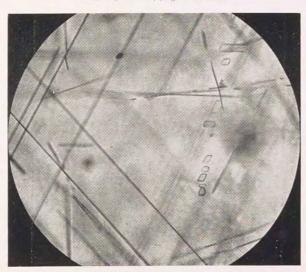
Kryſtalliſierte Einſchlüſſe im Granat.

Crystallized Enclosures　　　　　　　　　**Garnet**
Inclusions cristallisés　　　　　　　　　　*Grenat*
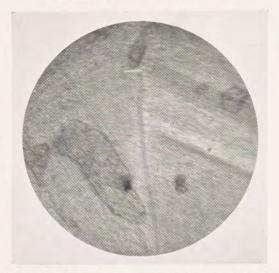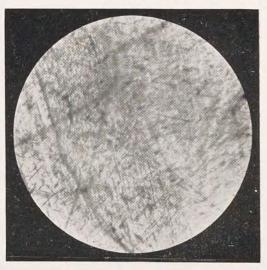
IX

a
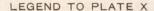
Crystallized Enclosures   **Sapphire from Ceylon**
Inclusions crystallisés   *Saphire de Ceylon*

Rutilnädelchen im Ceylon-Saphir.

b

Enclosures of Rutileneedles   **Sapphire from Ceylon**
Inclusions d'Aiguilettes de Rutile   *Saphire de Ceylon*

X
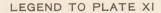
a CRYSTALLINE ENCLOSURES IN A
CEYLON SAPPHIRE. A large and
some small crystals of Calcite are em-
bedded in this Ceylon Sapphire. There
are also very fine particles (of Calcite
and of the colouring material of the crystal)
embedded in zones. Zonestructure.

Microphotograph enlarging 60 $\times$

b RUTILE NEEDLES IN A CEYLON
SAPPHIRE. The so-called and much
desired "silk" of the Corundum varieties
mostly visible as a silky glister over the
base of the stone is the effect of these
Rutile Needles. They are disposed in the
crystal according to the crystalline law
of the substance and intersect each other
under 60° under correct projection. Be-
sides these regularly disposed needles
there are also isolated irregularly em-
bedded Rutile Needles to be observed.

Microphotograph enlarging 80 $\times$
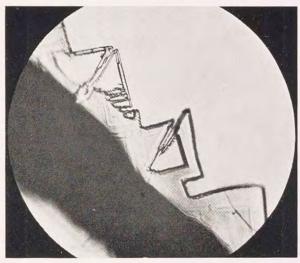
a and b CRISTAL SKELETONS
IN A COLOMBIAN EMERALD.
The interior of Colombian Emeralds
sometimes show thin, delicate skele—
tonlike films, which are embedded
following the laws of crystallization
and which probably, judging from
their appearance are Carbonates. They
extinguish simultaneously with the
stone in polarized light, under crossed
Nicols and are so thin that they do
not perceptibly increase the double
refraction of the Emerald.

They are more distinctly visible when
the diaphragma in the microscope
is reduced and the border rays of
the light shut off.

Microphotograph enlarging 120 $\times$
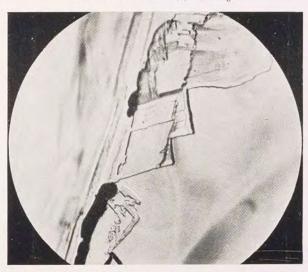
Enclosures cf crystalskeletons   Emerald from Colombia
Inclusions de squelettes de cristaux   *Émeraude de Colombia*

Kryſtallſkelette im columbiſchen Smaregd.
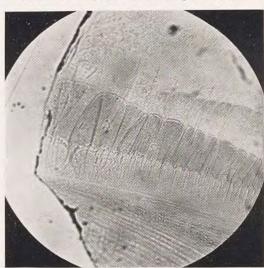
Enclosures of crystalskeletons   Emerald from Colombia
Inclusions de squelettes de cristaux   *Émeraude de Colombia*

XI
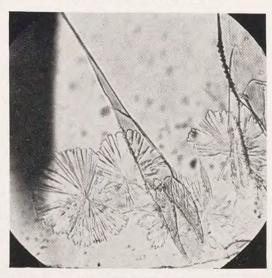
Häutchen von wahrscheinlich Eisenhydrogel im Spinell.

Enclosures of films of Ironhydrogel   **Spinel**
Inclusions de films solides (hydrogel de fer)   *Spinelle*

Häutchen in Rosettenform im Spinell.

Enclosures of solid substances (rosettes)   **Spinel**
Inclusions de matières solides (rosettes)   *Spinelle*

a FILMS OF PROBABLY IRONHY-
DROGEL IN A SPINEL. Spinels have
frequently enclosures of such yellowish to
brownish films, which often appear shrunk
or shrivelled up and probably consist of
Ironhydrogel.

Microphotograph enlarging 180 ✕

b These films of Ironhydrogel sometimes
appear in the shape of rosettes as shown
in the illustration. Next to these films and
rosettes which show no double refraction
there are also found flatly developed
formations of a micalike consistency.
These films are sometimes the cause of
cracks and rifts often partly filled with
air. The air then is the cause of forma-
tions of featherlike appearance, similar to
the ones created by the before mentioned
films, only the airfilled cracks are not
transparent and show dark in the picture.

Microphotograph enlarging 200 ✕
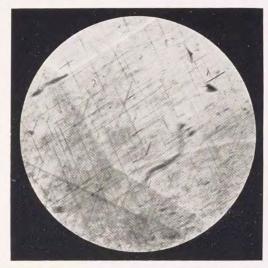
a RUTILE NEEDLES IN A RUBY
   FROM BURMA. (Compare table
   X b.) These Rutile needles are re-
   gularly disposed conformably to the
   law of crystallization. These regu-
   larly set Rutile needles are charac-
   teristic of the Rubies from Burma.

   Microphotograph enlarging 65 $\times$

b LIQUID ENCLOSURE IN A RUBY
   FROM SIAM. Delicate flat sheety
   formations, consisting of extended
   channels filled with liquid show in
   the interior of this Ruby together
   with solid hexagon tablets. Such
   Vanes of liquid are characteristic for
   Siam Rubies. The dark appearing
   spots are gasbubbles or subglobular
   cavities filled with a liquid of a
   higher refrative index.

   Microphotograph enlarging 120 $\times$

Gesetzmäßig orientierte Rutilnädelchen im Birma-Rubin.

Rutileneedles   **Ruby from Burma**
Aiguilles de Rutile   *Ruby de Birma*
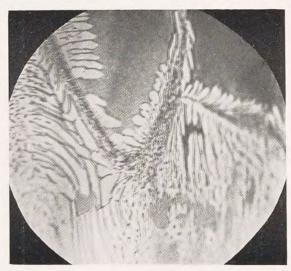
Flüssigkeitseinschluß im Siam-Rubin.

Liquid Enclosure   **Ruby from Siam**
Inclusion liquide   *Ruby de Siam*
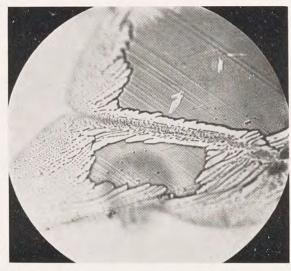
XIII

a

Liquid Enclosures
Inclusions liquides

Sapphire from India
Saphire des Indes

b

Liquid Enclosures
Inclusions liquides
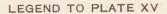
Sapphire from India
Saphire des Indes

a) and b) **LIQUID ENCLOSURES IN A SAPPHIRE FROM INDIA.** They start from apparently rough and grained surfaces of a more or less intense yellow to brownish colour, extending into thin cavities filled with liquid which in further continuation dissolve into single drops of liquid.

As a whole they show sharply bordered flatly shaped formations with rounded borders. The yellow surfaces are either uniformly coloured (a) or have a striped design which comes from the yellow colour substances heaped up along parallel lines and furnishing these skeletonlike formations (b).

Microphotograph enlarging 180 ✕
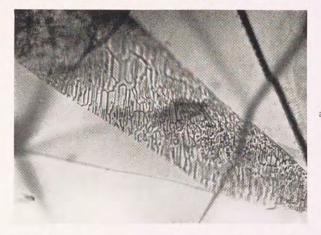
a and b LIQUID ENCLOSURES IN
A RUBY FROM SIAM. They are
arranged in stripes or vanes and
appear sharply bordered. (Compare
plate XIII b) The small channels
filled with liquid appear almost
parallel to each other and show.
(a) either orientation according to
the law of cristallisation of the sur-
rounding substance or (b) they are
arranged without any apparent in-
ternal regularity.

Microphotograph enlarging $\frac{a\ 130\ \times}{b\ 110\ \times}$

Flüſſigkeitseinſchlüſſe in einem Siam-Rubin.

a

Liquid Enclosures   Ruby from Siam
Inclusions liquides   *Ruby de Siam*

Flüſſigkeitseinſchlüſſe in einem Siam-Rubin.

b

Liquid Enclosures   Ruby from Siam
Inclusions liquides   *Ruby de Siam*

a

Liquid Enclosures Sapphire
Inclusions liquides *Saphire*

b

Liquid Enclosures Sapphire
Inclusions liquides *Saphire*

a and b **LIQUID ENCLOSURE IN A
SAPPHIRE.** In one and the same
stone one sometimes finds in differ—
ent dephts over and under one an—
other various vanes of liquid enclo—
sures and table XVI shows in both
illustrations two enclosures from
different dephts of the same jewel.
These are typical liquid enclosures.
The parts which are not focussed
sharply give dark broad spots without
any details in the microphotograph.

