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The EMERALD

by

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THE loveliness of the emerald of perfection colour has been aptly described in those lines written by Herbert Smith ; " which in its verdant beauty recalls the exquisite lawns that grace the courts and quadrangles of our older seats of learning," and there are few other mineral species which have varieties exhibiting the nuances and the rich velvet-green of quality emeralds. It is a stone that was offered in Babylon, the earliest known gem market, nearly four thousands years before the Birth of Christ.

ANCIENT LORE

Dedicated by the ancients to the Goddess Venus, emerald is steeped in superstition and lore. Fittingly it is the birthstone for May, thus symbolizing the beauty and promise of nature in Spring ; emerald has been called the symbol of immortality, the conqueror of sin, the symbolization of faith—and faith in adversity—and of kindness and of goodness. Emerald by changing its colour has been said to reveal the inconstancy of lovers, and to have the power to render a man invisible so long as he be unwed.

The fable, told by Pliny, that the emerald is beneficial to the eyes, may not be so completely false, for the restfulness of green light is well known. It is said that the gem cutters of Europe are accustomed to keep an emerald on their work benches so that they may look at it to relax their nerves and so sooth their eyes after severe strain.

In the early days emeralds were a popular curative agent. At first they were employed externally, Hindu doctors treating numerous illnesses by applying the gem in divers ways ; and powdered emerald was used until comparatively recent times as a cure for fevers, for dysentery and for the bite of venomous animals. Aristotle tells that if an emerald be worn it will prevent epilepsy, and Caesar collected the stones because he believed that this was so.

Herbert Smith states that the name emerald is derived from a Persian word, later appearing in the Greek as *smaragdos* and Latinized as *smaragdus*. It is from this derivative that the altered forms *esmeraude*, *émeraude* and *esmeralde* were derived, the present form not making its appearance in English until the 16th century. The name *emerald* has always been used for a green-coloured mineral, but often not for the emerald we now know. Green sapphire, chrysocolla, lapis lazuli, malachite, green turquoise, green alabaster, glass, and even the copper ore known as bornite (peacock ore) have been graced by the name of emerald.

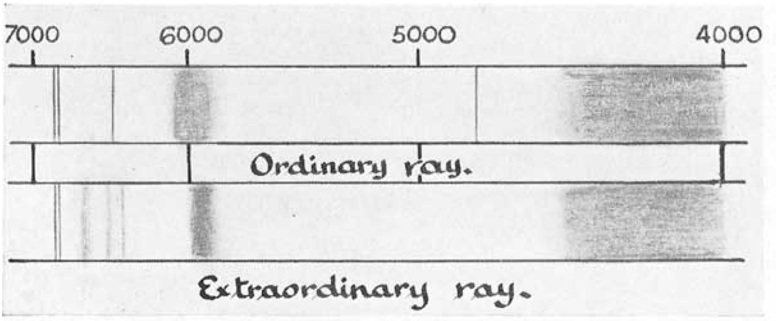
NATURE OF EMERALD

What is emerald ? It is the grass-green variety of the mineral beryl, in which a silicate molecule combines with the light metals aluminium and beryllium. The formula for the mineral is $Be_3 Al_2 (SiO_3)_6$, but considerable replacement of the beryllia by the oxides of the alkali metals and the alumina by the oxides of chromium and iron occurs. Beryl is one of the few minerals containing the element beryllium, an element previously known as *glucinum* owing to the sweet taste of its salts. This element was first discovered by Vauquelin in 1798 but was not prepared in a pure state until 1828. The purified element was prepared by the chemist Wöhler, who one year earlier had made the first preparation of pure aluminium. To-day, beryl of non-gem quality is assiduously mined as a raw material for beryllium, which has now obtained importance as a strategic metal.

Beryl crystallizes in the hexagonal system of crystal architecture, and emerald itself usually takes the simple habit of a six-sided prism closed by flat ends—the basal pinacoids. The atomic structure is formed by $Si_6 O_{18}$ groupings as independent six-fold rings formed by six SiO_4 tetrahedral groups linking through oxygen atoms. These rings are further bonded with the fairly small aluminium and beryllium cations which serve to bind the *rings* tightly together, both laterally and vertically. This strength of bonding cancels out the possibility of prismatic cleavage and allows only an ill-defined and poor cleavage parallel to the basal plane. The crystals are quarried out of the rock in which they are embedded ; they do not project into cavities as is the case with topaz and quartz. They will be discussed further in this article in connexion with the different localities in which they are found.

Emerald owes its verdant green colour to a trace of chromic oxide (Cr_2O_3), although a trace of vanadium may have some influence on the shade of colour. It is interesting to note that chromic oxide gives to ruby its magnificent red colour. The mechanism of this change of colour is, according to Anderson, due to the difference in intensity and the wavelength position of the broad absorption band which is such a characteristic feature of the absorption spectra of chromium-coloured minerals. The sharp bright lines in the red shown by the fluorescence spectrum of emerald tend to prove the small-scale isomorphous replacement by the chromium ion, as they do in ruby. Traces of iron are usually present in emerald and these again may have some bearing on the final shade of colour, as indeed they may have on certain other properties. This included iron is thought to be the cause of the lack of transparency to ultra-violet light below 3000A, as against the greater transparency of the probably purer synthetic emerald, which is transparent down to about 2250A.

The hardness of emerald is given as about 7½ on Mohs's scale, the density 2·70, and the refractive indices 1·57-1·58 with the small mean birefringence of 0·006. There are slight variations of these values for stones from different localities and these will be mentioned when each locality is discussed. The refraction is double and since the index for the extraordinary ray is less than for the ordinary ray the sign of the refraction is negative. The dichroism of emerald is distinct, with the "twin-colours" blue-green for the extraordinary ray and yellowish-green for the ordinary ray.



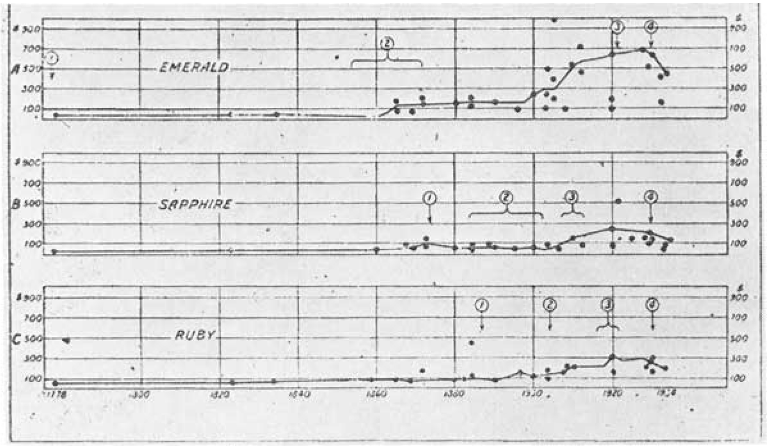
Absorption spectrum of the ordinary and extraordinary rays in emerald.

The absorption spectrum is that typical for chromium coloured minerals, showing fine lines in the red part of the spectrum, a weak diffuse central absorption with absorption of the violet, and rather weak lines in the blue. In emerald there is a distinct difference between the absorption spectrum for the ordinary ray and for the extraordinary ray. In that of the ordinary ray only two narrow lines can be seen in the red and they are of almost equal strength. These two lines consist of the main doublet (6830 and 6800A) and a clear cut line at 6370A, the central weak absorption patch covers from about 6250A to 5800A, and there is a narrow line in the blue at 4775A which may only be seen in very chrome-rich stones, when another line at 4725A may also be noticed. The absorption of the violet commences at about 4600A. In the spectrum of the extraordinary ray the doublet is rather stronger, particularly the 6830A line of the pair ; the 6370A line is missing and in its place are two rather diffuse lines at 6620 and 6460A, these being bordered on the short-wave side by characteristic transparency patches. The broad absorption region is now nearer to the red and is much weaker, and there are no lines in the blue.

Emerald, although a green stone, transmits a considerable quantity of the deep red, which is also a region of fluorescence, and it is this fluorescent red light which mainly gives the red colour seen when emeralds are viewed through the Chelsea colour-filter. Should this fluorescence be suppressed or dimmed by a fluorescence " poison," as by iron, such emeralds may not show red through the filter ; this may well be the reason for most South African and Indian emeralds remaining green when viewed through such a filter. The majority of the emerald imitations and simulating minerals show green through the filter, but there are exceptions, such as the older type of soudé emerald, and certain varieties of natural minerals, particularly the emerald green fluorite, the demantoid garnet, and green zircons, which show reddish through the filter. Synthetic emeralds, owing to their chrome-richness and freedom from those impurities such as iron, show a fiery red appearance through the filter. Although this strong red residual colour can indicate a synthetic emerald it must not be taken too literally, for some natural emeralds from the Chivor mines of the Bogotá region of Colombia behave similarly.

CUTTING

The cutting of emerald is usually performed on a copper lap charged with diamond dust and the polishing carried out on a similar lap with rottenstone as the agent. The best quality emeralds are almost universally fashioned in the trap-cut style with the corners truncated, giving an elongated octagonal outline, a style which has, owing to its common use for emerald, become known as the " emerald-cut." It is the style of cutting which, owing to its few plane facets, shows the saturated deep velvety-green of emerald to best advantage. Although the mixed-cut, with a brilliant-cut top and a step-cut pavilion, has been used for emerald, such a fashioning is rare and is said to give a glassy look. Poor quality



Price graph of emerald compared with ruby and sapphire, from the 18th to 20th century.

and badly flawed emeralds are cut *en cabochon* or as beads, and much Indian jewellery is set with such stones, which are usually poor quality emerald imported from Russia or the Transvaal. Native-cut stones are often " doctored " by boiling in fat which has been suitably coloured. Such " treated " emeralds tend to show spots at a later date, so if any suspicion is aroused it is best to soak the stones for some time in warm alcohol when some of the false material will dissolve out and reveal the trick, and, incidently, show the true colour of the stone.

An emerald cut with the table facet at right angles to the optic axis, that is at right angles to the length of the prism, will give a blue-green colour due to the ordinary ray. At right angles to this direction, that is with the table facet cut parallel to the prism (and of course the optic axis also) the colour is more yellowish-green due to about 50 per cent of the extraordinary ray. This latter colour is often more pleasing to many than the shade deeper in colour due to the ordinary ray.

Emeralds are often carved, especially if the material is of good colour but marred by many fissures and flaws. It is said that Cleopatra had her portrait engraved on many emeralds which were then made as gifts to her favourites. The five stones which Cortes presented to his bride, the niece of the Duke de Bejar, and by so doing mortally offended Queen Isabella, were said to have been worked into divers shapes—as a bell, a charm, a fish and a rose.

Large Stones

Emeralds, unlike large or historical diamonds, have rarely been honoured with individual names, steeped in history as many of them were. The only emerald which is at all well known by name is the Devonshire emerald, an uncut emerald crystal. This crystal, said to be from the Muzo mine in Colombia, is a fine green hexagonal crystal weighing 1,383·95 metric carats and was given to the sixth Duke of Devonshire by Dom Pedro the First, Emperor of Brazil, on coming to Europe after his abdication in 1831.

The English Crown Jewels contain many large and smaller emeralds, none of which have ever been graced with names. Outstanding amongst these gems is a large cabochon emerald in the front band of the Crown of India, and there is another trap-cut emerald in the cross-paté at the top of the same crown. Another large emerald is set on one side of the cross surmounting the Orb.

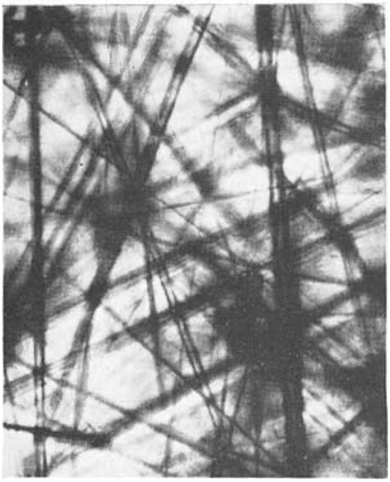
Seen by many who visited the exhibition of the Art Treasures of Vienna was the world's costliest unguent jar cut from a single emerald. This masterpiece was fashioned by Dionysio Miseroni about 1642 for the Hapsburg family. It was said to have been cut from a Colombian crystal and it weighs 2,680 carats. An example of the use of the hexagonal form of an emerald crystal is the watch mounted in such a case found in the so-called " Cheapside hoard." This hoard was found when a workman crashed his pick through the chalk floor of a building at the corner of Cheapside and Friday Street in the City of London, and into the remains of a box containing some two hundred and thirty pieces of jewellery including the watch. The hoard in all probability constituted the stock-in-trade of a jeweller, for in the 17th century Cheapside was the home of many goldsmiths. The watch consists of a single hexagonal emerald, seven-eighths of an inch across and similarly deep, into which the watch movement is centrally inserted, and over the green enamelled dial is a thin emerald slab forming a protective cover for the hands of the watch. This particular piece is of interest as watches were not known to have been worn in England until after 1540 when Henry VIII presented Catherine Howard with a girdle watch set in a carved emerald.

In the Gellatly collection of the American National Museum is a large emerald cup with a curious history. It is the so-called " Emperor Jehangir " cup carved from a single Colombian emerald. The story is told that Jehangir, Conqueror of the World, enjoyed the drinking of wine to the full, and with his companions imbibed the liquor from high cups of gold. His favourite wife, Nur Jehan, chid him for using a cup no better than those of his subjects and presented him with the emerald cup. Jehangir, it is said, was much pleased until he noted the smaller capacity of the new cup.

Said to be one of the largest emeralds in the world is the Kakovin emerald. Iakov Ivanovich Kakovin was the Director of the Ekaterinburg Cutting Works and in 1934 received a large emerald weighing 2,226 grams from the mines at Sretensk. Kakovin became enamoured with this stone and several others and kept them in hiding, but he was detected in this and rather than suffer punishment committed suicide. On its way to the Court this stone was again removed, by one Perovsky, a state official who collected beautiful stones. The Kakovin emerald later came into the hands of Prince Kochubey, whose heirs subsequently put the stone up for sale in Vienna. Having survived fire and robbery the emerald again returned to Russia, Czar Nicholas II having signed an edict which allowed the stone to be purchased for the Imperial State. In 1935 the emerald was transferred from Leningrad (the old St. Petersburg) to Moscow to leave there again for the safety of the Urals which gave it birth, during the period of the German invasion. Since victory the Kakovin emerald is again back in Moscow as one of the jewels of the Russian Diamond Treasury, which repository houses any number of fine emeralds including one of 250 carats, two dark green cabochons of 170 carats each and a plain stone bearing a Persian inscription weighing 153 carats. In all the emeralds of the Russian Treasury total 3,500 carats.