Microphotograph enlarging 200 ×

a LIQUID ENCLOSURES IN A SAPPHIRE
FROM AUSTRALIA. The channels filled
with liquid are almost parallel for a certain
distance. The position of these channels in
the jewel is approximately following the law
of crystallization. Different parts of the large
liquid vane a section, of which is herewith
reproduced show this reoccurring orientation.

Microphotograph enlarging 180 ✕
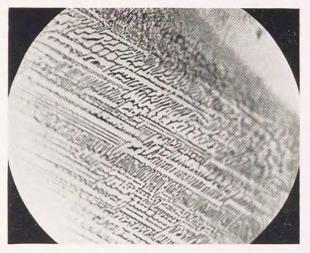
b ENCLOSURES OF TWO NON MIXAB-
LE LIQUIDS WITH FLOATING GAS
BUBBLES IN SMOKY QUARTZ.
Smoky quartz frequently shows liquid en-
closures with so—called double balancefly.
These enclosures consist of water, liquid
carbonic acid and carbonic acid gas. The
water fills the extreme ends of the lappet-
shaped cavities. The liquid carbonic acid
fills the inner parts showing as a heavily
bordered gasbubble and in this bubble floats
the balancefly of the carbonic acid gas.
The borders are displaced when the stone
is warmed up and the temperature of the
lightrays when photographing is sufficient to
displace these borders and make them ap-
pear indistinct.

Microphotograph enlarging 160 ✕

Flüffigkeitseinfchlüffe in einem auftralifchen Saphir.

a

Liquid Enclosures   Sapphire from Australia
Inclusions liquides   *Saphire d'Australie*

Einfchluß von zwei nicht mifchbaren Flüffigkeiten mit
Gaslibelle in Rauchquarz.

b

Liquid Enclosures   Smoky Quartz
Two non mixable Liquids   *Quartz fumé*
Inclusions de deux liquides non miscibles

XVII

Enclosures of two non mixable liquids   Topaz
Inclusions de deux liquides non miscibles   *Topase*

Zwei nicht mischbare Flüssigkeiten im Topas.

Enclosures of two non mixable liquids   Topaz
Inclusions de deux liquides non miscibles   *Topase*

XVIII

a ENCLOSURES OF TWO NON-MIXAB-
LE LIQUIDS IN A TOPAZ. The enclo-
sure situated a trifle below the exact centre of
this illustration shows distinctly an upper
part divided from a lower part by a strong
divisionline. The lower part shows clearly the
border between the two liquids. The less re-
fractive liquid (probably carbonic acid) fills
the inner part of this channel, both the ends
are occupied by a stronger refractive liquid,
(probably water). The upper part of the en-
closure is also filled with liquid, but the
liquid is bordered off towards the edge of
the enclosure by gas, so that the wall of
the enclosure is not wetted by the liquid.

Microphotograph enlarging 145 $\times$

b THIS ILLUSTRATION ALSO SHOWS
ENCLOSURES OF TWO NON-MIX-
ABLE LIQUIDS IN A TOPAZ. A liquid
of a lesser refractive index fills the inner
parts and a liquid of a larger refractive in-
dex the parts of the cavity towards the pe-
riphery. The parts of the cavity which are
filled with the more weakly refractive liquid
(probably carbonic acid) show parallel lines
which evidently are furrows in the walls of
the cavity. They are considerably less apparent
in the parts filled with water.

Microphotograph enlarging 145 $\times$

a LIQUID ENCLOSURES IN A TOURMA-
LINE. Capillary channels very thin and filled
with liquid, in some places enlarged, travers
this stone in curves apparently not influen-
ced by the law of crystallization. (Not oriented.)

Microphotograph enlarging 120 ×

b LIQUID ENCLOSURES IN TOURMA-
LINE. The dark triangles sometimes parallel
to each other represent flat cavities of a
triangle ground plan with a flat roof. These
cavities represent sharply bordered negative
crystals filled with liquid, mostly with a
floating gasbubble, clearly visible in some
parts of the illustration. The stone has been
examined approximately in the direction of
the main crystallographic axis of the Tour-
maline.

Microphotograph enlarging 120 ×

Liquid Enclosures   Tourmaline
Inclusions liquides   *Tourmaline*

a
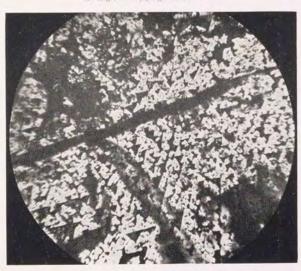
Flüssigkeitseinschlüsse im Turmalin.

Liquid Enclosures   Tourmaline
Inclusions liquides   *Tourmaline*

b

XIX

Flüssigkeitseinschlüsse im Granat.

Liquid Enclosures   Garnet
Inclusions liquides   *Grenat*

Flüssigkeitseinschlüsse im Smaragd.

Liquid Enclosures   Emerald
Inclusions liquides   *Émeraude*

XX

a LIQUID ENCLOSURE IN A GAR-
NET. The shape of these channels
is such that they appear completely
dark in this position.

Microphotograph enlarging 120 $\times$

b LIQUID ENCLOSURE IN AN
EMERALD. A part of this enclosure
is so disposed that it appears trans-
parent and other parts appear com-
pletely dark and non transparent due
to their position.

Microphotograph enlarging 56 $\times$

a LIQUID ENCLOSURES IN AN
EMERALD. The cavities filled with
liquid, showing gas bubbles floating
on top appear stretched and arranged
parallel to the main crystallographic
axis of the jewel.

Microphotograph enlarging 50 ✕

b LIQUID ENCLOSURE WITH
GAS BUBBLE IN AN EMERALD.
This is a strong enlargement of the
liquid enclosure showing a trifle to
the right from the centre of the above
picture (a). The cavity is a negative
crystal.

Microphotograph enlarging 520 ✕
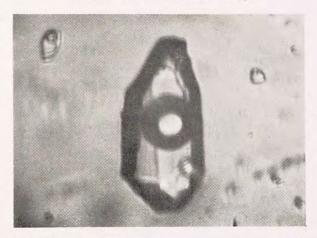
Flüffigkeitseinfchlüffe im Smaragd.

a

Liquid Enclosures with Gasbubbles   Emerald
Inclusions liquides avec Libelles de gaz   *Émeraude*
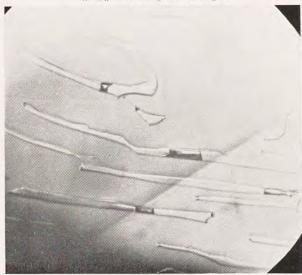
Flüffigkeitseinfchluß mit Libelle im Smaragd.

b

Liquid Enclosure with Gasbubble   Emerald
Inclusion liquide avec vésicule de gaz   *Émeraude*

XXI
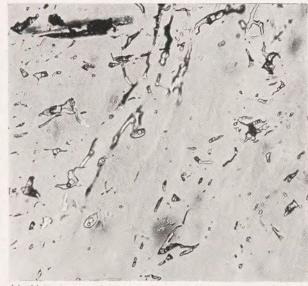
Liquid Enclosures   Emerald of Colombia
Inclusions liquides   *Émeraude de Colombia*

Flüssigkeitseinschlüsse mit Krystallausscheidungen und Libelle im Smaragd.

Liquid Enclosures with crystals and gasbubbles   Emerald
Inclusions liquides avec des cristaux et des vésicules   *Émeraude*

XXII

a LIQUID ENCLOSURES IN AN
EMERALD FROM COLOMBIA.
Worm shaped channels wind their
way through this Emerald without any
apparent orientation to crystalline
laws. The gas does not appear as a
round bubble here but fills a part of
the cylindrical channels towards their
center.

Microphotograph enlarging 160 ✕

b LIQUID ENCLOSURES WITH
SECERNMENTS OF CRYSTALS
AND GASBUBBLES IN AN EM—
ERALD. Emeralds from Colombia
show frequently liquid enclosures
which not only contain gas bubbles but
next to them small crystals of rec—
tangular and square section.
This crystalline substance shows no
double refraction it probably consists
of Chloride of sodium.

Microphotograph enlarging 210 ✕

a LIQUID ENCLOSURES IN A CEYLON
SAPPHIRE. The illustration indicates many
vanes of liquid enclosures situated alongside
one another and overlapping each other. Only
those parts of these enclosures are clearly
visible which lie exactly in the focus of the
microscope. By exploring the interior of the
stone downwards one can follow up the exact
continuation of every single one of the liquid
vanes.