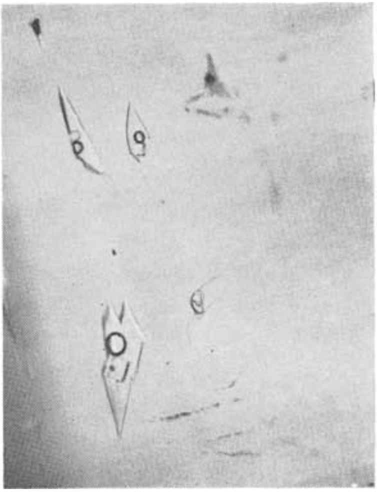
Another famous cup, the *sacro catino* or Holy Grail, in Genoa, was for centuries believed to be a single emerald of enormous size, although it was actually nothing more costly than green glass. The story is to the effect that the Genoese government being in financial distress offered the Grail to a wealthy Jew as a pledge for the loan of two million crowns. The Jew realizing that the cup was worthless resisted the proposal, but was forced to make the loan, although he protested that unfair advantage was being taken of the unpopularity of his race, since they could not find any Christian willing to advance the money. Some years afterwards the Government wished to redeem the priceless relic, but found that several persons claimed to have it in their possession. The Jew had turned his discomfort to profit, had had made imitations of the *sacro catino* and pawned each for a large sum, assuring each moneylender that the Government would redeem the pledge.

One of the most priceless pieces of emerald-set jewellery is said to be the " Crown of the Andes." The crown, stated to have been created in 1593, was sculptured from a solid block of pure gold, and encrusted with what is said to be the largest collection of fine emeralds in the world, and to be of inestimable value. Included in the galaxy of gems in this crown was said to be the Atahuallpa emerald, a 45 carat stone named after the last Inca of Peru. The crown was made for the statue of the Madonna in the Cathedral at Popayan, in which place full records of the history



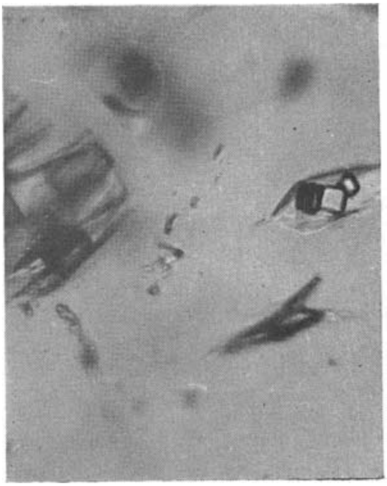
Grammatite (tremolite) inclusions in Habachthal emerald (photo. E. Gübelin).

Three-phase inclusions in an emerald from El Chivor Mine.



Included pyrites crystal in an emerald from El Chivor Mine.

Three-phase inclusions in an emerald from the Muzo Mine.



of the crown are documented. The crown had, during its long history, suffered capture by the English in 1650, who only held it for three days ; and again in 1812 the crown became a capital prize during the war and revolution in which Simon Bolivar freed the South American colonies from Spanish rule. In 1939 the crown was finally sold and it is understood broken up, its 453 emeralds weighing 1,521 carats being removed and sold separately but it was intended to preserve the gold crown itself in some museum.

Emerald, according to Ball, was for the period from 1567 until 1800 a depressed market owing to oversupply of the crystals from Colombia. Between 1852 and 1871 emeralds were very popular under the French Third Empire, and increased their popularity in the twentieth century, to a great extent because of the enthusiasm of the late Queen Mary. Despite two global wars and the production of the true synthetic emerald the popularity and value of good natural emeralds have remained undiminished.

Localities

(*a*) *Egypt*

Historically the earliest known locality for emerald was the group of mines by the Red Sea in Egypt, the so-called Cleopatra's emerald mines. These mines were probably worked some 2,000 years before the Birth of Christ and from them came most of the emeralds used in the ancient jewellery. The location of these mines was completely lost during the middle ages and not rediscovered until 1818 when Cailliaud, who had been sent by the Viceroy of Egypt to search for them, at last found the ancient workings. The mines are in the hillsides of Gebel Sikait and Gebel Zubara in Northern Etbai ; the hills lie parallel, and some 16 miles inland, from the Red Sea and about 100 miles north-east of Aswan, the ancient Syene. There are hundreds of shafts of the ancient workings, some of which had workings extending to a depth of some 800 feet, and in which tools and appliances dating back to the time of Sesostris (1650 B.C.) were found. Sporadic attempts have been made since the rediscovery to work the mines, but owing to the poor quality of the flawed crystals found in the micaceous and talcose schists which form the mother rock, the workings have been found unprofitable. Little data is available concerning the properties of these light-coloured and cloudy emeralds.

(*b*) *Austria*

Said to have been known since the time of the Romans there is an occurrence of emerald in a very inaccessible spot, some 7,500 feet above sea-level, on the east side of the Legbach ravine, a branch of the Habachthal, in Salzburg, Austria. The occurrence is of little importance, but mining by irregular methods has been carried on intermittently through the years, and in 1937 the mine was reopened on a small scale. Since World War II some crystals have been seen but whether these are from the 1937 working or from a resumption of mining since the war is not certain. The simple hexagonal crystals are found in a mica and chlorite schist, a type of mother rock similar to that of the Uralian source. Thus the inclusions seen in the Habachthal emeralds are in general similar in type to those seen in the Russian emeralds, namely actinolite rods and mica plates with rounded outline. The density of the Salzburg emeralds approximates to 2·74 and the indices of refraction are ω — 1·591 and ε — 1·584 showing a double refraction of 0·0068.

(*c*) *South America*

Who first discovered the lovely green crystals found in the Andes of Colombia, which give to this South American country the honour of being the source of the world's finest emeralds, will never be known. It is quite evident that the native Indians realized something of the value of the emeralds which they had used for barter with other neighbouring tribes, and which probably extended to those as far north as Mexico, and south to Bolivia and Peru. Despite three hundred years diligent search no other emerald bearing areas outside Colombia have been found in the Andean ranges, or in Central America or Mexico. The so-called " Peruvian " or " Mexican " emeralds were in all probability products of the ancient Colombian mines.

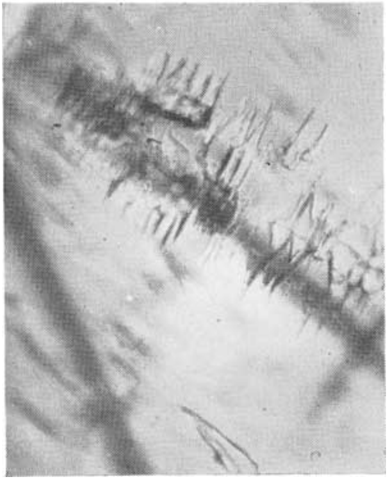
Europe first knew of the fabulous emeralds from South America when Pizarro ruthlessly conquered and despoiled Peru, taking from the Incas an immense quantity of emeralds, many of incredible size being sent to the Queen of Spain. Subsequently the old native workings in Colombia were found by the Spanish invaders and worked by them, sending the stones, both those mined and those stolen from the Indians, to Spain where they were later sent to Paris for sale.

The mines of Colombia are situated in the Cordillera Oriental, the eastern range of the Andes, and are principally in the Departments of Boyaca, and Cundinamarca and lie to the north of Bogotá, the Colombian capital. The only workings of importance are those of Muzo and Cosquez, and those of El Chivor, sometimes known as Somondoco, a word which means " God of the green stones." Some other small deposits are known, but, like those near Nemoncón, are of little more than scientific interest.

The first indication of the source of the South American emeralds came in 1537 when Gonzalo Jiménez de Quesada conquered Colombia, and was presented with nine green stones by the inhabitants of the town of Guachetá. Although the Indians carefully guarded the whereabouts of the mines, a youngster gave the invading forces the information that the emerald mines were at Somondoco, the mines now best known as El Chivor, so Chivor should be the first to be told of the famous South American emerald mines.

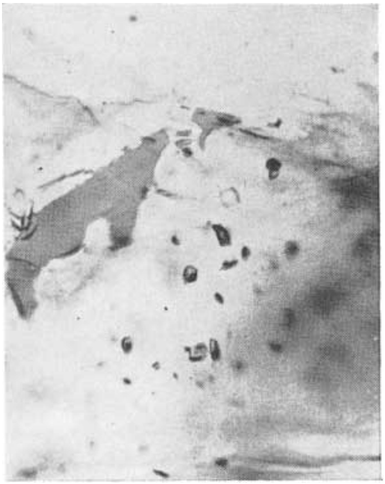
The Chibcha Indians of the high plateau of Colombia mined emeralds from Chivor (pronounced *she-vore*) before the Spanish conquest, the stones recovered being traded for gold from the Indian tribes across the Magdalena river. Some time after the Spanish subjugation of Colombia the conquistadores worked the mines of Somondoco. In 1592 Francisco Maldanaldo de Mendoza built an extensive viaduct, remnants of which still remain, in order to supply the water necessary to wash the mining debris away. Within one hundred years the mines were abandoned, either because of the lack of a successful yield or because of the discovery of the fruitful mines at Muzo some 150 miles to the north west. Chivor died out as a mine and the prolific growth of tropical vegetation effectively hid the workings for over 200 years.

After a long search the Somondoco/Chivor mines were rediscovered by Don Francisco Restrepo in 1896. Restrepo had nothing to go on except a note in a chronicle written by a friar on the Spanish Conquest, which said " The mines of Chivor are situated on the point of a ridge from which the llanos of the Orinoco can be seen." A company, The Chivor Emerald Mine Company, was formed by Restrepo, but, although the State tax was paid for twenty years, the mine was not successfully worked. The rights to the emerald mining at Chivor passed to a German commercial



Spiky-edged cavities in an emerald from the Muzo mine.

Inclusions in a Brazilian emerald.



Large actinolite crystal in a Russian emerald.

Typical inclusions in a Russian emerald.

group just before the first world war, and they, after having the report of Prof. R. Scheibe, sent, during 1911 and 1912, Herr Fritz Klein to test the mine workings. The outbreak of war in 1914 stopped further exploitation by the company. In 1919 the mines passed to an American company—The Colombian Emerald Syndicate Ltd, which was in 1926 converted into the Colombia Emerald Development Corporation of New York, and in 1927 Major P. W. Rainier took over the management of the mine for the lessors, and in his book *Green Fire*, he tells entertainingly of the trials of mining Chivor. The mine had many vicissitudes with periods of inactivity and bursts of frenzied activity. The mine was being worked in 1937, but little is known concerning the war years, indeed there was little news at all until 1950 when R. W. Alderton became manager. At the end of 1951, owing to litigation and depredations by the local banditry, Chivor ceased working and was for all intents and purposes closed.

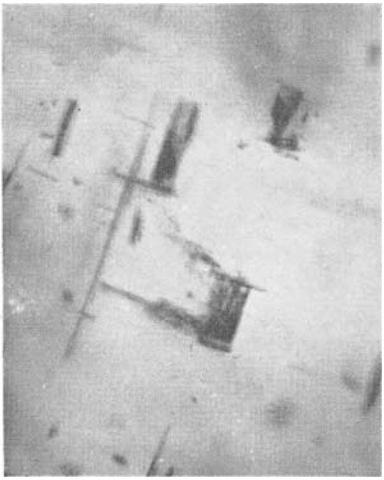
The emeralds of Chivor are found near the summit of the mountain overlooking the headwaters of the mighty Orinoco. When the Spaniards mined for emeralds they chose the western slopes, while the recent mining was carried out on the slopes facing the east. Until some six years ago when tunnel mining was commenced, the mining was of the traditional terrace-type, in which the emerald-bearing veins were exposed by digging horizontal terraces in step-like formation along gullies and washing the debris away with water released from a lake-like reservoir above the cuttings.

The emeralds are found in vein-shaped cracks some 20 centimetres wide and varying in length up to 70 metres. The crystals are usually in "strings" or in "nests" (pockets) containing anything from a few to over a hundred crystals. As the emerald pockets are approached there are showings of *moralla*, an uncrystallized form of green beryl, and this gives an indication that the miner may soon find a pocket of *canutillos*, the Colombian miners' name for good quality emerald crystals.

The crystals, usually of a good blue-green colour are unfortunately often shattered owing to the force of earlier geologic cataclysms. The crystals take the usual hexagonal prismatic form but often show small pyramidal faces. Often they are found loose in the pockets owing to their having been weathered out from the

Dark inclusions and mica plates in an emerald from Poona, Cue, W. Australia.

A mass of mica plates is a common inclusion in emeralds from the Transvaal.



Comma-like inclusions in an Indian emerald.

The masses of inclusions in this Norwegian emerald make the stone turbid.

parent rock and such emerald crystals are covered with a tenacious coating of limonitic red iron oxide. This coating needs to be cleaned off by acid in order to see the quality of the emeralds, which are then sorted into five qualities or grades.

The emeralds of Chivor have a density of 2·69 and refractive indices of ω — 1·577 and ε — 1·571, with a birefringence of 0·006. Chivor stones usually show a fairly strong red under the colour-filter and a red fluorescence when bathed in ultra-violet light and therefore behave somewhat like the synthetic stones. The inclusions seen in Chivor emeralds are the three-phase types common to South African emeralds, but most typical of Chivor stones are inclusions of well-formed crystals of pyrites.

The world's most beautiful emeralds are said to come from the mine at Muzo, which, with the mine at Cosquez, is operated by the Colombian Government ; the stones recovered are deposited in the Banca de la Republica for marketing. They are sold as the market warrants, and when the stock of emeralds in the bank is surplus to market needs the mines are shut down ; therefore the actual mining is carried on very sporadically.

The geology of the area is fundamentally similar to that of Chivor, but the emerald-bearing veins, containing calcite, quartz, dolomite, and pyrites, run through a black carbonaceous limestone and shale which form the country rock. The crystals, embedded in the vein material, have the simple forms of the hexagonal prism closed with basal pinacoids. The Spaniards mined Muzo by driving adits, but the method of terracing and washing away the debris is now employed.

The yellowish-green stones from the Muzo district have a warm velvety appearance which is most prized. The density of the emeralds from Muzo is generally slightly higher than for the Chivor stones, the values of the constants being for the density 2·71 and the indices of refraction, for the ordinary ray 1·584 and for the extraordinary ray 1·578, the double refraction being 0·006. Muzo stones usually show the typical three-phase inclusions of a bubble of gas in a liquid and a cubic crystal, which is probably sodium chloride (common salt), contained in a flat cavity having spiky or jagged outlines with tail-like appendages. Pyrites crystals, so common in Chivor stones, are not seen as an inclusion in the emeralds from Muzo and Cosquez, but occasionally there are seen in Muzo emeralds yellowish-brown prismatic crystals of the rare-earth mineral called *parisite*, a fluo-carbonate of the cerium metals, a species whose type-locality is the emerald mines of Muzo.

It has been said that the emeralds of Cosquez were the best quality, but other reports suggest that the Cosquez stones are more comparable to those of Chivor and are poorer in colour than the Muzo emeralds. Little is known of Cosquez ; the last news heard of it was that in 1951 Russell W. Anderton was negotiating for the lease of the mine from the Colombian Government ; what transpired and whether the mine is now being worked are not certain.

Early in 1934 a law was passed in Colombia requiring all persons engaged in cutting or selling emeralds to register with the Government. Emeralds being found in the possession of unregistered persons became liable to forfeiture. A report of 1951 states that it is illegal to transport rough emerald anywhere in Colombia without their first having been appraised and sealed by the officials of the Ministry of Mines, export being permitted on a reintegration basis with the official *peso* valued at approximately two to an American dollar.

The belief in mediaeval times that there was a fabulous source of emeralds in Brazil contributed in no small degree to the opening up of the interior of this vast country. The first expedition set of in 1554 under the leadership of one Bruzo Espinoso and a Jesuit priest. This expedition, and also a second under Martin Carvalho in 1567, failed to find the source of the coveted gem. The name of Sebastiao Fernandes Tourinho brings interest to the stories of the searches for emerald in Brazil, for he made three journeys into the interior, the first in 1555 and the third and most important in 1572. Taking his followers into the " barbarous forests of the Rio Doce," he eventually reached the watershed dividing the rivers flowing east from the tributaries of the Jequitinhonha and the Arassuahy. There he was said to have found many stones of divers colours, and finally emeralds themselves. On his return to Porto Seguro the stones were sent to Portugal where they were pronounced to be " emeralds from the surface baked by the sun, and stones that the earth had rejected as refuse." It was suggested that better stones would be found by " digging deeper."

This " digging deeper " suggestion led to more expeditions which were in the main organized by the Governor of Bahia. In 1574 Antonio Dias Adorno left with 650 followers and many slaves but failed to find anything but " baked emeralds." Twelve years later Martin Cao searched along the Rio Doce das Esmeraldas but found no emeralds, although he made a name for himself by his inhuman treatment of the Indians he took as slaves. Marcos de Azeredo Coutinho took out an expedition in 1612 and he did find green stones reported to be emeralds by Portugal. Coutinho died without revealing the secret of the locality. Five more expeditions, two led by the sons of Coutinho, failed to find the emerald area ; but a sixth, under Fernao Dias Paes Leme from Sao Paulo, did, in 1674, find Coutinho's locality of the green stones. Leme died before suffering the disappointment of finding that the stones never were emeralds, but only green tourmalines. The last expedition was organized in 1713, but its only claim to success was the discovery of the alluvial gold of the Rio das Contas.

Eventually the source of the Brazilian emerald was found at Brumadinho in Bahia, and emeralds were later located in the Rio Doce area ; so were Coutinho's emeralds genuine or were they misidentified in Portugal ? More recently deposits of emeralds have been found at Conquista in Bahia and at Itaberai in Goyaz and Ferros in Minas Gerais. In 1913 a find was made at Bom Jesus dos Meiros in Bahia, where the crystals were found in cavities in an altered marble capping a mountain. The crystals, often much flawed, are hexagonal prisms with basal pinacoids, with the edges truncated with small pyramidal faces. The yield is small and the mining primitive.

The density of the Brazilian emerald is 2·69 and the refractive indices are ω — 1·571 and ε — 1·566, with a birefringence of 0·005. Brazilian emerald, which appeared on the market about 1900, is a pale yellowish-green and so resembles ordinary green beryl that at first they were rejected as imitations. The stones are fairly free from inclusions, which further tends to give the impression that the stones are just green beryl rather than true emerald, but the existence of a chromium absorption spectrum effectively proves that the stones are true emeralds. When internal features can be seen in the Brazilian stones they are usually two-phase inclusions or tubes, or both.

(*d*) *Russia*

The source of the Uralian emerald was found quite accidentally when a peasant, in 1830, noticed some green stones at the foot of a tree torn out by a storm. After the discovery large Government mines were sunk in the dense forest amid marshes some 70 kilometres north east of the town of Sverdlovsk, which in the heyday of the Russian Empire was known as Ekaterinburg. The mines are on the Asiatic side of the Ural Mountains and on the Takovaya river. The crystals, generally large and cloudy and of poor colour, although smaller ones of good colour form valuable stones, are found in a mica schist which is interfoliated with talc and chlorite schists. The crystals are found in this locality in association with the other beryllium minerals *chrysoberyl* and *phenacite*, and with common beryl.

Russian emeralds have a density rather higher than the emeralds from the sources previously discussed, being 2·74, and the refractive indices are 1·588 for the ordinary ray and 1·581 for the extraordinary, the double refraction being 0·007. The characteristic inclusions seen in Siberian emeralds are mica plates and actinolite needles in single individuals or as dishevelled groups. Three-phase inclusions are said to have been observed in Siberian emeralds, but in these emeralds the solid phase is rhombic in form. Such inclusions are not commonly observed. For a number of years during the inter-war period the mines were worked by an American company, but how they are operated to-day is another secret hidden behind the Iron Curtain.

(*e*) *Australia*

The first discovery of emerald in Australia was in 1890 when W. A. Porter, while prospecting for tin, found green crystals in a dyke off-shoot from a greisen granite where it had taken on the form of pegmatite. The locality is some nine miles north by east of Emmaville in New South Wales. Prof. David inspected the site in 1891 and found the crystals to have a density of 2·67 and to be inter-crystallized with topaz, frequently penetrating fluorite as delicately accicular prisms, or sometimes embedded in a kaolinized rock and occasionally surrounded by mispickel. In that year a crystal weighing 23 carats was found completely embedded in mispickel. In 1891 and 1892 the mine was worked by the Emerald Proprietary Mines, who mined some 25,000 carats of emerald each year. Since then the mines have closed down and have only been worked sporadically by prospectors.

A tin prospector named Ryan, found in 1909, in a biotite schist and in pegmatite dykes, another source of emerald at Poona, a place some 40 miles north-west of Cue in Western Australia. In 1912 the State Mining Engineer made an independent discovery in the area. He secured several promising stones that were cut in Sydney and in London, where Mr. E. Hopkins reported very favourably upon them. In the same year J. Pearl opened up one of the deposits but found it nearly worthless, although two fine stones were sent to Paris for cutting, one of which weighed 5 carats and was sold for £100 to the Montana Sapphire Syndicate, who resold it for £170. This Montana Sapphire Syndicate then took over the mine and spent £5,000 on equipment but the outbreak of the first World War stopped the project. After the 1914-1918 war the mines at Poona remained more or less dormant until the Star Emerald Syndicate commenced development. Little is heard of this now.

The Poona emeralds are associated with quartz, albite, oligoclase, topaz, tourmaline and fluorite, and with the micas—biotite, muscovite, lepidolite and zinnwaldite. The stones are mostly pale in colour and badly flawed, but there are some which are a fine colour, including one found by H. Mandelstam embedded in a small quartz leader in the dark biotite schist. Batchelor reports one fine stone of thirty carats from the same locality.

A few small crystals of emerald were found in the Wodgina district of Western Australia which reached some 10 mm. in length but were too turbid and flawed to be worth cutting. In South Australia a few poor emeralds have been found near Mt. Crawford near Williamstown, where they occur with aquamarine and heliodor in pegmatite. The occurrence at Mt. Remarkable in the same State, mentioned by Bauer, seems debatable, for there appear to be no records in the publications of the South Australian Department of Mines.

(*f*) *Africa*

In the year 1927 beryl crystals, many of which had the colour and other qualities of true emerald, were found some 12 miles east-north-east of Gravelotte station in the Leydsdorp district of the Letaba area of north-eastern Transvaal. The deposits are associated with acid pegmatite intrusions in biotite, chlorite and actinolite schists belonging to the Swaziland system. The gemmy crystals occur almost invariably in the biotite schists at or near contact with the pegmatite bodies. Associated with the emeralds are such minerals as quartz, apatite, schorl, molybdenite, pyrite and feldspar.

The crystals have the usual prismatic form and range in size up to two inches or more in length, but most often are variable in colour, cloudy, cracked and flawed. Some clear pieces, however, have been sold for £100 per carat for cut stones. The flawed material has usually been cut into cabochons.

In 1929 some five companies operated in the area, including the Beryl Mining Company's " Somerset Mine " which was worked by a shaft and by open cast mining. This mine was installed with mechanical treatment plant capable of treating up to 200 tons of emerald-bearing schist per day. This recovery plant employed a modified form of tube mill to separate the emerald crystals from the enveloping mica schist. During the period before the second global war the only consistent producers were the Somerset mine and a mine operated by Cobra Emeralds Ltd., and in 1930 some 12 pounds weight of emerald crystals were being sent to London cutters each week.

During the slump of 1930 and 1931 most of the workings were abandoned, or at least ceased working, and this included the Somerset mine. In 1934 increased demand opened a new interest, but the only consistent producer was the Cobra Emerald Company. Mining during the war years for all intents and purposes ceased, except perhaps for the winning of crude beryl for beryllium. After the war the mines restarted to some extent but productivity has been marred by the trade boycott with India, which took much of the poorer flawed material for cutting into cabochons and used it in native jewellery.

At one time an emerald cutting project was started in Johannesburg but the endeavour did not bear fruit. In 1947 there was talk of reopening the Somerset mine by the Beryl Mining Comany, which, it seems, is still in existence, as is the Cobra Emerald Mining Company with its New Chivor mine. Other groups are also registered, including the operator of the Green Pigeon Emerald Mine.

South African emeralds have a somewhat higher refractive index than most other emeralds. Typical values are 1·593 for the ordinary ray and 1·586 for the extraordinary, the birefringence being 0·007 ; and the density is near 2·75. The inclusions are typically brownish mica plates and if these are profuse they tend to make the stones dark or even brownish. The South African emeralds rarely show red through the Chelsea colour-filter and hence have at times been rejected as imitations.

(*g*) *India*

The emerald has been held in high esteem in India from ancient times, but until the find in 1943, a source of true emerald in India was not known. A number of references exist about Indian emerald resources, but despite careful investigation no proof of an emerald locality in India was forthcoming. The locality called " Canjargum " or " Cangagam " given as a source of Indian emeralds seems to refer to the aquamarine mines of Padyur near Kangayam in the Coimbatore district of Madras. It is interesting to note that some small green rolled pebbles, which the natives regarded as emeralds, have been found at Ajmere, Rajasthan, which is perhaps better known as the old State of Rajputana. Although these stones were officially understood to be ordinary green beryls, in the light of the 1943 discovery there must always be a doubt whether or not emerald has been mined in days long past.

Even if emerald was mined in India in past days it would not account for the vast quantities of emerald used in native jewellery for some 1,500 years. J. Coggin Brown refers to old Sanskrit writings which tell of emeralds from " a mountain situated on the edge of the desert near the sea coast," a description which would well apply to the mines of Gebel Sikait and Gebel Zubara alongside the Red Sea. In more recent times the emeralds from the mines in Siberia were the source of the emeralds used in Indian jewellery, and in the 19th century much emerald of the poorer quality was exported to Asiatic countries from the stone markets of London and Paris. Much of the emerald mined in the Transvaal was sent to India, but since the trade boycott between the two countries the sale of South African rough has stopped, with the consequential pile up of emerald stocks in the Transvaal while new markets are sought.

The finding of emerald in the Arawalli mountain range of Rajasthan in 1943 was the result of the war-time search for beryl and mica as strategic minerals. During the search some small green crystals were found in the Kaliguman area of Udiapur, and these were identified as emeralds. A mining lease over the Kaliguman area was granted by the Udiapur authorities, then the independent State of Rajputana, to Sir Bhagchand Soni and his partner Seth Banjilal Thulia, the latter an emerald merchant of Jaipur. The first mining efforts in 1945 met with immediate success and crystals up to four inches in length were recovered. The emeralds are found in bands of biotite (mica) schist. Further searches followed this first successful attempt at emerald mining in India and other finds have been made both in Udiapur and Ajmere-Merwara. In 1947 quarrying was begun at the Rajgarh mine some 15 miles south of Ajmere, in which the emeralds are found in a soft talcose-biotite schist. Another source is near Bhilwara.

The Indian emeralds vary greatly in quality ; the stones from the Rajgarh mine, and other sources in Ajmere-Merwara, have, in general, a better quality than those from the Kaliguman mines, although good stones of large size have been recovered from the first discovered locality. The density of Indian emeralds is commonly 2·73 to 2·74 and the refractive indices are ω —1·593, ε —1·585, the double refraction being 0·007. The inclusions seen in Indian emeralds are typically characteristic and are of a type not reported from the stones of any other locality. These inclusions consist of two sets usually running at right angles to each other. Oriented parallel to the vertical axis of the crystal are oblong cavities containing a liquid and a bubble of gas. These cavities are characterized by having a shorter columnar projection on the edge of one end, giving them the appearance of " commas." Gübelin has shown that these cavities are groups of negative hexagonal crystals, one being remarkably longer than the others. The second type of inclusion Gübelin found to be biotite tablets oriented parallel to the basal plane. Like the South African emeralds the Indian stones may not exhibit a red residual colour through the colour-filter. The Indian stones are marketed mainly in Jaipur.