Microphotograph enlarging 40 ✕

b LIQUID ENCLOSURES IN A CEYLON
SAPPHIRE. A small part of the above
stone interior under stronger enlargement.
It is clearly visible that all these enclosures
are set in relation to each other following
approximately the crystallographic orientation.
The directions of the crystaledges intersect
under certain angles.

Microphotograph enlarging 210 ✕
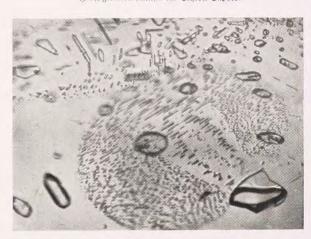
a

Liquid Enclosures
Inclusions liquides

Sapphire from Ceylon
Saphire de Ceylon

b

Liquid Enclosures
Inclusions liquides
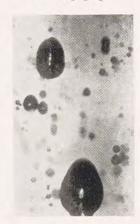
Sapphire from Ceylon
Saphire de Ceylon

Gasblase im Glas.

Gasblasen im synthetischen Rubin
alter Erzeugung.

a

b

Gasbubble in Glas
Vésicule dans un verre

Gasbubbles in synthetic Ruby
(old. manufacture)
*Vésicule de gaz dans un Ruby synthétique
(manufacture ancienne)*

Gasblasen im synthetischen Rubin.

Luftgefüllte Sprünge.

c

d

Gasbubbles in synthetic Ruby
(new manufacture)
Vésicules de gaz dans un Ruby synthétique

Cracks filled with air
Crevasses remplis d'air

a GAS BUBBLE IN GLASS. Characteristic is the wide dark non transparent border.

Microphotograph enlarging 50 ✕

b GAS BUBBLES IN A SYNTHETIC RUBY OF OLDER MANUFACTURE. The large gas bubbles are partly distorted and appear dark except for a small spot in their centre.

Microphotograph enlarging 48 ✕

c GAS BUBBLES IN A SYNTHETIC RUBY OF NEWER MANUFACTURE. The Gas Bubbles are considerably smaller and appear in heaps in the stone. The greater part of the interior of a good synthetic stone should be almost free of such bubbles but a single such bubble in a stone clearly designates the stone as synthetic.

Microphotograph enlarging 48 ✕

d INTERNAL CRACK FILLED WITH AIR. If in any stone a crack fills with air, the air filled part appears dark and non transparent. Frequently wing like formations similar to the one illustrated in d are found.

Microphotograph enlarging 35 ✕

a STRIPES OF AUGMENTATION IN A GREEN
SYNTHETIC SAPPHIRE. The more or less curved
stripes are more or less close to each other and appear
sharp and distinct. These stripes of augmentation are
generated during the manufacture of the synthetic
stone.
The molten substance of the constituent materials
appears in melted drops which are blown onto a ro-
tating clay cone. Naturally the material, though well
mixed, shows a slight difference of colour which is the
cause of these stripes in almost all synthetic stones.
curved stripes of augmentation are an absolute charac-
teristic of synthetic jewels and the appearance of
these curved stripes (Striations) is complete
evidence of a stone being synthetic.
Synthetic Rubies, green Sapphires as well as Dark
Synthetic Spinels show this augmentation striping espe-
cially clearly and sharply.

Microphotograph enlarging 60 $\times$

b AUGMENTATION STRIPES IN A BLUE
SYNTHETIC SAPPHIRE. Here the aug-
mentation stripes are much broader and
more indistinct than in the Ruby or the
green Sapphire. These stripes of augmen-
tation in a blue Sapphire are already visible
with the naked eye when the stone is em-
bedded in a highly refractive liquid (Benzol
or Mono Bromo Naphtalin). (Look for Gas-
enclosures with the Microscope.)

Microphotograph enlarging 60 $\times$

Anwachsstreifen in grünem synthetischen Saphir.

a

Lines of Augmentation (Striations)   **Synthetic green Sapphire**
Lignes d'Augmentation   *Saphire vert synthétique*
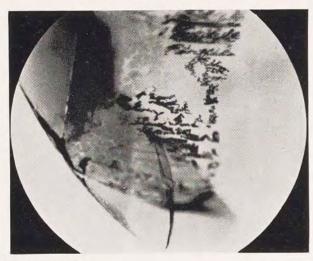
Anwachsstreifen in synthetischem blauen Saphir.

b

Lines of Augmentation (Striations)   **Synthetic blue Sapphire**
Lignes d'Augmentation   *Saphire bleu synthétique*

a

Crystal Skeletons   **Synthetic Ruby**
Squelettes de cristaux   *Ruby synthétique*

b

Skeletons of cristals   **Synthetic Ruby**
Squelettes de cristaux   *Ruby synthétique*

a & b SKELETONLIKE FORMATIONS IN A SYNTHETIC RUBY. The colouring materials used for the initial mixture in the manufacture of synthetic stones, Rubies especially, secern these sometimes skeletonlike appearing dark non transparent formations. The appearance of such skeletons in a stone is not in itself a clear indication as to whether the stone is natural or synthetic because similar forms appear in both cases. It is necessary to look for the other indications of synthetic Rubies before condemning the stone, as for instance: curved augmentation stripes, gas bubbles etc. Natural stones show zone structure, liquid enclosures or crystalline enclosures etc. which are never found in synthetic material.

Microphotograph enlarging $\dfrac{\text{a } 120 \times}{\text{b } 80 \times}$
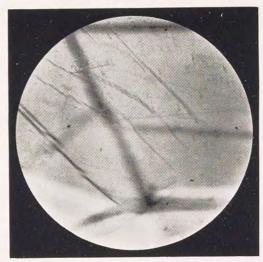
a INTERNAL CRACKS IN A SYNTHETIC
SAPPHIRE. The synthetic stones being
created under high temperature have internal
tensions and strains which sometimes result
in these internal cracks and fissures. The
appearance of these internal cracks
should always arouse suspicion and
invite further accurate examination.
Internal cracks of course also appear some—
times in natural stones, as they for instance
are sometimes brought about by careless
handling in grinding the stone.

Microphotograph enlarging 48 ✕

b CRACKS IN A SYNTHETIC RUBY.
Starting from the edge of a facet a series
of small cracks runs trough the stone, surely
a suspicious condition, which especially in-
dicates the necessity of an exact examina-
tion of the stone.

Microphotograph enlarging 48 ✕

Sprünge im synthetischen Saphir.

Internal cracks and fissures   Synthetic Sapphire
Crevasses intérieures   *Saphire synthétique*

a

Sprünge im synthetischen Rubin.

Internal Cracks & Fissures   Synthetic Ruby
Crevasses intérieures   *Ruby synthétique*

b

XXVII

Gasbubble & Softly curved striae   Glass
Vésicule de gaz et lignes striées   *Verre*

Mikroskopisches Bild einer Granatdoublette.

Doublette. Microscopie picture   Garnet & glass
Photographie microscopique d'une doublette   *Grenat et Verre*

a GAS BUBBLES IN GLASS, WITH
SOFTLY FURROWED STRIAE. Glasses
are recognized by the complete lack of
Pleochroism, by gas bubbles as enclosures
and also by the appearance of these softly
curved furrowed. Lines, especially distinct
when the diaphragma of the microscope is
made smaller to shut off the border rays.

Microphotograph enlarging 65 ✕

b MICROSCOPIC PICTURE OF A DOUB-
LETTE. The upper part of a garnet con-
tains regularly disposed Augite needles and
is pasted together with a lower part of
glass. The division surface shows air
bubbles. The black line cutting through the
picture shows the "Rondiste" (facet–edge)
coarsely broken out.

Microphotograph enlarging 40 ✕

GENERAL INTRODUCTION

INTO THE USE OF THE IDENTIFICATION TABLES
FOR THE EXAMINATION OF COLOURED STONES.

The separate columns of these tables contain constant physical data for the different varieties of jewels, expressed in figures or letters, hereafter called "Constantes" which can be quickly ascertained by simple apparatuses:

THE SPECIFIC GRAVITY is ascertained with a Balance.

THE LIGHT REFRACTION (the refractive index) is measured with a Refractometer.

THE PLEOCHROISM is established with a Dichroscope.

THE REFRACTION: The fact whether a stone shows single or double refraction may be ascertained either with the Dichroscope or with a Microscope equipped with Polarizing Prisms.

These Constantes vary within certain limits for the same variety of stone on account of the variability of their chemical composition. As an example the Garnet varies considerably in chemical composition and consequently also varies as to its specific gravity and light refractive qualities. The specific gravity may also be greatly influenced by internal imperfections and inclusions.

The figures given therefore constitute limits within which the exact figures are generally to be found.

The column: "Greatest Difference between the Refractive Indices" indicates within which limits the other refractive indices are to be found after one has been established. (The Refractometer shows several borderlines when doubly refractive stones are examined.)

The figures for the refractive index vary according to the chemical composition but also according to the different colours of light, under which the examination is made. The faculty of colour dispersion of a jewel finds its expression in the dispersion of the light within the jewel. It is different in different jewels and may be the cause of widely different values for the refractive indices.

As an example: The index of refraction of the Diamond varies as follows:

$$\text{In green light: } n = 2.43$$
$$\text{In red light: } n = 2.41$$
$$\text{In blue light: } n = 2.45$$

It is generally advisable to employ yellow light for the examination of a gem for its index of refraction by using a Natrium Burner, viz a Gasburner into which Rocksalt is fed. The indices obtained are values for yellow light.

For non transparent substances a small quantity is scratched off and the powder imbedded in liquids, the refractive indices of which are known, thereby establishing the index of refraction of the opaque substance.

While perfect completeness is unattainable a large number of stone varieties are found classified in the following tables and there is hardly a stone used in the trade, which has not found due mention and classification.

As to the multitude of colour shades in jewels they are sometimes difficult to classify and a stone of mixed colour (greybrown, browngreen etc.) could have been classified in various sections of the tables. Stones of non descript colouring will be found in sections classifying stones of a colour nearest to the one in question. Should it not be possible to find a colour in complete coincidence, it will be advisable to consult the neighbouring table.

The System of Crystallization is expressed by letters: h, t, r, rh, m, tr:

r = regular (isometric)	m = monoclinic
h = hexagonal & trigonal	tr = triclinic
t = tetragonal	a = designates an amorphous (not crystallized substance)
rh = rhombohedral	

Refraction: s = single refraction
d = double refraction.

s (single refraction) is always combined with r (regular) or a (amorphous). (Regular or amorphosous substances are always singly refractive).

Tetragonal or hexagonal crystals are uniaxial or have one axis of optical symmetry in which direction a ray of transmitted light suffers no double refraction. (Compare forgoing text in Pocketbook).

Orthorhombic, monoclinic and triclinic crystals are biaxial and have three directions at right angles to each other in which the indices of refraction are different.

According to the kind of selective absorption the crystal may be dichroic or trichroic (or in general pleochroic) they have the property of exhibiting different colors in different crystallografic directions. Pleochroic Phenomena are rendered according to their degree of intensity and according to their colour shades. The two or three maximally different colours appear connected by the word "and" or &.

Examples of Pleochroism are found on Colour Plates VI & VII. The introduction thereto explains the influence of daylight and artificial light upon the phenomena. It was of course impossible to bring all existing colourshades of all varieties, but the tables will be found of

ample completeness and containing all varieties which the jeweler might possibly run across.

Synthetic Stones, Glasses, Doublettes are not contained in these tables, but the main characteristics of glasses and doublettes have been enumerated in separate tables. The pleochroic qualities of synthetic stones are also tabulated in special sheets, which should be consulted in all cases where stones are suspected of being synthetic.

SPECIAL REMARKS TO THE TABLES

Besides the physical "Constantes", deposited in the tables there are other observations to be considered. The very important matter of the Enclosures and the Colour-distribution have been already especially treated. (Compare Plates IX—XXVIII and informations thereto.)

HERE ARE SOME CHARACTERISTICS WHICH HAVE NOT BEEN CONSIDERED AS YET:

ELECTRIC PHENOMENA: (The power to become strongly electrified by friction or heating).

Electricity is generated through friction in the following substances:

Tourmaline
Topaz
Cordierite (Iolite)
Cyanite
Amber (simultanously producing aromatic odor).

Electricity is generated through heating in: Tourmaline & Cordierite (Iolite).

CLEAVAGE: Cleavage is the natural fracture of a crystallized mineral yielding more or less smooth surface. Cleavage is highly developed in Euclase, Spodumene, Hiddenite, Kunzite, Topaz, Sphalerite.

LUSTER: Strikingly high luster when compared to other stones of the same colour are exhibited by:

The Diamond
Sphalerite
Diamantoid
Phenacite
Hiddenite
Kunzite
and some Zircons

HARDNESS: Cyanite (Disthene) shows differences in hardness according to the direction in which it is proved.

Hardness is the resistance offered by a smooth surface to abrasion. It is measured by reference to the following scale of Mohs:

1. Talc	3. Calcite	5. Apatite	7. Quartz
2. Gypsum	4. Fluorite	6. Feldspar	8. Topaz

9. Sapphire
10. Diamond

IREDESCENCE:

Opals show irisating areas and internal deposits.

Many Quartzvarieties, amongst them also those which have gone through a process of annealing and subsequent coloring also show iredescence. Such stones which have been cooled off too abruptly after the heating receive cracks and crevices into which the colouring material has penetrated alongside with the air, all of which combines to give an irisating effect to the colouring. (Craquelé.)

IMPORTANT DEVIATIONS IN LIGHTREFRACTION AND SPECIFIC GRAVITY:

The Zircon group shows strong deviations in these two respects. There are two groups to be distinguished:

Zircons of low density (light weight) and low refractive index:

spec. grav. 4.0 — 4.2
refr. Index : 1.82 — 1.8

These Zircons are often greenish in colour.

Zircons of higher density heavier:

spec. grav. up to 4.8
refr. Index to 1.92 — 1.98.

These Zircons are mostly either colorless, red or blue.

GENERAL PROCEDURE
FOR THE
EXAMINATION OF A JEWEL.

HOW TO PROCEED WITH THE EXAMINATION OF A STONE:

The proceeding will depend upon wether the stone is loose or in a setting and furthermore upon the instruments the jeweler has at his disposal.

The following tables show the way generally recommended for the examination. According to the grade of his experience the jeweler will satisfy himself by ascertaining a smaller or larger number of the characteristics before he arrives at a definite conclusion. In the beginning it will be advisable to make too many rather than too few of the determining examinations.

It is always necessary to extend the examination into ascertaining more than one of the characteristics to avoid mistakes, because jewels may be alike in one characteristic and still widely apart in species and value.

It is generally recommended to proceed with the examination under employment of the following tables in the order cited herewith:

1. Ascertainment of the Character depending upon DOUBLE REFRACTION and PLEOCHROISM.
   Thereafter Classification into TABLE I or TABLE II (next pages).
2. EXAMINATION of the MAIN CHARACTERISTICS:
   Enclosures
   Colordistribution
   Examination with the hardened steelpoint (Glass or Jewel?)
   Examination of the Rondiste (Contour Edge) for the possibility of being a doublette
   Thereafter division into the groups a, b, c, d, of the following table I.
3. Further Examination by ascertainment of the:
   Specific Gravity or Density
   Light Refraction
   Light Absorption with the Filterlamp (Detectoscope)
   Luminescence phenomena.
   Exact examination of the Enclosures and the Examination of the Hardness

---

For Stones in a Setting it is necessary to deviate from the above way of procedure in cases where it is not permitted to take the stones out of their setting. In these cases it is impossible to ascertain the specific gravity, or to examine the Rondiste, and even the optical examination is often hindered by the setting. It is possible to cover up a lot of blemishes by clever setting, and the possibility of being taken advantage of is much greater in set stones than in stones without a setting.

The usual procedure in examining a stone in a setting is as follows:

1. Double Refraction and Pleochroism
2. Examination of the Enclosures
3. Examination with the hardened steelpoint
4. Light Refraction (Finding the Index of refraction)
5. Immersion in Liquids and examination for defects
6. Examination with the Detectoscope
7. Examination for Luminescence (Rayonneur).

I. PRODUCTS SHOWING SINGLE REFRACTION AND NO PLEOCHROISM

Material	Examine for the following characteristics
a Glass	Minor Hardness Warmer to the Touch Efflorescence. Halo keeps longer when warmly breathed upon Colorsubstance distributed in irregular softly curved folding lines. (Striations) Gas Enclosures Total absence of liquid enclosures Specific characteristics in filtered light Assailability by acids Specific gravity and lightrefraction may be the same as in genuine jewels
b Doublettes	Divisionline on the Rondiste (contour—edge) Differences in colouring of the different parts when immersed in liquids Inclusions in the different parts and gasbubbles on the joining surface Luminescence phenomena Hardness of upper and lower part are different (Garnet doublette) Specific gravity and lightrefraction may be the same as in genuine jewels
c Natural Jewels	Colour Specific gravity Light Refraction Enclosures, at the same time Liquid Vanes, Defects cracks etc. Immerse in Liquid! Colour Distribution (Zonar Structure) Behaviour in Filtered Light Luminescence Phenomena
d Synthetic Stones (Spinel)	Enclosures (Gasbubbles) Augmentation Stripes Luminescence phenomena Series of cracks on the facets Signs of internal tensions (spotted parts showing double refraction)

In all cases it is necessary to examine for introduced colorfilms, artificial colouring, laquering and painting etc.

II. PRODUCTS WITH DOUBLE REFRACTION AND PLEOCHROISM

Material	Examine for the following characteristics
a Doublettes	Division Line on the Rondiste Differences in Colour of the different parts. Immerse in Liquid! Enclosures in the different parts and on the dividing plain (gasbubbles) Hardness of upper and lower part differs frequently Lightrefraction and specific gravity may be the same as those of genuine jewels Double refraction may be a deciding factor in cases when no position is attainable in which the light extinguishes under crossed Nicols Pleochroism sometimes not to be established in vividly coloured stones even though they be strongly double refractive. (They are Doublettes with colourless upper and lower part with coloured isotropic layer between)
b Natural Jewels	Colour Specific Gravity Light Refraction Pleochroism Behaviour in Filtered Light Inclusions and Colour distribution (Zonar structure) Defects, Vanes, Cracks. Immerse in Liquid! Luminescence Hardness as a factor of verification Determination of the place where the stone has been found by Enclosures and luminescence phenomena
c Synthetic Stones (Corundum)	Enclosures (Gasbubbles) Augmentation Stripes Crevices and cracks. Series of cracks Luminescence phenomena

In all cases examine for introduced coloured layers or films, artificial deepening of colours through lacquering and painting etc.