(*h*) *Norway*

Emeralds have been found at Eidsvoll, at the southern end of Mjøsa lake some 35 miles north-north-east of the capital, Oslo.

The crystals are found embedded in granite, and are nearly always turbid. The density of a specimen of Norwegian emerald, cabochon cut, of good colour but very turbid, was found to be 2·68. The dichroism of this specimen was found to be distinct and the absorption spectrum strong, and under the filter the stone showed a bright red. Observation by microscope of the internal features of this stone showed that it was filled with masses of inclusions, mostly "mossy" in character, but combined with a vast number of interconnecting cavities rather like vesicles. To these masses of inclusions is due the turbidity of the stone, which would preclude such a stone being successfully cut with facets, although as a cabochon it was quite attractive.

(*i*) *North America*

Occasional crystals of emerald have been reported from Stony Point, Alexander Co., North Carolina, at Haddam, Connecticut, and at Topsham in Main and New Hampshire, all localities in the United States of America. They have local significance only. Reports of occurrences of emerald in the Harrach and Bouman rivers of Algeria, and also *in situ* in the neighbourhood, are not, as far as is known to the writer, fully substantiated and the mineral may be simply green tourmaline.

IMITATION AND SYNTHESIS OF EMERALD

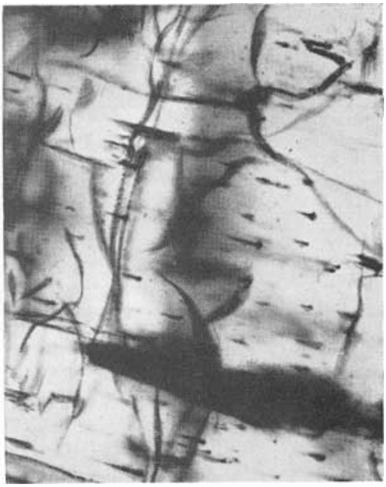
Such a prized gemstone as emerald invited imitation, simulation and synthesis.

Emerald, unlike corundum and spinel, on fusing forms a glass and does not recrystallize ; therefore, the Verneuil method of flame fusion by blowpipe cannot be employed in synthesizing beryl. In general crystallization can occur in three main ways ; from a fusion, by sublimation, or from a saturated solution, and, although the details of the modern synthesis of emerald are not fully known, it is clear that the solution method is the one employed.

The earliest well-recorded attempts at the synthesis of emerald were the experiments carried out by Ebelman, one time Director of the Sèvres Porcelain factory, who, in 1848, obtained microscopic crystals of emerald by heating powdered emerald with boric acid, a form of reconstruction rather than one of synthesis. Other workers employing similar methods but different formulae also

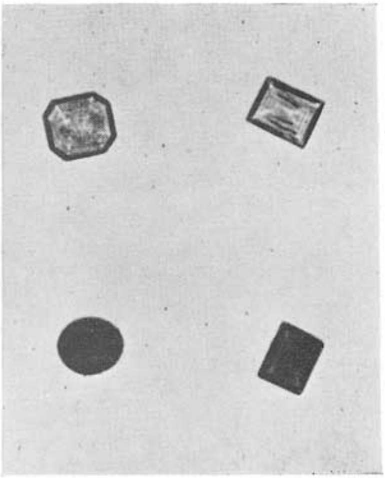
Small twisted veil-like feathers and general turbidity in a synthetic emerald made by Prof. Nacken.

Inclusions in German synthetic emerald (Igmerald) showing twisted veil-like structure and a number of two-phase inclusions.



Twisted veil-like feathers in an American synthetic emerald.

Differential transparency of synthetic and natural emeralds to short-wave ultra-violet light.



obtained limited success. Although only of academic interest, as the resultant crystals were far too small to be cut into gemstones, the experiments of P. G. Hautefeuille and A. Perrey in 1888 deserve mention. In their most successful experiment a mixture of alumina, beryllia and silica (with a trace of chromic oxide) in the correct proportions for beryl was placed in a platinum crucible and the mixture covered with a layer of lithium molybdate. The charged crucible was then placed in an autoclave and the temperature raised to a dull red heat for some twenty-four hours, after which the temperature was raised to 800°C. and kept at that value for fifteen days. The fused mass when cooled was broken up and digested in dilute hydrochloric acid. It was discovered during these experiments that if the temperature was allowed to rise above 800°C. the beryllium silicate mineral known as phenacite (Be_2SiO_4) was formed ; and it was further found that if the experiment was conducted at a temperature of 750°C., the crystals were short tabular hexagonal prisms and at the higher temperature of 800°C. their habit was prismatic, the length being some one and a half times that of the diameter across the prism. These workers also found that the colouring oxide was wholly taken up by the crystals if it was only a thousandth part of the mixture, but if as much as three thousandth parts were employed much of the oxide remained in the gangue material.

In 1912 Prof. Nacken, then of Frankfurt University, commenced experiments on the problem of synthesizing emerald and other minerals usually classed as extremely insoluble in water. Nacken's first experiments were to attempt the synthesizing of such minerals by crystallizing them from water or dilute aqueous solution in the neighbourhood of the critical temperature. The critical temperature being that temperature, characteristic for each gas, above which it is no longer possible to liquify it by compression. In 1928 Nacken succeeded in synthesizing a number of minerals including emerald crystals up to 1 carat in weight.

The method Nacken used was to grow on a " seed " crystal larger crystals, making use of the fact that the solubility of these minerals in water becomes appreciable at high temperatures and pressures. The technique used was crystallizing from a solution by sealing up the requisite raw materials in an autoclave (an autoclave, or " bomb," is a thick-walled vessel with a tightly fitting lid, in which substances may be heated above 100°C. by superheated steam) which was heated to the critical temperature of water. The thick-walled steel autoclaves used consisted of a cylindrical vessel with a capacity of about thirty cubic centimetres, closed at one end with an internal screw plug. The vessel was lined with silver and the seed crystal was suspended from a silver wire attached to the plug. The solvent, which was water containing traces of a weak alkali, occupied about twenty per cent of the volume at room temperature. The raw material, consisting of a mixture of beryllium oxide, alumina and silica in the correct proportions, was placed in the autoclave, which was then closed and the temperature raised to about 370°-400°C. and was kept at that temperature for a few days. Under these conditions the water is in the neighbourhood of the critical point and completely fills the vessel. The largest crystals made were up to 1 cm. in length and 2 to 3 mm. in width.

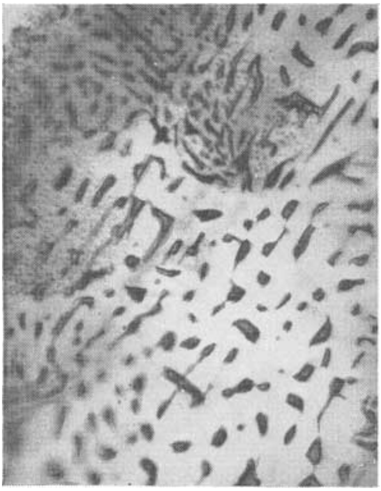
About 1934 the results of an emerald synthesis by H. Espig and E. Jaeger at the North Bitterfeld factory of the German dyestuff combine I. G. Farbenindustrie, were announced, and groups of such crystals were exhibited at the Paris Exhibition about 1936, and a few cut stones were circulated, mainly in scientific circles. These true synthetic emeralds were called *Igmerald* from I.G. and emerald, but these synthetic stones never became a problem for the jeweller. The nature of the process, said to be slow and expensive, was not divulged, but was assumed to be hydrothermal and a modification of Nacken's method. With the rise of Hitlerism and the outbreak of the Second World War nothing further was heard of these synthetic emeralds, and since the cessation of hostilities, with the Bitterfeld factory in that part of Germany in Soviet hands, the term *igmerald* has become just a name in gemmological history.

Quite independent of the European synthesis, Carroll F. Chatham commenced experiments earlier than 1930 on the synthesis of emerald at his laboratory in San Francisco, California, in the United States. Not beset with the ravages of war these experiments were continued and to-day a commercial production is maintained with ever-increasing quantity, quality and size of crystals. It is said that to-day some 50,000 carats of rough crystals are produced annually of which less than 10 per cent is of gem quality and the top quality sells for 120 dollars per carat (about £40).

That Chatham's method employed in growing the crystals is hydrothermal there is little doubt; indeed in the brochure issued by Chatham it is stated, " The general method of *culturing* emeralds is similar to the recent hydrothermal quartz process, simulating superheated springs under tremendous pressure several miles below the surface of the earth. By using the very small building rocks of nature, each emerald—large or small—is slowly grown in an artificial mine under ideal conditions for at least a year."

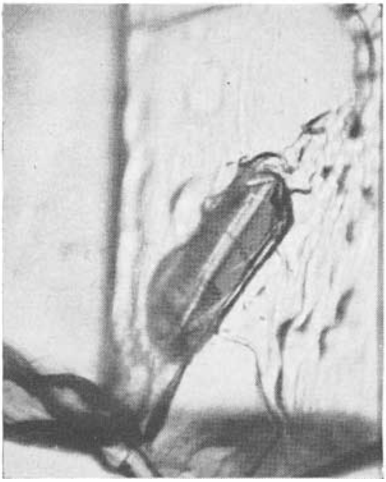
While no sound information is available of Chatham's process, much can be learnt from the report of the synthesis of quartz which has been freely published. There are two methods, both of which employ an autoclave. In one method, the so-called *temperature-gradient method*, proved more successful. In this method with silica glass, as a source material, above it. The contained alkaline water is kept at a constant temperature of 360°C., and in this condition the vitreous silica glass kept at saturation and the " seed " at supersaturation, with consequential deposition of silica on the seed as quartz, growing it to a larger crystal. The method, however, was found to have defects, and a second method, the *temperature-gradient method* to be more successful. In this method the "seed" is again suspended in an alkaline solution in the bomb, with crushed quartz at the bottom as the source material. The temperature at the bottom of the autoclave is 400°C and at the top 360°C. Thus the saturated hot liquid as it rises becomes supersaturated at the cooler top and deposits the quartz on the " seed." It is presumably some such method as these which Chatham employs, indeed he states so, and owing to the use of a seed he prefers to call his emeralds *cultured* rather than *synthetic*, but " synthetic emeralds " will be the term used for these " man-made " emeralds by all gemmologists.

The characters of these synthetic emeralds, so near in appearance and even in inclusions, to the natural stones, do, however, show features by which they can be distinguished from natural stones. They are usually of a saturated colour, and, like natural emeralds, are sorted into five grades of quality. The density of the synthetic emerald is perceptibly lower than for the natural stones, being near to 2·66, which is only just above that of quartz. Thus, in a bromoform/monobromonaphthalene mixture in which quartz just floats, a synthetic emerald will either just float or be freely suspended, while natural emeralds will sink decisively. This is the



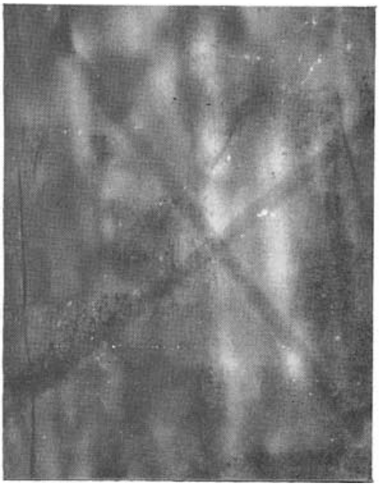
Magnified view of part of a veil-like feather in an American synthetic emerald.

Feathers in parallel arrangement common in synthetic emeralds.



Phenacite crystal in an American synthetic emerald.

Anomalous double refraction shown by a synthetic emerald when examined between crossed nicols.



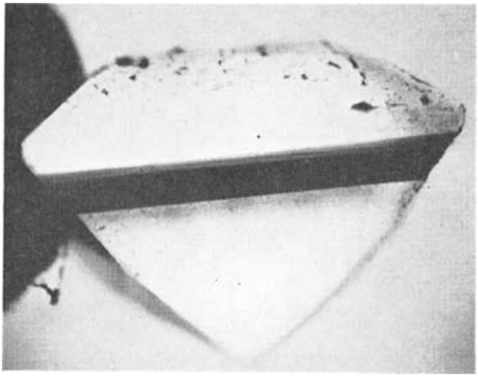
position as it is known at the moment, but future syntheses may not be so helpful in this way, and the gemmologist must forever be on his guard.

The refractive indices for the synthetic emerald are also lower, being, as far as all the specimens so-far examined have shown, 1·564 for the ordinary ray and 1·561 for the extraordinary ray, thus, the birefringence is as low as 0·003. Therefore, a low refractometer reading would betoken a synthetic and indicate that such a stone should be further examined.

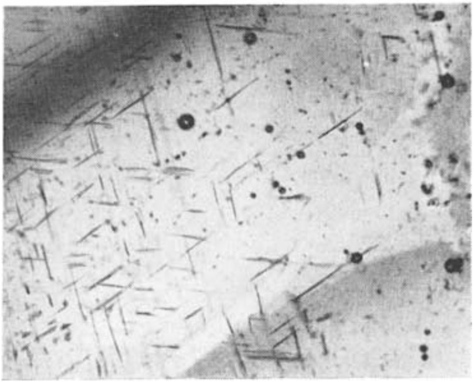
When viewed through the Chelsea colour-filter, synthetic emeralds show a strong red residual colour, but again this can only be indicative, for some natural emeralds, particularly those from El Chivor, may show as strong a red. This warning also applies to the fluorescent red glow shown by synthetic emeralds when they are bathed in invisible ultra-violet light, of which the short-wave lamp (2537A) may supply the more diagnostic radiation. Indeed, by the use of this lamp the greater transparency to ultra-violet light of the synthetic emerald to that of the natural stone may be demonstrated, or even used as a test. Possibly owing to the trace of iron in natural stones they cut off radiations below about approximately 3100A, while the synthetic stones are transparent down to 2300A.

The inclusions so-far observed in synthetic emeralds are usually diagnostic, provided that the stone is not clean ; and clean stones are far from common. Grown in a more natural way, the characteristic signs shown by corundums and spinels made by the flame-fusion process of curved lines and included gas bubbles are not present in synthetic emerald, and the inclusions seen in the latter stones are most " natural-looking " feathers. These consist mainly of two-phase inclusions in the form of "curtain-like" feathers, which, when profuse, make the stone appear cloudy. These feathers are sometimes arranged in parallel bands. Straight and angular zoning is common, and in the lower grades of quality dark masses of inclusions mar the beauty of the stone. Phenacite crystals, as well may be expected from their similarity of chemical composition, are sometimes found as inclusions in synthetic emeralds.

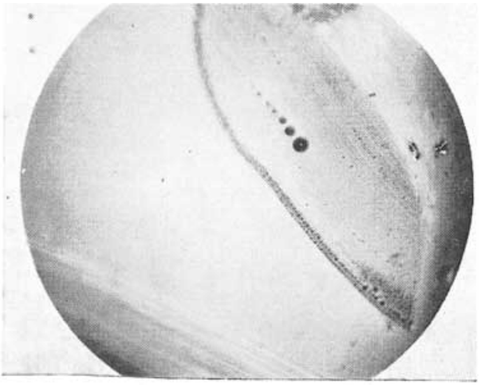
Chatham, in his advertising brochure, says " The synthetic crystals are free from impurities and strain so can be raised to an incipient white heat while a natural stone is destroyed far below



A soudé emerald when immersed in liquid and held sideways will show the clear top and base, with the colour layer distinct.



Microscopic examination of a garnet-topped doublet usually shows a layer of bubbles in one plane and natural inclusions in the garnet top.



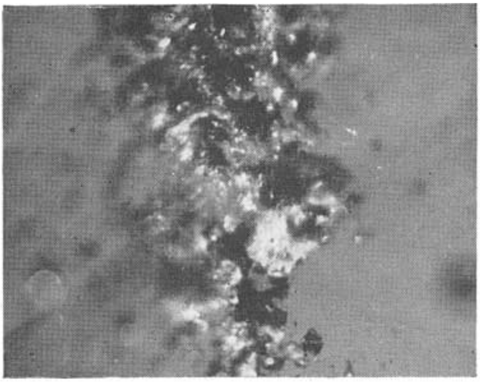
Swirl bubbles in paste.

the visible temperature range." Experiment has shown that natural emeralds do fracture and cloud at a lower temperature than the synthetic, but the absence of strain is rather denied by the effect shown when synthetic emeralds are examined between crossed nicols, the stripy nature of the anomalous double refraction belying the absence of strain.

Pale natural emeralds are sometimes painted on the back with a green pigment in order to enhance the colour. This, when the stones are set with open backs, is easily detected and easily removed. When, however, the stones are set in closed settings the problem is not so easy and examination by microscope may be necessary in order to see the patchiness of the blobs of colour below the stone ; or the strength of the absorption spectrum may indicate the true colour of such backed stones. Pale emeralds, or even rock crystal, are set in a closed setting containing a suitably coloured foil. It has been pointed out by M. D. S. Lewis that such a green foil may cause the stones to appear red when viewed through the colour-filter owing to selective reflection of light. The spectroscope will assist in such cases.

It is not easy to assess when the so-called soudé emeralds were first produced, but from perusal of literature it seems that the earlier types must have been marketed at the turn of the century. These earlier soudé emeralds were constructed of two pieces of rock crystal, selected often because they had natural feathers, or two pieces of nearly colourless beryl have been similarly used, cemented together with a thin layer of green-coloured gelatine between them. From this composite piece of material a stone is cut so that the green layer lies along the plane of the girdle. Most effective as these stones are, the quartz types are quickly unmasked by a refractometer reading, or either type by the aid of a spectroscope. Two characteristics of this earlier type of soudé emerald are that the gelatine layer caused the stone to show red through the colour-filter, and, further, that the green colour tended to deteriorate and turn yellow.

A newer and better type of soudé emerald later came on the market, which it is believed was devised by d'Horne. Fundamentally the stone is the same as the older type—the two pieces of rock crystal with the green-coloured layer between ; but it is this green layer which supplies the difference. In this later type the residual colour seen through the filter is green and the colour is stable. The



A glass imitation emerald showing masses of solid matter giving the stone a superficial natural appearance.

density of these pieces, however, is higher than what one would expect knowing that the bulk of the material is rock crystal (2·65) for the values obtained are about 2·8. The earlier type with gelatine filter does give values at 2·65. This high density implies a colouring agent with a heavy atom, but the actual nature of the colouring material and the method of bonding of the two pieces of quartz has not yet been satisfactorily determined—no information seems to be available from the maker. That copper is present has been proved, but so far the rest is conjecture. The best theory is that it is a metallo-organic compound colouring a sintered layer between the two quartz halves.

It is interesting to note that neither the synthetic corundum nor similarly produced spinel have ever been made in an emerald-green colour. Maybe this fact (and perhaps because it could be produced cheaper) led to the production in 1951 of a type of soudé emerald in which the quartz (top and base) is replaced by synthetic white spinel. These emerald doublets, or *soudé sur spinelle* as they are called, will give the refractometer reading for synthetic spinel (1·728), and again the density is slightly higher than for synthetic spinel, because of the nature of the green layer which seems to be the same as for the quartz type, the density varying between 3·66 to 3·69 (syn. spinel 3·63). The stones do not show red through the filter and an extra test is the whiteish glow seen from the white spinel when the stones are bathed in short-wave ultra-violet light—the quartz types being inert under the lamp, while true emeralds show a reddish tinge under short-wave ultra-violet.

The writer cannot recall hearing of a true emerald doublet made from two pieces of real emerald. Commonly found, however, are the garnet-topped doublets made by fusing a slice of red garnet to a base of green glass and then cutting the composite piece so that the harder garnet forms the crown of the stone. Tricky as these stones are when set in closed back settings, they are given away by the colour not being just right for emerald and often slight reddish gleams proclaim the fake. Technical detection is by the refractometer reading for garnet, usually about 1·79, and by the layer of bubbles in one plane due to the melting of the glass when the two pieces were fused together and by the crystal inclusions which may often be seen in the garnet top.

Earlier in this article it has been mentioned that emerald will not fuse and recrystallize like corundum and spinel but simply solidify as a glass—a beryl glass. It is recorded that over 70 years ago Greville Williams fused emeralds and found that the density decreased from 2·70 to 2·40, and the same worker prepared beryl glasses by fusing together a mixture of the same composition as beryl, colouring them by the addition of various metallic oxides—green with chromic oxide, blue with cobalt oxide and pink with didymium oxide. These beryl glasses had a density of 2·42. Beryl glasses, usually of a blue or green colour, have been met with in jewellery, but are rare. It has been found that such stones have a density between 2·39 and 2·49, but are generally about 2·42 ; the refractive index is near 1·52, and they have a hardness near to 7 on Mohs's scale. They contain usually a profusion of gas bubbles. Quite recently the writer examined five so-called " synthetic emeralds " supposedly obtained from Spain. These stones had every indication of being just beryl glasses. Their hardness was 6¼ on Mohs's scale ; the index of refraction of four of the stones, two dark green and two yellowish green, was 1·53, and of the fifth, a bluish green stone, 1·521. The density of the four stones with same R.I. was 2·39 and of the odd one out 2·37.

Glass imitations of emerald can be very effective, of good colour and appearance, and they are often embellished with " flaws " and " feathers " produced by layers of bubbles or by included extraneous matter. The so-called Ferrer's emerald is a glass which usually has a density about 2·69 and an index of refraction of 1·63, and is made specially as an emerald imitation. No emerald imitation in glass need present difficulty, for rarely is its refractive index near to that of true emerald, and, further, it is isotropic and can only show one shadow edge. It is non-dichroic, and even if the colouring is by a chromium compound, the characteristic absorption spectrum of emerald is lacking. Of other counterfeits of emerald mention may be made of the so-called "Indian emeralds," which are simply green-dyed crackled quartz.

In conclusion the writer tenders his thanks to all those who have assisted in this compilation by giving of their own personal information and other help. Among these many helpers especial thanks are due to Prof. Rex T. Prider and Mr. Allan Wilson of the University of Western Australia, for the information on Australian emeralds and the gift of specimens of Cue emeralds ; Mr. Simpson of the Dept. of Mines, South Africa House, London ; Mr. Hans Myhre for the opportunity of examining the Norwegian emerald ; Mr. W. C. Buckingham for information on imitations ; and Dr. E. Gübelin for the photograph of the inclusions in Habachthal emerald.

REFERENCES

The list of references given below is of selected papers and does not include standard text-books on gemstones.

GENERAL

Aitkins (I). *Emeralds.* U.S. Bureau Mines Inform. Circ. 6459. 1931.
Anderson (B. W.) : Payne (C. J.). *Absorption spectrum of emerald.* Gemmologist, Vol. XXIII, No. 279, pp. 183-188. 1954.
——*Gemstones and the spectroscope ; the absorption spectra of emerald and alexandrite.* Gems & Gemology, Vol. 6, pp. 263-266 and 291. 1950.
Anon. *The age of emerald.* Gemmologist, Vol. III, No. 28, p. 113. 1933.
Bandy (M. C.). *The emerald in fable and history.* Gems & Gemology, Vol. 5, No. 12, pp. 497-499. 1947.
Borovick (S. A.). *Content of scandium in beryls and some other minerals (emerald from Urals).* Compt. Rend. (Doklady) Acad. Sci. URSS, Vol. 40, pp. 111-112. 1943.
Doelter (C.). *Die farben der mineralien.* Samml. Vieweg, No. 27, p. 56. 1915.
Frondel (C.). *Effect of heat on the colour of beryls.* Gemmologist, Vol. XXI, No. 256, pp. 197-200. 1952.
Groom-Grjimailo (S. V.). *On the colouring of minerals caused by chrome (emerald mentioned).* Trav. Lab. Crist. Acad. Sci. URSS, No. 2, pp. 73-86 (English manuscript p. 85). 1940.
Gübelin (E.). *Diagnostic importance of gemstone inclusions.* Journ. Gemmology, Vol. II, No. 7 (emerald), pp. 286-287. 1950.
——*Differentiation between Russian and Colombian emeralds.* Gems & Gemology, Vol. 3, No. 6, pp. 88-92. 1940.
——*Gemstone inclusions.* Gems & Gemology, Vol. 5, pp. 319-320. 1946.
Henderson (E. P.). *A cat's-eye emerald.* Gems & Gemology, Vol. 5, No. 2, p. 222. 1945.
Holstein (O.). *Identifying the emerald.* Gemmologist, Vol. V, No. 54, pp. 157-159. 1936.
Mathews (C.). *Emeralds.* Gemmologist, Vol. I, No. 3, pp. 87-89. 1931.
Pough (F. H.) : Rogers (T. H.). *Experiments in X-ray irradiation of gemstones.* Amer. Min., Vol. 32 (emerald), pp. 35-37. 1947.

EGYPT

Anon. *Report of the department of mines and quarries.* Ministry of Finance, Cairo (emerald), p. 26. 1928.
Ball (S. H.). *Egyptian gemstones of the pre-Ptolemaic days.* Jewelers Circular-Keystone (New York), Feb. 23, Apl. 26 and May 3, 1928. Abstr. Mining Mag. Vol. 39, pp. 129-131. 1928.
Ismalun (M.). *Émeraudes et béryls.* Bull. Soc. Roy. Géogr. Égypte, Vol. 21, pp. 51-60. 1943.

AUSTRIA

Leitmeier (R.). *Das Smaragdvorkommen im Habachtal.* Mitt. Wein. Min. Ges., No. 92, pp. 11-15. 1930.

Michel (H.). *Das Smaragdbergwerk im Habachtal.* Deutsche Goldschmiede-Zeitung, No. 15, pp. 138-139. 1938.

COLOMBIA

Anderton (R. W.). *Report on Chivor emerald mines.* Gems & Gemology, Vol. 6, No. 12, pp. 376-377 and 379. 1950.

Anon. Informe del Ministro de Haceinda al Congresso. Bogotá, Colombia. 1920 (emerald), pp. 82-83 ; 1921 (emerald), pp. 61-62.

——*Notes on emeralds in Colombia.* Colombian Trade Review. Vol. 3, pp. 132, 151, 243, 1923.

——Reports. Dept. overseas trade on the industry and trade of Colombia. March, 1924 (emerald p. 12) ; May, 1925 (emerald p. 32) ; July 1929 (emerald pp. 57-58).

——*The Republic of Colombia.* Colombian Government Bureau pamphlet. London. (emerald p. 6). 1923.

Bell (P. L.). *Colombia ; commercial and industrial handbook.* Bur. For. Domestic Commerce. Spec. Agents, Ser. 206. Washington. (emerald pp. 250-251). 1921.

Clements (T.). *The emerald mines of Muzo, Colombia, South America.* Gems & Gemology, Vol. 3, No. 9. pp. 130-134. 1941.

Codazzi (R. L.). *Minas de esmeraldas.* Bol. de Min. y Petról, Colombia, Vol. 1, pp. 114-143. 1929.

Ives (R. L.). *Colombian emerald resources.* Rocks & Minerals, Vol. 24, pp. 339-345. 1949.

Kellner (G. T.). *Beiträge zum Smaragdbergbau in der Republik Kolumbein, Sudamerika.* Leits. f. prakt Geo., Vol. 35, pp. 70-74. 1927.

Lentz (M.). *Emeralds of Chivor.* Lapidary Journal, U.S.A. 1951.

MacFadden (C. K.). *Emerald mining in Colombia.* Gems & Gemology, Vol. 1, No. 6 pp. 149-154. 1934. Also Tech. Pub. No. 258, Am. Inst. of Min. & Met. Engineers.

Maria (H. A.). *Apuntes sobre las esmeraldas.* Rev. Acad. Colombiana, Bogotá, Vol. 7, pp. 324-327. 1947.

Monsalve (D.). *Colombia cafetera.* Printed for the Republic of Colombia, Barcelona. (emerald pp. 679-681).

Olden (C.). *Emeralds ; their mode of occurrence and methods of mining and extraction in Colombia.* Trans. Inst. Min. Met., Vol. 21, pp. 193-209. 1911-12.

Oppenheim (V.). *The Muzo emerald zone, Colombia, S. America.* Econ. Geo., Vol. 43, No. 1, pp. 31-38. 1948.

Pogue (J. E.). *The emerald deposits of Muzo, Colombia.* Trans. Inst. Min. Eng., Vol. 55, pp. 910-934. 1916.