COMBINED
TABLES
FOR

SPECIFIC GRAVITY

SYSTEM OF CRYSTALLIZATION

LIGHT REFRACTION

REFRACTIVE INDEX

LARGEST DIFFERENCE BETWEEN REFRACTIVE
INDICES

PLEOCHROISM

&

HARDNESS

1. Colourless Stones

Name	Specific Gravity (Density)	System of Crystallization & Light Refraction		Index of Refraction	Greatest difference between the Indices of Refraction	Pleochroisms	Hardness
Zircon	4.7 —4.2	t	d	1.97—1.93	0.04		7¹/₂
Sapphire	4.0 —3.9	h	d	1.77—1.76	0.008		9
Spinel	3.65—3.5	r	s	1.72	—		8
Grossularite	3.66—3.55	r	s	1.74	—		6—7¹/₂
Topaz	3.6 —3.4	rh	d	1.63—1.62	0.01		8
Diamond	3.52	r	s	2.43	—		10
Fluorite	3.2 —3.1	r	s	1.453	—		4
Apatite	3.2	h	d	1.64—1.63	0.005		5

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Colourless Stones

CONTINUED

Name	Specific Gravity (Density)	System of Crystallization & Light Refraction		Index of Refraction	Greatest difference between the indices of Refraction	Pleochroisms	Hardness
Spodumene	3.20—3.13	m	d	1.676—1.660	0.016		$6^{1}/_{2}$
Euclase	3.1	m	d	1.671—1.652	0.019		$7^{1}/_{2}$
Tourmaline	3.1	h	d	1.64—1.62	0.015		$7—7^{1}/_{4}$
Phenacite	3.0 —2.97	h	d	1.670—1.654	0.016		$7^{1}/_{2}$
Beryl	2.8 —2.6	h	d	1.577—1.572	0.005		$8—7^{1}/_{2}$
Quartz (Rock-crystal)	2.7	h	d	1.55—1.54	0.009		7
Moonstone (Adular)	2.6	m	d	1.53—1.52	0.006		$6^{1}/_{2}—6$
Hyalite	2.2	a	s	1.45—1.44	—		6—5

2. Red and Rosered Stones

Name	Specific Gravity (Density)	System of Crystallization & Light Refraction	Index of Refraction	Greatest difference between the indices of Refraction	Pleochroism	Hardness
Zircon	4.7 — 4.2 (also to 4.0)	t d	1.98—1.93	0.040	very weak, lighter & darker	$7^{1}/_{2}$
Almandine	4.3 — 3.9 (also to 3.6)	r s	1.76	—	none	$7^{1}/_{2}$—7
Ruby	4.0 — 3.9	h d	1.77—1.76	0.008	strong, yellow—red and deep—red to blueish—red	9
Pyrope Capegarnet Cape ruby Bohem, Garnet	3.86—3.7	r s	1.81—1.77	—	none	$7^{1}/_{2}$—7
Hessonite	3.75—3.50	r s	1.77—1.74	—	none	$7^{1}/_{2}$—7
Spinel	3.75—3.50	r s	1.720—1.715	—	none	8
Rhodonite	3.70—3.40	tr d	1.740—1.730	0.01	distinct, rosered & blueish green to brown	6—5
Topaz	3.60—3.50	rh d	1.63—1.62	0.01	distinct blueish—red & yellowish—red	8

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Red and rosered Stones

CONTINUED

Name	Specific Gravity (Density)	System of Crystallization & Light Refraction	Index of Refraction	Greatest difference between the indices of Refraction	Pleochroism	Hardness
Diamond	3.52	r s	2.43	—	none	10
Fluorite	3.20—3.10	r s	1.435	—	none	4
Kunzite	3.18	m d	1.676—1.660	0.016	strong, lilac & pale pink to almost colourless	6½
Tourmaline	3.10	h d	1.64—1.62 (also to 1.68)	0.020—0.010	strong, pure red & yellow—red	7¼—7
Morganite (Beryl)	2.8 —2.6	h d	1.58—1.57	0.006	distinct, lightblueish—red & light yellow—ish—red	8—7½
Rosequartz	2.7	h d	1.55—1.54	0.009	very weak	7
Fire Opal	2.2	a s	1.45—1.35	—	none	6—5
Amber	1.1 —1.0	a s	1.54	—	none	2½—2

3. Redbrown and greybrown Stones

Name	Specific Gravity (Density)	System of Crystallization & Light Refraction		Index of Refraction	Greatest difference between the indices of Refraction	Pleochroism	Hardness
Hyacinth (Zircon)	4.7 —4.2 (also to 4.0)	t	d	1.97—1.93	0.040	very weak, reddish—brown & yellowish—brown	$7^{1}/_{2}$
Ruby (Siam, poor quality)	4.0 —3.9	h	d	1.77—1.76	0.008	distinct, brown—red & yellow—red	9
Almandine	4.3 —3.9 (also to 3.6)	r	s	180—1.76	—	none	$7^{1}/_{2}$—7
Spessartine	4.3 —4.0	r	s	1.82—1.79	—	none	$7^{1}/_{2}$—7
Staurolite	3.7 —3.4	rh	d	1.75—1.76	0.010	distinct, yellowish & red	$7^{1}/_{2}$
Topaz	3.6 —3.4	rh	d	1.63—1.62	0.010	strong, red and yellow	8
Pyrope	3.86—3.7	r	s	1.80—1.77	—	none	$7^{1}/_{2}$—7
Hessonite	3.70—3.55	r	s	1.77—1.74	—	none	$7^{1}/_{2}$—7

Redbrown and greybrown Stones

CONTINUED

Name	Specific Gravity (Density)	System of Crystallization & Light Refraction		Index of Refraction	Greatest difference between the Indices of Refraction	Pleochroism	Hardness
Epidote	3.50—3.25	m	d	1.77—1.71	0.05—0.01	strong, brown & grey & yellow	7—6
Vesuvianite	3.45—3.35	t	d	1.73—1.72	0.005	distinct, rosered & nearly colourless	6½
Axinite	3.30—3.25	tr	d	1.68—1.67	0.010	strong, violet & brown & greenish	7—6½
Andalusite	3.20—3.16	rh	d	1.645—1.630	0.010	strong, yellow to yellowgreen & reddish	7½—7
Tourmaline	3.10	h	d	1.68—1.62 mostly 1.64 to 1.62 (also to 1.68)	0.02	strong, lighter & darker brown	7¼—7
Quartz	2.7	h	d	1.55—1.54	0.009	weak, lighter & darker brownyellow	7
Fire Opal	2.2	a	s	1.45—1.35	—	none	6—5
Amber	1.1—1.0	a	s	1.54	—	none	2½—2

4. Brownyellow and yellowbrown Stones

Name	Specific Gravity (Density)	System of Crystallization & Light Refraction	Index of Refraction	Greatest difference between the indices of Refraction	Pleochroism	Hardness
Hyacinth (Zircon)	4.7 —4.2	t d	1.97—1.93	0.04	very weak, reddish—brown and yellow—brown	$7^1/_2$
Sphalerite	4.2 —4.0	r s	2.4	—	none	$4—3^1/_2$
Sapphire	4.0 —3.9	h d	1.77—1.76	0.008	weak, lighter and darker brownish & yellow	9
Hessonite	3.70—3.55	r s	1.77—1.74	—	none	$7^1/_2$—7
Chrysoberyl	3.65	rh d	1.76—1.745	0.01	weak, lighter & darker	$8^1/_2$
Topaz	3.80—3.40	rh d	1.63—1.62	0.01	distinct, yellow & brownred	8
Titanite	3.56—3.40	m d	2.03—1.89	0.14	noticeable	$5^1/_2$—5
Diamond	3.52	r s	2.43	—	none	10

Brownyellow and yellowbrown Stones

CONTINUED

Name	Specific Gravity (Density)	System of Crystallization & Light Refraction		Index of Refraction	Greatest difference between the indices of Refraction	Pleochroism	Hardness
Epidote	3.50—3.25	m	d	1.77—1.71	0.05—0.01	strong, green & brown & yellow	7—6
Vesuvian	3.45—3.35	t	d	1.73—1.72	0.005	distinct, greenyellow & lightyellow	6½
Chrysolith	3.40—3.30	rh	d	1.70—1.66	0.03	weak, greenishbrown & yellowishbrown	7
Fluorite	3.20—3.10	r	s	1.435	—	none	4
Tourmaline	3.10	h	d	1.68—1.62 mostly 1 64 to 1.62	0 02—0.01	distinct, redbrown & yellowgreenbrown	7¼—7
Beryl (Heliodor)	2.8 —2.6	h	d	1.58—1.57	0.006	weak, greenishyellow & brownyellow	8—7½
Citrine (Burned Amethyst)	2.7	h	d	1.55—1.54	0.009	weak, reddishyellow & cleaneryellow	7
Amber	1.1 —1.0	a	s	1.54	—	none	2½—2