Rainer (P. W.). *The Chivor-Somondoco emerald mines of Colombia.* Amer. Inst. Min. Eng. Tech. Publ. 258, Class H, No. 11. 1929.

Scheibe (R.). *Das Smaragdvorkommen von Nemoncón.* Neues Jahrb. f. mineralogie, Abt. B., Vol. 53, pp. 321-324. 1926.

——*Die Smaragdlagerstatte von Muzo (Kolumbien) und ihre nähere Umgebung.* Neues Jahrb. f. mineralogie., Abt. B., Vol. 54, pp. 419-447. 1926.

——*Informe Geológico Sobre la mina de Esmeraldas de Muzo.* Compilación de los Estudios Geológicos Oficiales en Colombia, Vol. 1, pp. 169-198. 1933.

BRAZIL

Anon. Relatorio do Serviço Geologico Ministerio da Agric., Ind. et Comm. Rio de Janeiro. (emerald p. 188). 1923.

Just (E.). *Emeralds at Bom Jesus dos Meiras, Bahia, Brazil,* Econ. Geol., Vol. 21, pp. 808-810. 1926.

Oliveira (E. P. de). *Mineral resources of Brazil.* Serv. Geol. e Min. do Brasil. (emerald pp. 6-7). 1930.

RUSSIA

Fersman (A.). *Precious and coloured stones of the USSR.* Gemmologist, Vol. XVI, No. 191. (emerald pp. 168-9 and 174). 1947.

Grigoriev (D. P.). *Coloured stones of the Urals.* Sverdlovsk, State Publishing House. 1944.

Mikhijev (N. S.). *Preliminary note on the Ural emerald mines.* Bull. Soc. oural Sci. nat., Vol. 32 p. 80. 1913.

Pyatnitzki (P.). *Geological explorations in the emerald region of the Urals.* Bull. Com. Géol. Leningrad, Vol. 48, pp. 283-306. 1929.

SOUTH AFRICA

Anon. *Plant for production of beryl emeralds at Somerset mine, South Africa.* S. Africa Min. Eng. Journ., Vol. 40, Pt. 1, pp. 621-622. 1929.

——*Remarkable beryl discovery.* S. Africa Min. Eng. Journ., Vol. 40, Pt. 1, pp. 461 and 477-480. 1929.

——*The emerald mining of the Transvaal.* Min. Ind. Mag. S. Afr., Vol. 11, pp. 107, 109, 185. 1930.

——*The mineral deposits of the Merchison range, east of Leydsdorp.* Mem. 36, Geo. Surv. S. Africa. 1939.

——*The Mineral Resources of the Union of South Africa.* Dept. of Mines. (emerald pp. 102-104). Pretoria. 1940.

——*The pegmatite area south of the Orange river in Namaqualand.* Mem. 321, Geo. Surv. S. Africa, p. 81. 1937.

——*The position of the Beryl Mining Company.* South Africa Min. Eng. Journ., Vol. 41, Pt. 1, pp. 470-471. 1930.

——*Transvaal emeralds.* South Africa Min. Eng. Journ. Yearbook, 1928, pp. 585-588. *Also* S. Africa Min. Eng. Journ., Vol. 39, Pt. 1. pp. 101-103. 1928.

Ball (S. A.). *The African beryl and emerald mines.* S. Afr. Min. Eng. Journ., Vol. 39, Pt. 1, p. 629. 1928.
LeGrange (J. M.). *The Barbara beryls.* Trans. Geo. Soc. South Africa, Vol. 32, pp. 1-25. 1925.
——*South African emeralds.* Gems & Gemology, Vol. 2, No. 9, p. 146. 1938.

AUSTRALIA

Anon. Dept. Mines. W. Australia. 1927, 1928 & 1929. (emerald p. 6 in each year).
Brown (H. Y. L.). Records of the Dept. of Mines. of South Australia, p. 359, 4th Edn. 1908.
Pitman (E.). *Mineral resources of New South Wales.* Geol. Surv. of New South Wales, pp. 406-408. 1901.
Simpson (E. S.). *Minerals of Western Australia.* Vol. 1. (emerald pp. 202-204). 1948.
——*The occurrence of common and precious beryl at Poona.* Dept. Mines. W. Australia. Ann. Prog. Rept. Geo. Survey, Appendix 1, p. 177. 1921.
Wilson (R. C.). *The beryl deposits of Poona and Ferndale.* Repts. Dept. Mines. W. Australia, Appendix 3, pp. 81-83. 1925.

INDIA

Alexander (A. E.). *Emeralds from the Ajmir district, India.* Journ. Gemmology, Vol. III, No. 1, p. 14. 1951.
Brown (J. Coggin). *Emeralds in India.* Gemmologist, Vol. 22, Nos. 265-266, pp. 133-136 ; 165-168. 1953.
Crookshank (H.). *Emeralds in Mewar.* Ind. Min., Vol. 1, pp. 28-30. 1947.
Gübelin (E.). *Some additional data on Indian emeralds.* Gems & Gemology, Vol. 7, No. 1, pp. 13-22. 1951.
Schlossmacher (K.). *Emeralds in India.* Edelsteine u. Schmuck. 1 (2), pp. 238-239. 1949.
Webster (R.). *Some notes on Indian emeralds.* Gems & Gemology, Vol. 6, No. 11, pp. 344-345. 1950.
Zaveni (V. D.). *Emerald cutting in India.* Gemmologist, Vol. 4, No. 42, pp. 185-187. 1935.

NORTH AMERICA

Field (D. S. M.). *Canadian gems and gem localities.* Journ. Gemmology, Vol. 2, No. 5 (emerald p. 188). 1950.
Kirk (H. N.). *Beryl possibilities in New Hampshire.* Rock Prod., Vol. 32, p. 49. 1929.

SYNTHETICS

Anon. *New synthetic emerald developments.* Gems & Gemology, Vol. 2, No. 8, pp. 131-134. 1937.
——*Synthetic beryl.* Gems & Gemology, Vol. 1, No. 10, pp. 281-283. 1935.
——*The detection of synthetic emerald.* Gems & Gemology, Vol. 2, No. 10, pp. 163-168. 1938.
Anderson (B. W.). *A new test for synthetic emerald.* Gemmologist. Vol. XXII, No. 264, pp. 115-117. 1953.
——*Identification of synthetic emerald.* Gemmologist, Vol. 7, No. 78, pp. 407b-410b. 1938.
——*Igmerald.* Gems & Gemology, Vol. 1, No. 10, pp. 284-285. 1935.
——*Igmerald—the German synthetic emerald.* Gemmologist, Vol. IV, No. 46, pp. 295-300. 1935.
——*More news of synthetic emerald.* Gemmologist, Vol. XI, No. 122, pp. 9-11, 1941.
Ebelman (?). Ann. Chim et Phys, Vol. 22, p. 237. 1848.
Foshag (W. F.). *Comparison between natural and synthetic emeralds.* Gemmologist, Vol. VII, No. 81, p. 105c. 1938.
Gübelin (E.). *Gemstone inclusions.* Journ. Gemmology, Vol. 1, No. 7, p. 25.
Hautefeuille (P.) : Perrey (A.). Comptes Rendus de l'Acad des Sciences, Vol. 106, pp. 1800 and 1888, Paris 1888. Also *Sur les combinations silicitées de la glucine.* Annales de chimie et de physique, ser 6, Vol. 20, pp. 447-480. 1890.
Holstein (O.). *Real and synthetic emeralds.* Gemmologist, Vol. VI, No. 65, pp. 116-117. 1936.
Pough (F. H.). *Distinguishing the synthetic emerald.* Gemmologist, Vol. 7, No. 76, p. 205b, 1937 ; also *Identification of synthetic emerald.* Ibid., Vol. 7, No. 78, p. 407b. 1938.
——*Synthetic emerald made in U.S.A., How to detect it.* Jewelers Circular-Keystone (New York). 1941.
Praagh (G. van). *Synthetic emeralds.* Science News (3). pp. 22-24. Penguin Books. 1947.
——*Synthetic quartz crystals (emeralds mentioned).* Geol. Mag. Hertford, Vol. 84, pp. 98-100. 1947.
Rogers (A. F.) : Sperison (F. J.). *American synthetic emerald.* Amer. Min., Vol. 27, pp. 762-768. 1942.
Schlossmacher (K.). *Der neue synthetische Smaragd.* Gold u. Silber, 1951 4 (a), 10-11.
Shipley (R. M.) : Gübelin (E.). *The synthetic emerald.* Gems & Gemology, Vol. 3, No. 10, pp. 146-150. 1941.
Switzer (G.). *Improvements in quality of synthetic emerald.* Gems & Gemology, Vol. 5, pp. 305-307. 1946.
Webster (R.). *Secrets of the synthetic emerald.* Gemmologist, Vol. XXI, Nos. 252-3, pp. 117-121, 140-145. 1952.
Wild (G. O.). *Synthetic emerald.* Gems & Gemology, Vol. 1, No. 10, pp. 285-286. 1935.

IMITATIONS

Anon. *New gem substitute resembles emerald.* Gems & Gemology, Vol. 7, No. 1, p. 29. 1951.
Feldhaus (F. M.). *Imitation emerald problems in the 16th century.* Gemmologist, Vol. XXIII, No. 278. pp. 174-176. 1954.
Lewis (M. D. S.). *Selective reflection and its possible bearing on gemmology. (refers to foiling of emeralds).* Journ. Gemmology, Vol. 1, No. 4, pp. 10-14. 1947.
Webster (R.). *New spinel doublet.* Journ. Gemmology. Vol. 3, No. 5, pp. 199-201. 1952.

Gemmological Abstracts

Chudoba (K. F.). *Zur Erkennung künstlich gefärbter Diamanten.* Recognizing artificially coloured diamonds. Gold und Silber, No. 1, pp. 12—13, 1955.

Intensely green and blue diamonds are rare, and it is often wrongly assumed that all such diamonds are artificially coloured. The artificial coloration can usually be determined. Diamonds have been coloured green by embedding them in radium salt. Such stones are radio-active on the surface; this causes the stone to fog photographic paper when placed on it for about 8–12 hours. Those diamonds which are coloured by bombardment with deuterons, protons and alpha particles are only radioactive for about one hour after treatment. Such stones usually have a very distinct parting line between the coloured portion of the stone and the uncoloured one; this can be observed particularly well if the stone is immersed in a highly refractive liquid, e.g. methylene iodide. Neutron bombardment often colours the complete stone, so that no dividing line can be observed. Martin L. Ehrmann (1950) once examined a 14-carat green diamond. After eight months it could only be said that the stone had not obtained its green colour by radio-active treatment, but no guarantee could be given that the stone was naturally green. F. H. Pough and A. A. Schulke (1951) observed a concentration of colour near the surface when a stone had been coloured by cyclotrons. M. L. Ehrmann saw tiny black specks on the surface as if the stone had been burned there. When recut, the cutting may go deeper than the layer affected by deuterons, so that the stone loses its green colour and regains its former shade. J. F. H. Custers and H. D. Deyer observed that artificially blue-coloured diamonds are coloured only to a depth of 0·5 mm. In a brilliant-cut stone it is difficult to see this. At a voltage of 125 and at 0·1 mA. naturally blue diamonds of about 1 carat became red hot; with larger stones a higher voltage was necessary; artificially coloured blue diamonds, however, did not conduct electricity, and did not turn red. There is also a difference in the transmission of infra-red and ultra-violet light which can be shown with selective filters.

E.S.

SALLER (X.). *Süsswasser-Zuchtperlen aus Japan.* Cultured fresh water pearls from Japan. Zeitschr. d. Deutsch. Ges. f. Edelsteinkunde, No. 12, pp 6–8, 1955.

This variety of cultured pearls owes its importance to the fact that the pearls—like the genuine ones—do not have an inner mother-of-pearl bead or another distinguishable core. The fresh water mussel *Hyriopsis Schlegeli*, locally called " Ikochogai," is greenish-black from the outside. The inner side of the shell is covered with a mother-of-pearl layer of very fine colour and good lustre. This mollusc slowly reaches a size of about $9\frac{1}{2}$ by 5 inches and may be about $2\frac{1}{2}$ inches thick. It lends itself well, therefore, to the production of big pearls. After six to seven years, when it has reached a size of about 5 inches, it is ready for the " operation." The locality is " Biwa-Ko " (Lake Biwa), the biggest fresh water lake in Japan. (The shape of the lake corresponds roughly to that of a " biwa," a Japanese string instrument.) The lake is about 40 miles long and $12\frac{1}{2}$ miles wide at the widest part. In the north it is about 300 feet deep. The southern third is narrow and only about 16 feet deep. Here, in the Hirako Reservoir, with its rocky, sandy and muddy ground, the living conditions are well suited for the mollusc. It lives on (vegetable) phyton-plankton, although the water contains 60 per cent animal and only 40 per cent vegetable plankton. Early experiments after the first world war were abortive, mainly because the majority of the mussels died, when beads were inserted. This led eventually to the application of a new method. A mussel is carefully opened and its mantle separated from the shell with a spatula. From this mantle, i.e. from the side nearest to the shell, about half the thickness is cut out with sharp scissors and divided into strips of about $1\frac{1}{2}$ by $\frac{1}{4}$ inch. (The deeply coloured mantle rim must not be used.) The strips are cleaned and divided again into squares of about $\frac{5}{32}$ inch. These squares of mantle tissue are then placed into another mussel which has been carefully opened and is held in a special frame. About three or four tissue squares are inserted from one side, preferably into the sex glands. Then the mussel is turned round, and three to four other tissue squares are pressed into position. Thus, each mollusc contains six to ten " scions." In contrast to the " surgical " operation with marine pearl oysters, the " grafting " of mussels consists of simply pressing into position the tissue squares, which form into (and take over the functions of) pearl sacs. Nearly every tissue square develops into a pearl, i.e. in each surviving mussel an average of eight pearls will be found. In 1946, only 2,000 out of 50,000 mussels survived; in 1948, the technique had been improved already to such an extent, that 40,000 out of 50,000 mussels survived the operation. The pearls are reported to be of very fine colour and of good lustre; the shapes, however, leave much room for improvement. The author leaves no doubt that the new pearl ought to be called " cultured." The difficulty of determining its nature will be shown in a forthcoming article.

W.S.

SCHMIDT (P.). *Turmalin—der Proteus unter den Edelsteinen.* Tourmaline—the Proteus of the gem world. Zeitschr. d. Deutsch. Ges. f. Edelsteinkunde, No. 10, pp. 9–11, 1954/5.

Tourmaline is not one of the more precious gems, but just as Proteus, the Greek God of the Seas, was capable of changing his appearance, so tourmaline is found in many varieties. The stone was not known in ancient times. In 1703 children of an Amsterdam merchant played with his wares, which he obtained from Ceylon. The children noticed that under the lowering sun the stones attracted small particles of ash, paper, straw, and thus the stone was called " aschentrekker," i.e. attracter of ashes. It is found to-day in Madagascar, Ceylon, Burma, S.W. Africa, California, the American States of Maine and Connecticut, and chiefly in Brazil, where it is wrongly called " Brazilian emerald." There are brief notes about the physical characteristics. Because of its electrical properties it is used for the measurement of radium emanation. In submarines it is used to show small differences in pressure.

E.S.

ROULET (R.). *Die Perlenfischerei in der Lüneburger Heide.* Pearl fishing in the heath of Luneberg. Zeitschr. d. Deutsch. Ges. f. Edelsteinkunde, No. 11, pp. 16–19, 1955.

Fresh-water pearls were found in mussels in the rivers of the Lüneberg Heath in the middle ages, and used by monks for embroidery, etc. During the latter part of the middle ages, the Dukes of Lower Saxony took over the monopoly, but poaching was very common, and thus most of the mussels were exterminated.

E.S.

MEYROWITZ (R.). *A compilation and classification of immersion media of high refractive index.* Amer. Min., Vol. 40, pp. 398–409, 1955.

In this useful paper Meyrowitz brings together the multifarious media of high refractive index which have been proposed from time to time for use as immersion or contact liquids. The substances are classified by Meyrowitz into four groups: 1. Pure Liquids, 2. Liquid solutions, 3. Pure solids, 4. Mixed solids.

The list of pure liquids is a short one, consisting of methylene iodide (1·74), phenyl-iodoarsine (1·85) and selenium monobromide, for which Borgström in 1929 claimed an index of 2·1, but which Anderson and Payne (1934) found when fresh to give a value of 1·96, which rises on exposure to air due to decomposition and self-saturation with selenium.

The solutions and mixtures are too numerous to quote in a brief abstract. Meyrowitz himself has proposed new liquids with arsenic trichloride as a basis, giving an index value of 2·07 for a mixture of arsenic tribromide, arsenic trisulphide, and sulphur (presumably fused together). Most of the liquids mentioned in the paper are obnoxious in one way or another, if not positively dangerous in use. Up to the present, it appears that the solution of sulphur and tetraiodoethylene in methylene iodide (proposed by Anderson and Payne in 1934), which has a refractive index of 1·81, is still the highest index liquid which does not seriously damage the soft lead glass of the standard refractometers. With diamond or blende refractometers the matter is different, and some of the unholy mixtures proposed in this paper may be worth a trial. The paper concludes with 85 references to the relevant literature.

B.W.A.

CUSTERS (J. F. H.). *Large type II diamonds.* Nature, Vol. 176, p. 360, 1955.

In a recent article in *Nature* by Sutherland, Blackwell and Simeral (see abstract in this Journal, Vol. V., p. 88, 1955) the authors stated " . . . in our experience all large diamonds of gemstone quality are always type I diamonds." Commenting on this sweeping statement, Dr. Custers states that in actual fact the four largest and finest diamonds examined since 1951 in the Diamond Research Laboratory in Johannesburg were all of type II. These stones weighed 34½, 66, 160 and 426½ carats, respectively. All four were pure white in colour, showed laminations, and were transparent to short-wave ultra-violet light. None of the diamonds showed fluorescence under long-wave ultra-violet rays, but two of them showed the green-blue phosphorescence after irradiation with short-wave ultra-violet and the semi-conductor properties which Custers associates with his type IIb diamonds (see this Journal, Vol. IV, p. 300, 1954). Custers further expresses the opinion that nearly all the larger gem diamonds belong to the type II category, and also remarks that the Premier Mine produces a higher percentage of type II stones than any other mine. With this in mind, it would be interesting to test one of the minor stones cut from the Cullinan, which was also recovered from the Premier mine.

It would seem that the legend that type II diamonds are exceedingly rare is gradually breaking down. Of four " portrait stone " diamonds from different sources tested by the abstractor, three were transparent to short-wave ultra-violet light, and come into the type II category.

B.W.A.

Schaller (W. I.): Hildebrand (F. A.). *A second occurrence of the mineral sinhalite.* Amer. Min., Vol. 40, p. 453–457, 1955.

In 1932 Larsen and Schaller wrote an account of an occurrence of the rare mineral serendibite in Warren County, New York State. The mineral occurs in thin layers of a contact zone between limestone and an intrusive granite, and is of hydrothermal contact-metamorphic origin. Among the associated minerals were diopside and two undetermined species which the authors designated " mineral A " and " mineral B." Mineral A remains unidentified. Mineral B has now proved to be sinhalite, as shown by comparison of X-ray powder photographs made from fragments of material remaining from the former investigation with those published by Claringbull and Hey for sinhalite in 1952. This announcement does not mean that a new source of gem-quality sinhalite is now available, but it is extremely interesting scientifically, as it indicates a probable origin for the sinhalite found in the gem gravels of Ceylon. Serendibite is known to occur near Ambakotte, Ceylon, in contact zones between limestone and a granulite, accompanied by blue spinel, apatite, scapolite, and diopside. It is suggested that re-examination of specimens of serendibite from Ceylon might reveal the presence of sinhalite *in situ* as an associated mineral

B.W.A.

SHAUB (B. M.). *Recent discovery of fine gem tourmalines in Maine.* Gems and Gemology, Vol. VIII, No. 5, pp. 131–136, Spring, 1955.

Tourmaline was first found in Maine at Paris, at the locality now known as Mount Mica. A relatively small quantity of gem crystals from this locality is now available. It is mentioned that practically the only area which has produced gem tourmalines is a narrow zone near the south-west border of the State of Maine, extending from Auburn to Andover and west to New Hampshire. The recent discovery reported is from a location in the town of Norway where a number of trial pits were sunk for the recovery of mica. During these trial borings a pocket of gem-bearing material was located. This material was removed and by softening with water a number of tourmaline crystals were recovered. There were about 14,000 carats of crystals found, many of which had been broken across the prism by natural forces before mining operations opened the pocket. Of this quantity of crystals about 8,000 carats will produce gems, and 4,000 carats of bluish indicolite may cut into cabochons. Many crystals were terminated with etched and dull faces. Most of the material is bluish-green in colour, the few pieces of pink coloured material not being suitable for gems. Much information is given on the associated minerals.

4 illus. R.W.

SHAUB (B. M.). *Recent discoveries of topaz.* Gemmologist, Vol. XXIV, No. 288, pp. 124-127, July, 1955.

Tells the story of some recent finds of topaz crystals from microlitic crystal-lined cavities and fissures in a medium- to coarse-grained granite. The locality of the find is near Conway in New Hampshire, U.S.A., not far from the borders of Maine. The crystals, varying in colour from white to weak brown-yellow, are found in association with crystals of reddish microcline, smoky quartz, albite and fluorite. The article, further, gives a report of the tourmaline find in the town of Norway in Maine. (*See abstract from Gems and Gemology above.*)

3 illus. R.W.

ELLISON (J. G.). *Advantages in recutting star stones.* Gems and Gemology, Vol. VIII, No. 5, pp. 151—153, Spring, 1955.

Discusses the value of recutting badly shaped, off-centred,

and too heavily based star stones. Seven reasons are given for the advantage of recutting, the cost of so doing being negligible compared to the increased value of the stone.
5 illus. R.W.

RICHARDSON (H. L.). *The art of gem engraving.* Gems and Gemology, Vol. VIII, No. 5, pp. 137–144, Spring, 1955.

Gem carving or engraving is said to date from approximately 3800 B.C. and the earliest were copies of the sacred scarabs made in steatite, carnelian, chalcedony etc. Later early engraved gems served the purposes of seals and were used as personal marks before the invention of writing. Some engraved gems were simply amulets, and some were family seals handed down from generation to generation and were the forerunners of the family crest. The designs used on ancient seals depicted every phase of life. Cylinder seals were used in Ancient Egypt, Babylonia and Assyria. Three-sided seals from the Minoan culture of Crete were made of steatite. Earliest known engraved portrait stone is about 1500 B.C. Cameo carving attained its greatest splendour at the beginning of the Roman Empire. The history of cameos, and of the methods used in cutting them from mediaeval times till the present time is told. Shell cameos are cut from the Bull's Mouth shell found in the East Indian seas. The article closes with the story of the engraving of a monogram on a flat diamond.
9 illus. R.W.

MITCHELL (R. K.). "*Bloodshot*" *iolite.* Gemmologist, Vol. XXIV, No. 287, pp. 110–112, June, 1955.

Reports the characters of two unusual iolites which exhibited a red colour. The colour was found to be due to countless minute ultra-thin hexagonal plates of an included blood-red mineral, which, it is suggested, may be hematite or goethite, the former being the most probable. Fuller examination showed that there were two types of inclusions in the matrix of normal iolite; they are the hexagonal plates already mentioned, and short needle-like forms at right angles to the plates. The plate-like habit of the hexagonal type of inclusion gave, owing to their thinness, a pseudo dichroic effect. Mention is also made of the colourless labradorite feldspar found in Utah.
2 illus. R.W.

WEBSTER (R.). *X-Rays and their use in gemmology.* Gemmologist. Vol. XXIV, Nos. 287/8/9, pp. 106–109; 131–135; 148–151, June/July/August, 1955.

The series continues with notes on modern X-ray tubes, and gives elementary theory of the production of X-rays. X-rays are produced by the rapid deceleration of a fast electron stream colliding with the target. This produces a continuous or as it is called "white" radiation. When the energy of the bombarding electrons is powerful enough to ionize the target material, radiation of discrete wavelengths is produced. This gives a " line " spectrum known as the " characteristic radiation." The production of monochromatic X-rays is briefly touched on. X-rays are employed in gem testing in three main ways; by the luminescence induced by the rays; by the variable transparency of different materials to the rays, and thirdly, by the diffraction of the rays from the atomic planes of the material. The luminescence of gem materials under X-ray bombardment is only touched upon in the article as the subject has been well covered in an earlier series (*Gemstone luminescence*) by the same author. Differential transparency, or radiability, is a function of the atomic weight of the element or elements forming the substance. The use of this differential transparency is discussed in relation to diamond doublets and gemstones with greatly differing transparency to the rays, and to the direct radiographic (skiagram) method of testing pearls. The techniques needed in such a method of pearl testing are explained. The diffraction methods are discussed, with particular attention to the lauegram method of pearl testing. The " powder " method is briefly explained, and the modification of the Sach's back reflection method devised by Holmes and Switzer is mentioned. The article closes with a warning that some gemstones tend to turn to a different colour after extensive bombardment by X-rays.

15 illus. P.B.

SMALL (J.). *Weight estimation of pearls.* Gems and Gemology, Vol. VIII, No. 4, pp. 99–105, Winter, 1954/5.

A set of tables for the weight estimation of pearls according to diameter in millimetres. The formula employed for working out the tables is given. The table gives the weights for pearls from 1 mm. diameter to 17·7 mm. diameter. The weights being given in " pearl grains," " mommes," " carats " and " grams." Owing to an error in the computation of the " momme " (given as 1 momme equals 0·0132 ounces instead of 0·132 ounces) the " momme " column is incorrect by one place of decimals, the decimal point needing to be moved one place to the left. This error is corrected by an announcement on page 157 in the succeeding issue. A graph is also incorporated.

R.W.

LIDDICOAT (R. T.): CROWINGSHIELD (G. R.). *Strontium titanate.* Gems and Gemology, Vol. VIII, No. 5, p. 148, Spring, 1955.

A report on the new synthetic strontium titanate. Not a synthetic equivalent to any mineral in nature; closest in minerals is *perovskite* ($CaTiO_3$). Strontium titanate, a product of the Verneuil furnace, has a hardness of 6; a refractive index of approximately 2·409; a dispersion (N_F—N_C) of 0·108. The specific gravity is approximately 5·13. The material is opaque to X-rays and displays no fluorescence. The critical angle is 24° 32″, and the melting point of the material is 2080°C. The stones are to be marketed under the name " Starilian."

R.W.

LEECHMAN (G. F.). *Lattice structure in precious opal.* Gems and Gemology, Vol. VII, No. 5, pp. 154–155, Spring, 1955.

Refers to the work of C. V. Raman on the colour of opal. Common opal is said to be completely amorphous, but precious opal, from X-ray investigations, contains tridymite and cristobalite, and may be said to consist of amorphous hyalite containing random blocks of crystal lattices formed of parallel laminae, presumably with the structure of cristobalite. Mention is made of the regular structures induced in colloid gels under certain conditions and of the nearly monochromatic nature of the light reflected from such structures—having what is called a " film pack " structure.

R.W.

RAMAN (C. V.): JAYARAMAN (A.). *X-ray study of fibrous quartz, chalcedony, iridescent agate.* Gems and Gemology, Vol. VIII, No. 4, pp. 106–107, and 125, Winter, 1954/5.

An abstract made of three articles appearing in the " Proceedings of the Indian Academy of Sciences " Vol. XXXVIII, Nos. 4 and 10; and Vol. XL, No. 3. Mineralogists designate a mineral as fibrous when it consists of visibly distinct rods or threads, irrespective of whether these are separable from each other. Quartz pseudomorphs of fibrous minerals also have fibrous structure. Microscopical investigation in polarized light shows the quartz fibres to be parallel to the " c " axis and such fibrous quartz may be described as polycrystalline quartz with a strongly preferred orientation for the crystallographic " c " axis. In chalcedony the crystallites of quartz have been found by X-rays to have the " a " axis parallel to the fibre length. Lamellar structure is said to be due to variations of the " c " axes of the crystallites in the successive layers which are perpendicular to the length of the fibres. With the rarer iridescent agate it is stated the crystallites of quartz form fibres elongated in the direction of the " a " axis, while their " c " axes lie in the planes of banding but are oriented in a periodic manner in these planes so as to build up a structure which functions as a diffraction grating. It is known that quartz exhibits a type of twinning in which the " c " axis in the two components of the twin are nearly at a right angle to each other. It is inferred that the fibres of quartz in iridescent agate may be described as polysynthetic twins in which the alternate elements are related to each other presumably in the same manner as the twins referred to.