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5. Yellow Stones

Name	Specific Gravity (Density)	System of Crystallization & Light Refraction		Index of Refraction	Greatest difference between the indices of Refraction	Pleochroism	Hardness
Zircon	4.7 — 4.2 (also to 4.0)	t	d	1.97 — 1.93	0.040	very weak differences	$7\frac{1}{2}$
Sapphire	4.0 — 3.9	h	d	1.77 — 1.76	0.008	very differences in depth of colour	9
Spinel	3.8 — 3.5	r	s	1.72	—	none	8
Chrysoberyl	3.65	rh	d	1.76 — 1.745	0.01	weak differences in depth of colour	$8\frac{1}{2}$
Topaz	3.65 — 3.50	rh	d	1.63 — 1.62	0.01	distinct, light dear-yellow and darker brownishyellow	8
Diamond	3.52	r	s	2.43	—	none	10
Chrysolith	3.40 — 3.30	rh	d	1.70 — 1.66	0.03 — 0.02	weak, greenish & yellowgreenish	7
Spodumene	3.20 — 3.13	m	d	1.676 — 1.660	0.016	entirely weak	$6\frac{1}{2}$

Name	Specific Gravity (Density)	System of Crystallization & Light Refraction		Index of Refraction	Greatest difference between the indices of Refraction	Pleochroism	Hardness
Fluorite	3.20—3.10	r	s	1.435	—	none	4
Tourmaline	3.1	h	d	1.64—1.62 (also to 1.68)	0.015	distinct, darkyellow & lightyellow	$7^{1}/_{4}$—7
Phenacite	3.0 —2.97	h	d	1.67—1.654	0.016	not noticeable	$7^{1}/_{2}$
Beryl	2.8 —2.6	h	d	1.58—1.57	0.006	weak, greenyellow & goldyellow	8—$7^{1}/_{2}$
Citrine	2.7	h	d	1.55—1.54	0.009	weak, lighter & darker yellow	7
Fire Opal (Pale)	2.2	a	s	1.45—1.35	—	none	6—5
Amber	1.1 —1.0	a	s	1.54	—	none	$2^{1}/_{2}$—2

6. Yellowgreen Stones and green Stones

Name	Specific Gravity (Density)	System of Crystallization & Light Refraction		Index of Refraction	Greatest difference between the indices of Refraction	Pleochroism	Hardness
Zircon	4.4 — 4.0 (also above)	t	d	1.97—1.98	0.040	very weak differences	$7^{1}/_{2}$
Sapphire	4.0 — 3.9	h	d	1.77—1.76	0.009	distinct, green & brownishgreen	9
Spinel	4.0 — 3.65	r	s	1.72	—	none	8
Demantoid	3.9 — 3.8	r	s	1.90—1.88	—	none	$7^{1}/_{2}—6^{1}/_{2}$
Chrysoberyl	3.65	rh	d	1.76—1.745	0.01	strong, yellow & green tints	$8^{1}/_{2}$
Alexandrite	3.65	rh	d	1.76—1.745	0.01	in natural light: strong, green & yellow & red; in artificial light: strong, raspberryred and orange-red & green	$8^{1}/_{2}$
Topaz	3.65—3.50	rh	d	1.63—1.62	0.01	distinct, yellowish & greenish	8
Titanite	3.56—3.40	m	d	2.03—1.89	0.014	distinct, yellow & green & redbrown	$5^{1}/_{2}—5$

Yellowgreen Stones and green Stones

CONTINUED

Name	Specific Gravity (Density)	System of Crystallization & Light Refraction		Index of Refraction	Greatest difference between the indices of Refraction	Pleochroism	Hardness
Diamond	3.52	r	s	2.43	—	none	10
Uvarovite	3.52—3.40	r	s	1.838	—	none	7
Epidote	3.50—3.25	m	d	1.77—1.71	0.05—0.01	strong, green & yellow & brown	7—6
Vesuvian	3.45—3.35	t	d	1.73—1.72	0.005	distinct, green & yellow	6½
Diopside	3.45—3.20	m	d	1.69—1.66	0.03	weak	6—5
Chrysolith	3.40—3.30	rh	d	1.70—1.66	0.03	weak, green & yellowishgreen	7
Dioptase	3.30	h	d	1.70—1.644	0.05	noticeable, lighter and darker green	5
Hiddenite	3.20	m	d	1.676—1.660	0.016	strong, bluegreen & yellowishgreen	6½

Yellowgreen Stones and green Stones

CONTINUED

Name	Specific Gravity (Density)	System of Crystallization & Light Refraction		Index of Refraction	Greatest difference between the indices of Refraction	Pleochroism	Hardness
Apatite	3.20	h	d	1.64—1.63	0.005	noticeable, reddish-yellow & blueishgreen	5
Andalusite	3.20—3.10	rh	d	1.645—1.630	0.010	strong, yellow & green & red	7½—7
Fluorite	3.20—3.10	r	s	1.44	—	none	4
Tourmaline	3.10	h	d	1.64—1.62 (also to 1.68)	0.02—0.01	strong, bluegreen & yellowgreen to brown-green	7¼—7
Euclase	3.10	m	d	1.671—1.652	0.019	not noticeable	7½
Prehnite	2·9	rh	d	1.650—1.616	0.034	weak	6
Emerald	2.75—2.65	h	d	1.58—1.57	0.006	strong, bluegreen & yellowgreen	8—7½
Moldavite	2.36	a	s	1.5	—	none	5½

7. Bluegreen Stones

Name	Specific Gravity (Density)	System of Crystallization & Light Refraction		Index of Refraction	Greatest difference between the indices of Refraction	Pleochroism	Hardness
Sapphire	4.0 —3·9	h	d	1.77—1.76	0.008	distinct, bluegreen & yellowgreen	9
Spinel	3.9 —3.65	r	s	1.72	—	none	8
Topaz	3.6 —3.50	rh	d	1.63—1.62	0.010	distinct, colorless & greenishblue	8
Diamond	3.52	r	s	2.43	—	none	10
Fluorite	3.20—3.10	r	s	1.44	—	none	4
Euclase	3.10	m	d	1.671—1.652	0.019	not noticeable	7¹/₂
Tourmaline	3.10	h	d	1.64—1.62 (also to 1.68)	0.02—0.01	strong, lighter & darker bluegreen	7¹/₄
Beryl	2.8 —2.6	h	d	1.58—1.57	0.006	distinct, blueishgreen & yellowishgreen	8—7¹/₂

8. Blue Stones

Name	Specific Gravity (Density)	System of Crystallization & Light Refraction		Index of Refraction	Greatest difference between the Indices of Refraction	Pleochroism	Hardness
Zircon	4.7 — 4.6	t	d	1.97—1.93	0.040	strong, steelblue & dirty fleshcolored	$7^{1/2}$
Sapphire	4.0 — 3.9	h	d	1.77—1.76	0.008	distinct, darkblue to violetblue & lightblue to greenish	9
Spinel	3.8 — 3.5	r	s	1.72	—	none	8
Cyanite	3.7 — 3.6	tr	d	1.728—1.712	0.016	strong, colorless & violetblue & cobalt-blue	7 — 4
Benitoite	3.65	h	d	1.804—1.757	0.047	strong, almost color-less & purpleblue	6
Topaz	3.6 — 3.5	rh	d	1.63— 1.62	0.010	distinct, blue & light-yellow	8
Diamond	3.52	r	s	2.43	—	none	10
Vesuvian (Cyprine)	3.50—3.30	t	d	1.73—1.72	0.005	distinct, darkblue & colorless	$6^{1/2}$

Blue Stones

CONTINUED

Name	Specific Gravity (Density)	System of Crystallization & Light Refraction		Index of Refraction	Greatest difference between the indices of Refraction	Pleochroism	Hardness
Apatite	3.20	h	d	1.64—1.63	0.005	distinct, skyblue & palewinered	5
Fluorite	3.20—3.10	r	s	1.435	—	none	4
Tourmaline	3.10	h	d	1.64—1.62 (also to 1.68)	0.02—0.01	strong, lighter & darkerblue	$7^{1}/_{4}$—7
Euclase	3.10	m	d	1.671—1.652	0.019	not noticeable	$7^{1}/_{2}$
Beryl	2.8 — 2.6	h	d	1.58—1.57	0.006	distinct, lighter & darker blue	8—$7^{1}/_{2}$
Cordierite (Iolite)	2.66—2.6	rh	d	1.55—1.535 (also to 1.59)	0.007	strong, darkvioletblue & yellowgrey & grey—blue	$7^{1}/_{2}$—7
Haüynite	2.5 —2.4	r	s	1.496	—	none	6
Sodalite	2.30—2.15	r	s	1.483	—	none	6

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9. Purplecoloured, violet & lilac-coloured Stones

Name	Specific Gravity (Density)	System of Crystallization & Light Refraction		Index of Refraction	Greatest difference between the indices of Refraction	Pleochroism	Hardness
Zircon	4.7 —4.2 (also below)	t	d	1.97—1.93	0.040	weak differences	7¹/₂
Almandine	4.3 —3.6	r	s	1.80—1.76	—	none	7¹/₂—7
Sapphire	4.0 —3.9	h	d	1.77—1.76	0.008	distinct, violet & red-dish	9
Spinel	3.7 —3.5	r	s	1.72	—	none	8
Rhodonite	3.70—3.40	tr	d	1.744—1.726	0.010	distinct, red & green-ish to brown	6
Benitoite	3.65	h	d	1.804—1.757	0.047	strong, reddishgrey, almost colorless and purpure	6
Manganese-Epidote	3.30—3.25	m	d	1.77 —1.71	0·05—0.01	strong, orange & violet & red	7—6
Violan-Diop-side	3.45—3.20	m	d	1.69—1.66	0.03	weak, lightvioletblue & lightreddishviolet	6—5

Purple coloured, violet & lilac=coloured Stones

CONTINUED

Name	Specific Gravity (Density)	System of Crystallization & Light Refraction		Index of Refraction	Greatest difference between the indices of Refraction	Pleochroism	Hardness
Axinite	3.30 — 3.25	tr	d	1.68—1.67	0.010	strong, violet & brown & green	7—6½
Fluorite	3.20 — 3.10	r	s	1.44	—	none	4
Apatite	3.20	h	d	1.64—1.63	0.005	entirely weak	5
Kunzite	3.18	m	d	1.676—1.660	0.016	strong, lilac & pale lilac to colorless	6½
Tourmaline	3.10	h	d	1.64—1.62 (also to 1.68)	0.020—0.010	distinct, lighter & darker lilac	7¼—7
Phenacite	3.0 — 2.97	h	d	1.670—1.654	0.016	not noticeable	7½
Amethyst	2.7	h	d	1.55—1.54	0.009	distinct, lilac & pink	7
Cordierite (Iolite)	2.66—2.6	rh	d	1.55—1.535	0.007	strong, darkvioletblue & yellowgrey & grey—blue	7½—7

SYNTHETIC STONES

ARE NOT INCLUDED IN THESE TABLES

Synthetic Stones show in general the same physical qualities as the natural Spinels and Corundums. But synthetic jewelry stones are manufactured in colour varieties and tints which do not occur at all in natural genuine gems, or at least not in such purity flawlessness and intensity of colour.

The following table gives the pleochroitic colours of synthetic stones of such unnatural colour varieties

Darkgreen synthetic spinels of recent appearance upon the market show a change of colour when brought into artificial light from daylight and vice versa, giving an effect similar to the quality of the genuine Alexandrite to change its colour.

This colour change however has nothing to do with Pleochroism.

Such dark Russiangreen spinels (dark olivegreen) appear brownred to redbrown in the artificial light but show no trace of Pleochroism.

Very remarkable however are some synthetic Alexandritelike Corundums of the latest manufacture. They exhibit pleochroic qualities much closer to the Pleochroism of the genuine Alexandrite than similar stones of previous manufacture but the differences are still too apparent to make deception of the initiated possible.

PLEOCHROISM OF SYNTHETIC CORUNDUM VARIETIES

VARIETY	Colortints in the Dichroscope
Rosered Corundum.............	Yellowish & pink
Violetrosered Corundum	Yellowish & Lilac
Dark rosered Corundum	Yellowred–violet
Fireopalred Corundum	Yellowred & violetred
Darkred Corundum	Strong, yellowred & blueishred
Orangeyellow Corundum (called Padparadshah)	Dark orangered & light greyyellow
Ochreyellow Corundum	Very feeble. Lighter & Darker yellow
Citrinyellow Corundum.........	Very feeble
Lightgreen (yellow green) Corundum (Amaryl)	Feeble. Yellowishgreen & blueishgreen
Darkgreen Corundum	Strong, Bluegreen & yellowgreen
Alexandritelike Corundum (old variety	In natural daylight: Very strong. Dirty bluegreen & yellowgreen. In artificial light: Bluered & yellowred
Alexandritelike Corundum (new variety)	In natural daylight: Very strong. Bluegraygreen & yellowgreen with red side tints. In artificial light: Very strong. Vividly raspberryred & greyblue to vividly blue.
Lightblue Corundum...........	Very feeble
Darkblue Corundum	Strong. Lightyellowblue to greenishblue & darkblue
Purple Corundum	Violet & bluegrey
Lightvioletblue Corundum	Colorless–blueish

10. Non transparent Stones

Name	Colour	Hardness	Specific Gravity	Index of Refraction
Jadeite	white to grey	6½—7	3.33	near 1.655
Nephrite	white to grey	5½—6	3.0	near 1.62
Chalcedony	white to grey	6½	2.6	1.537
Opal	white, milky	5—6	2.2	near 1.45
Smithsonite	blue	5	4.1—4.5	near 1.62—1.82
Azurite	blue	3½—4	3.8	1.73—1.83
Lazulite	blue	5½	3.1	1.60—1.64
Bone Turquois	blue	5	3.0—3.5 also below	variable
Turquois	blue	6	2.6—2.8	1.61—1.65

Non transparent Stones
CONTINUED

Name	Colour	Hardness	Specific Gravity	Index of Refraction
Coloured Agate	blue	$6\frac{1}{2}$	2.6	near 1.54
Lazurite (Lapis Lazuli)	blue	$5\frac{1}{2}$	2.4	—
Glass Paste	blue	5	changeable	variable
Chrysocolla	blue	2—4	2.0—2.3	near 1.58—1.60
Malachite	green	$3\frac{1}{2}$	3.7—3.8	1.70—1.90
Jadeite	green	$6\frac{1}{2}$—7	3.33	near 1.655
Nephrite	green	$5\frac{3}{4}$	3.0	near 1.62
Prehnite	green	6—$6\frac{1}{2}$	2.8—3	1.61—1.65
Turquois	green	6	2.6—2.8	1.61—1.65

Non transparent Stones
CONTINUED

Name	Colour	Hardness	Specific Gravity	Index of Refraction
Prase	green	7	2.65	near 1.540
Chrysoprase	green	7	2.65	near 1.540
Serpentine	green, interveined	4—5	near 2.6	near 1.56
Amazonestone	green	6	2.55	near 1.520
Chrysocolla	montaingreen	2—4	2.0—2.3	near 1.58—1.60
Opal	green	6	1.9—2.2	near 1.45
Iserine	black	5½—6	4.5—5.2	—
Hämatite	black	5½	4.7	—
Pleonaste (Ceylonite)	black	7¼	3.6—3.8	—

Non transparent Stones
CONTINUED

Name	Colour	Hardness	Specific Gravity	Index of Refraction
Obsidian	black	$5^{1}/_{2}$	2.5—2.6	variable
Jet	black	3—4	1.35	—
Carnelian	yellow & brown	$6^{1}/_{2}$	2.6	near 1.54
Fire Opal	yellow & brown	6	1.9—2.2	near 1.45
Amber	yellow & brown	2—3	1.1—1.0	near 1.54
Rosequartz	red	7	2.65	near 1.545
Carnelian	red	$6^{1}/_{2}$	2.6	near 1.540
Agate	varicoloured	$6^{1}/_{2}$	2.6	near 1.540
Heliotrope	green with red points	$6^{1}/_{2}$	2.6	near 1.540

11. ASTERIA

STONES WITH REGULAR STELLATE OPALESCENCE (ASTERISM)

Stones showing starshaped lighteffect when viewed in the direction o the vertical axis of the crystal called asterism

Name	Specific Gravity	Hard-ness	
STARSAPPHIRE	4.1 – 3.9	9	Regular sixrayed Star, produced by minute needleshaped en-closures, symmetric-ally arranged parallel to the edges of the sixsided prism. Crys-talline faces which have been artificially etched also some-times exhibit Asterism
STARRUBY	4.1 – 3.9	9	
ALMANDINE	4.3 – 3.6	7 1/2	Regular circles of light, In certain position appearance of four-rayed star produced by minute inclusions arranged parallel to the four edgezones of the Rhombodode-kathedron

12. STONES WITH GLISTENING INTERNAL DEPOSITS:

Name	Specific Gravity	Hard-ness	
LAPIS LAZULI LAZURITE	2.45 – 2.40 (also above)	5 1/2	Contains often larger grains of Pyrite, glistening in gold-yellow colour
AVENTURINE QUARTZ	2.7 – 2.6	7	Contains fine mica scales
AVENTURINE FELDSPAR or SUNSTONE	2.65	6	Contains small tablets of Hematite

13. STONES WITH BILLOWY GLEAMING LIGHTEFFECT
(CHATOYANT STONES)

Name	Spec. Gravity	Hard-ness	Lighteffect
ZIRCON	4.7 – 4.0	$7\frac{1}{2}$	irregular gleam due to crystalline inclusions
SAPPHIRE CATSEYE	4.0 – 3.9	9	strong billowy gleaming light
CHRYSOBERYL CATSEYE (CYMOPHANE)	3.75 – 3.65	$8\frac{1}{2}$	very strong billowy streaky gleam
TOURMALINE CATSEYE	3.1 – 3.0	$7\frac{1}{4}$	irregular billowy gleam caused by inclusions
APATITE	3.1	5	billowy gleaming light
HAWKEYE	2.8 – 2.7	7	blackblueish fibrous mass, consisting of Krokydolith fibres saturated with Silicic acid
TIGERSEYE	2.8 – 2.7	7	derived from Hawkeye by decomposition, causing red–yellow colouring of the finely fibrous matter. Now called Tigerseye
QUARTZCATSEYE	2.7 – 2.65	7	billowy gleaming light caused by deposits of Amianthus needles
SATIN SPAR	2.7 – 2.6	3	fine fibrous Carbonate of Lime
MOONSTONE	2.55	6	strong billowy streaky gleam

14. STONES OF MORE THAN ONE COLOUR
(RIBBONED, DOTTED)

Name	Spec. Gravity	Hardness	Appearance
MALACHITE	4.1 − 3.7	$3\frac{1}{2}$	ribboned in varying dark colours
AZUR MALACHITE	3.9 − 3.8	$4 − 4\frac{1}{2}$	Malachite and Azurite in diverse layers
ONYX MARBLE	2.8 − 2.6	3	ribboned, variegated calcareous sinter
TURQUOIS MATRIX	2.9 − 2.6	6	Turquois with brown or yellowbrown remnants of the surrounding stone in which the T. is imbedded
SERPENTINE	2.7 − 2.5	4 − 3	ribboned and speckled in various dark green tints
ONYX & AGATE	2.7 − 2.55	$7 − 6\frac{3}{4}$	ribboned in various colours
MOSS STONE	2.7 − 2.55	$7 − 6\frac{3}{4}$	Quartz with heaped up inclusions, consisting of Actinolite needles
HELIOTROPE (BLOODJASPER)	2.65 − 2.60	$7 − 6\frac{3}{4}$	dark leekgreen Chalcedony with spots of red Jasper
MOTHER OF OPAL	2.3 − 1.9	6 − 5	Opal with remnants of the mother stone
AMATRIX	varying greatly	7 − 6	Motherstone with sprinkles of green Variscite (Utahlite and Wardite) and with grey to redbrown Chalcedony

GLASSES

Examine for	Characteristics
Hardness	Below that of Quartz. Attacked by file and hardened steel point
Thermal Conductivity	Warmer to the touch than genuine stones Efflorescence keeps longer when warmly breathed upon, than in genuine stones which lose the halo quickly
Specific Gravity	May be in coincidence with that of genuine stones
Light Refraction	May be in coincidence with that of genuine stones
Double Refraction	Only appears in the shape of "Tensional Double Refraction"
Pleochroism	Absent
Enclosures	Gasbubbles, often dilated bubbles, heaped in Vanes No liquid enclosures. Soft curving folding Striations
Colour Distribution	Often distributed in softly curved Striations

Examine for	Characteristics
Rondiste	The joining of two parts (on the coatouredge)
Coloring of the parts immersed in liquid	Often appearing difference in colours of the different parts
Hardness of the component parts	Often different, but may also coincide with the hardness of genuine stone
Specific Gravity	May be the same as that of genuine stone
Light Refraction	May be the same as that of genuine stone
Double Refraction	May be deciding factor, when position in which the field of vision is extinguished under crossed Nicols in a polarizing Microscope cannot be ascertained. Doublette with two differently oriented Lamniae
Pleochroism	May be totally missing in the case of vividly colored stones Doublettes with colored intermediate layer, or lower part of coloured glass and double refractive colorless upper part
Enclosures	Gasbubbles on the deviding plains, Inclusions in upper and lower parts sometimes alike sometimes different (for instance in the case of genuine upper part & lower part of glass)
Luminiscence	May be different in upper and lower part

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LUMINESCENCE
PHENOMENA

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GENERAL COMMENTS CONCERNING
LUMINESCENCE PHENOMENA

Luminescence is the quality of a substance to emit light-rays and to seem aglow when under the influence of certain agitating rays although the substance is cold and its temperature altogether below the glowing point.

As an example:

The Emerald emits a red to blue-violet light of its own when placed into the translucent light of a strong electric lamp. Although its temperature is only that of the room the Emerald exhibits strong Photoluminescence.

Rubies begin to glow when struck by Ultra Violet Rays or by Cathode Rays.

These manifold Luminescence Phenomena when systematically observed under various physical influences give an excellent and rich material for the classification of Jewels and the means to answer satisfactorily a large number of questions relating to Jewels.

It is not only the colour of the light emitted but also the duration of the apparation, its intensity and an often observable polarization of the luminescence light which will determine certain questions as to the classification of a gem.

The Luminescence Phenomena to be taken into consideration are mainly the Luminescence under the influence of:

> Cathode Rays
> Ultra Violet Rays
> X Rays and the
> Rays of Radium

The Luminescence Phenomena manifested when the Jewels are exposed to these rays can be used to classify the different gem varieties not only but also to determine the place and mine whence they come.

As an example:

The Sapphires from Ceylon, India and Montana show different Luminescence phenomena which together with the examination of their respective enclosures will make valuable decisions possible.

TABLE OF LUMINESCENCE PHENOMENA
RED STONES

Name	Colour	Luminescence Phenomena under Cathode Rays	Luminescence Phenomena under X Rays	Luminescence Phenomena under Ultra Violet Rays
Almandine	red	none	none	none
Beryl	rose–colour	Bright–red (distinctly different from the Ruby) Afterglow	Bright–red, feeble	Hardly noticeable
Kunzite	rose–red	Very strongly orange–yellow. Strong afterglow	Somewhat weaker than under Cathode Rays	Strong Yellow–red
Genuine Ruby	In different shades of red, except red–violet	Vividly red. Responds very easily. Some stones show afterglow. An afterglow of dark stones vanishes more quickly than in the case of synthetic Rubies	Vividly red, responds very quickly. Afterglow vanishes very quickly, also in case of light coloured Rubies	The Burma Ruby shows strong red Luminescence. The Siam Ruby shows feeble red Luminescence
Synthetic Ruby	In various shades of red	Vividly red. Responds very easily. Mostly strong afterglow in all colour varieties	Vividly red. Responds very easily. Mostly strong afterglow in all colour varieties, same as in Cathode Rays	Strong red Luminescence light effect
Spinel a	Pure–red same as Burma Ruby	Red. Feeble response (similar to violet Siam Ruby)	Same as in Cathode tube	Strong. Red
Spinel b	Brown–red (garnet–colour)	no response	no response	Unnoticeable, Red
Tourmaline	Red	no response	no response	no response

TABLE OF LUMINESCENCE PHENOMENA
GREEN STONES

Name	Colour	Luminescence under Cathode Rays	Luminescence under X Rays	Luminescence under Ultra Violet Rays
Alexandrite	delicate green, dirty greenred rich in enclosures	orangeyellow } red	no response	feeble. dark red
Corundum synthetic (Alexandrite—like)	greygreen to winered	sombre red to orange—yellow (sometimes rosecolour) no afterglow	no response	vividly rosered
Corundum genuine natural	darkgreen	no response	no response	no response
Corundum synthetic	green	darkorange no afterglow	no response	darkred
Emerald	green	darkred	in high vacuum feeble. red	distinct Luminescence—light (with red or yellow filter)

TABLE OF LUMINESCENCE PHENOMENA
BLUE STONES

Name	Colour	Luminescence phenomena under Cathode Rays	Luminescence Phenomena under X Rays	Luminescence Phenomena under Ultra-violet Rays
Aquamarine	delicate bluegreen	no response	no response	noticeable with blue filter
a Synthetic Sapphire	darkblue or lightblue	lightblue, tinge of violet sometimes reddish	nontransparent opaque enamel-like dirty blue or dirty red	feeble redviolet
b Montana Sapphire	lightblue	winered	no response	reddishblue
c Austral. Sapphire	greenblue	very feeble in blue or lacking entirely	no response	feeble
d Burma Sapphire	darkblue	dark winered or greenblue	no response	feeble
e Ceylon Sapphire	lightblue	vividly red	red, very feeble	reddishblue
f Spinel synthetic	darkblue synthetic	brightred	redviolet feeble	strong red
Zircon	blue	in high vacuum lightblue in lower vacuum yellowblue always very strong afterglow		

Name	Colour	
Aquamarine	delicate bluegreen	
a Synthetic Sapphire	darkblue or lightblue	
b Montana Sapphire	lightblue	
c Austral. Sapphire	greenblue	v b
d Burma Sapphire	darkblue	da
e Ceylon Sapphire	lightblue	
f Spinel synthetic	darkblue synthetic	
Zircon	blue	in li in ye alwa af