R.W.

WEBSTER (R.). *Stichtite—an ornamental stone.* Gems and Gemology, Vol. VIII, No. 5, pp. 149—150, and 156, Spring, 1955.

Describes, and gives the history of the finding at different localities, of the mineral stichtite. The mineral has been cut *en cabochon* and has been suggested as usable for inlay work as a contrasting coloured material in ornamental stonework. The material is found massive in matted aggregates of plates or scales. The hardness is between 1½ to 2; the refractive index approximately 1·53, and the density was found to vary from 2·15 to 2·22 (determined on specimens from Transvaal). The rose-coloured mineral is a hydrated carbonate-hydroxide of magnesium and chromium. The material shows no luminescence and the absorption spectrum is of chromium type.

1 illus. P.B.

Goodwin (Peter). *Points on judging jade.* Printed by the South China Morning Post Ltd., Hong Kong.

A companion booklet to *Ten points about pearls* by the same author (*reviewed in Journal of Gemmology, July*, 1955). The points indicated include " Is it jade ? "—which mentions seven other materials imitating jade, namely glass, plastics, green-stained chalcedony, the so-called " New Jade," verdite, New Zealand jade and Yunnan jade. The texture of jade—and it is clear that the author is writing about jadeite, so often called " Chinese jade "—is discussed. Emphasis is placed on the " dimpling " seen on the surface of polished jade, and this is described as being due to a difference in hardness in the composition of the stone, which, according to the author, is composed of two minerals rather coarsely mixed together. The surfaces of glass and plastics are said to be usually quite smooth and regular. The extremely low hardness of plastics appears to have been overlooked. Point 3 deals with the substitutes, or at least three of them; New Zealand jade and Yunnan jade are mentioned as varieties of jade from the mineralogist's point of view, and these do not show the dimpled structure and their colour is much less pleasing. The so-called " New Jade " is described as having " a sickly yellow-green colour, is quite translucent and looks like good quality candle grease of a fancy shade . . . it hardly seems to have been worked by hand but gives the appearance of having been moulded." This material is said to be seldom used for jewellery but mainly as carved figures. It would be interesting to know what this " New Jade " really is. Point 4 describes other green stones, and these are confined to chalcedony and, strangely, verdite. The chalcedony is said to be stained a very bright green and sold always as jewellery and never as carved ornaments. Verdite, of which the author admits having seen only one piece—a necklace—in the Far East, is well described as to its appearance and its low hardness is remarked upon. Malachite is also described and prase and chrysoprase are mentioned. This is followed by a short summing-up. The value of jade pieces is then discussed with respect to quality, weight and spread, and the final point discusses the value of the setting. The concluding pages, give a general summary. The booklet, consisting of sixteen pages, is well printed on pale green paper and has an imitation snake-skin cover of similar hue.

R.W.

Anderson (B. W.): Payne (C. J.). *The spectroscope and its application to gemmology.* Gemmologist, Vol. XXIV, Nos. 287/8/9, pp. 102–105; 128–130; 143–146, June/July/August, 1955.

These three instalments (Parts 23, 24 and 25) of this important series continue with the stones which owe their colouring to ferrous iron. In the description given of the absorption bands of enstatite and diopside a discussion is made of the chemical affinities of enstatite, bronzite and hypersthene; and also of diopside. The absorption spectrum of enstatite is characterized by a single sharp line in the blue-green at 5060A. There are a number of weaker and vaguer bands to be seen in favourable specimens, and these are tabled. Comparison of the 5060A line is made with other lines near this wavelength in other minerals coloured by ferrous iron. The 5040A line seen in some diamonds is very similar in appearance to the enstatite line but seems to be due to a totally different cause. Diopside shows bands and lines at 5470, 5080, 5050 and 4900A, of which the narrow lines at 5080 and 5050A are alone prominent. In the case of the chrome diopsides the " chromium lines " in the red are seen, with the doublet at 6900A fairly strong. The ordinary dull green diopsides show feeble absorption spectra which have small diagnostic value. The absorption spectrum of kornerupine is weak and varies somewhat for the gamma ray and beta ray—the bands in these two cases being tabled. The only bands at all prominent are 4460A band in the green ray and the 5030A band in the yellowish-brown ray. The attractive green kornerupines from Burma show no definite absorption spectra. In axinite the bands are in general weak, but there is a narrow line at 4150A which is fairly strong. The influence of iron and manganese in the coloration of green and pink tourmalines is discussed in relation to the ferrous iron coloration of the green and blue-green tourmalines. In this connection the work of the Bradleys on the X-ray crystallography and absorption curves of tourmaline is mentioned. The absorption spectrum of green tourmaline shows the red absorbed up to 6400A, and in some cases even further; the yellow-green freely transmitted except for a faint absorption region near 5600A. In the blue-green coloured stones a typical ferrous iron band at 4980A with a weaker band at 4680A. In some specimens of green tourmaline, particularly in the blue-green coloured stones, a strong band may be seen in the violet at 4150A, which may be present in the dark green or the brownish-green tourmalines but masked by

the strong absorption in that region. The strong pleochroism of iolite is discussed, the different coloured rays being linked up with the optical directions, before the absorption spectrum of this stone is described. The absorption spectrum of iolite is not spectacular and consists of a number of weak bands, the most prominent being at 6450, 5930, 5850, 5350 (most clearly seen in the yellow ray), 4920, 4560, 4360, and 4260A. The bands at 6450A and the one at 4260A are best seen in the yellow ray for the absorption of the red and the blue-violet mask them in other rays.
7 illus. R.W.

REICHEL (F.). *Neuer Aufschwung der japanischen Perlenindustrie.* Increase in the Japanese pearl industry. Gold und Silber, No. 1, p. 13, 1955.

In November, 1954, the Japanese pearl industry opened a new centre at Kobe, through which 80 per cent of the Japanese sales are made. There is a shortage of large pearls, as for financial reasons pearls which are only one year old are put on the market. Investments are asked for, to produce more mature pearls. Export maximum prices are to be fixed and low quality goods excluded. From January, 1952, to August, 1952, the U.S.A. bought Japanese pearls to the value of Mill.$2·2, partially for re-export. Japanese pearl fishers are prevented from working nearer than 10 miles to the Australian coast.

E.S.

MARTIN (J. G. M.). *Kokichi Mikimoto—a tribute.* Gems and Gemology, Vol. VIII, No. 4, pp. 108–122, Winter 1954/5.

A short appreciation of Kokichi Mikimoto who died earlier in the year. The article is built up mainly from extracts from the Cahn report (*Journ. Gemmology*, Vol. III, No. 8, pp. 337–8, 1952), and as such is sound and provides a valuable abridged version of this important American Government Publication.
7 illus. R.W.

ASSOCIATION NOTICES

OBITUARY

SIR JAMES WALTON

The Association records with deep regret that Sir James Walton, K.C.V.O., M.S., F.R.C.S., F.G.A., the Chairman of the Association, died at his home in Mayfield, Sussex on August 27th, 1955, at the age of 73. Sir James was a distinguished surgeon who made the study of gemmology his hobby. He was extra surgeon to Her Majesty the Queen and had been surgeon to King George V, King George VI, and to the Royal Household. From his student days he was intimately connected with the London Hospital and became senior surgeon. He held other appointments in the medical world, including the presidency of the Association of Surgeons, the Medical Society of London, and the Vice-Presidency of the Royal College of Surgeons.

He had a brilliant career obtaining his B.Sc., M.B. and M.R.C.P. degrees rapidly, and in 1907 became a Fellow of the Royal College of Surgeons. He obtained the M.S. degree in 1909. He was created K.C.V.O. in 1935. Other honours that came to him were Chevalier of the Legion d'Honneur and honorary fellowship of the American College of Surgeons.

When he was nearing retirement as a surgeon he was attracted to the study of gemstones, and in 1945 qualified in the Association's diploma examination with distinction. His hobby absorbed much of his time and he became Curator of the Association's gem collection in 1947. In 1951 he was elected Vice-Chairman and in February of this year he became Chairman. In addition to important medical books, Sir James wrote *Physical Gemmology*, published in 1952, and a *Pocket chart of ornamental and gem stones* (1954). The National Association of Goldsmiths were greatly honoured when Sir James accepted an invitation to become President of that organization, and he served in office from 1953 until his death. He was a distinguished and lovable gentleman and he will be sadly missed.

MEMORIAL SERVICE

A service in memory of Sir James was held at St. Philip's Church, Stepney Way, London, on Tuesday, 13th September. The Queen was represented by Sir Arthur Porritt, Serjeant-Surgeon to Her Majesty. Members of the Association present included Mr. F. H. Knowles-Brown, Dr. E. H. Rutland, Mr. J. R. Chisholm, Mr. J. H. Saunders, Dr. W. Stern, Mr. T. Stern, Mr. G. F. Andrews, Mr. A. R. Popley, Mr. B. W. Anderson, Sir Cyril Dyson (National Association of Goldsmiths) and Lady Dyson, and Mr. I. Tarratt and Mr. J. Holgate, members of the Council of the National Association were also present.

B. W. ANDERSON writes

One of the earliest of many treasured memories of Sir James Walton is so typical of him that it is worth recounting. It was June, 1945; I was invigilating the practical examination of the Gemmological Association at Chelsea Polytechnic, and Sir James was one of the entrants. Coming up to the table where the heavy liquids were assembled, Sir James dropped the stone he was testing first into one liquid and then another, handling the tongs with a surgeon's sure precision (in contrast to the nervous fumblings of the younger students) and meticulously wiping clean the specimen and tongs between each operation. He caught my glance of amused admiration, and as he passed by me whispered enthusiastically, " I say, Anderson, this *is* fun ! "

Yes, gemmology *was* fun to Sir James, and continued fun, to the end. *Serious* fun, of course. He was the eternal student, and took the keenest delight in all the impedimenta connected with his hobby. His notebooks were a pleasure to behold: page after page packed with his characterful and very legible hand, and illustrated by careful diagrams and drawings.

In the post-diploma class at Chelsea, Sir James was for many years the most distinguished member of a memorable " front bench " of enthusiasts. On these occasions his attaché case revealed itself as a portable laboratory from which issued microscope, polariscope, heavy liquids (the latter mounted cunningly on gimbals, so as to remain upright when the case was being carried) . . . and an old Herbert Smith refractometer, to which he was greatly attached.

From time to time he could be persuaded to give lectures himself to the class on subjects on which he had read and thought extensively, such as the structure of the atom, jade and the jade-like minerals, or the internal structures of quartz. He was a delightful and polished lecturer. Invariably he had been at great pains to prepare his verbal and illustrative material to the last detail. The exposition was clear and orderly, yet there was no rigid adherence to notes to mar the interest.

His book, " Physical Gemmology," which was derived from his own carefully compiled notebooks, was, for all its minor faults, original in conception and a distinctive addition to our literature, which, one must admit, tends to become rather hidebound.

Sir James's ingenious mind and craftsman's hands resulted in the production of many gadgets, models, and intruments, some of which are now being manufactured by Rayner on a commercial scale.

He served the Gemmological Association well in many capacities—as councillor, curator, Vice-Chairman, and (all too briefly) as Chairman. All who knew him held him in high affection and esteem. His simple, natural friendliness, complete lack of snobbery or " side," his courtesy and kindness, his generosity and humour, all combined to make a most lovable personality. He will indeed be profoundly missed by all of those who were fortunate enough to have been his friends.

COUNCIL MEETING

A meeting of the Council of the Association was held at Saint Dunstan's House, Carey Lane, London, E.C.2, on Tuesday, 23rd August, 1955. Mr. Norman Harper, Vice-Chairman, presided.

The Council heard with deep regret that the Chairman, Sir James Walton, was gravely ill and that he would be unable to attend any further meetings.

The results of the 1955 examinations were presented to the Council, together with the report of the examiners. In general the standard in the examinations was higher than in 1954. (A list of successful candidates is given in these Notices.) The Worshipful Company of Goldsmiths had kindly given permission for the presentation of awards to be held in the Livery Hall on 9th November.

The following were elected to Ordinary Membership:—

Benjamin A. Clay, Halesowen.
John Morgan-Smith, London.
John G. Thomas, Carlton, Australia.
Brian Simpson, Swansea.

TALKS BY MEMBERS

Caffell, E. W. : " Gemstones." Westfield and Kingfield Women's Institute, Surrey, 1st September, 1955.

Ewing, D. J. : " An introduction to gemmology." Dunfermline Naturalist Society, 10th October, 1955.

Melrose, R. A. : " Gemstones." Rotary Club, Seaham, 30th August, 1955.

Melrose, R. A. : " Gemstones." Inner Wheel, Blyth, 6th July, 1955 ; *id.* Rotary Club, South Shields, 14th July, 1955.

Webster, R. : " The use of the microscope in gem testing." Central School of Arts and Crafts, London, 15th June, 1955.

1955 EXAMINATION RESULTS

The 1955 examinations in gemmology, held by the Gemmological Association of Great Britain, were again marked by a large number of entries. One hundred and forty-eight candidates entered for the preliminary examination, of whom one hundred qualified, and fifty-four out of eighty-three candidates qualified in the diploma examination. Last year's Rayner Prizeman, Mr. R. E. Muir of Wilmslow, Cheshire, has been awarded the Tully Medal. The Rayner Prizeman is Mr. M. S. D'Arcy of Peterborough, for the knowledge of the subject shown in his papers.

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

Diploma

Qualified with distinction

F. E. Alexander, Romford.
W. Bialek, Birmingham.
C. Bonanno, Washington, D.C.
S. C. Henderson, Dundee.
R. Klippel, Sherman Oaks, Calif.
R. E. Muir, Wilmslow.
F. H. R. Parkes, Brierley Hill.
A. J. Sibley, West Wickham.
Miss G. E. Todd, London.

Qualified

J. Anfield, Edinburgh.
A. J. R. Bennett, Cheltenham.
F. Brinks, Leiden.
J. S. Cameron, Auckland.
Miss J. R. Chalmers, London.
A. R. Clark, Glasgow.
J. A. Clark, Forfar.
P. Collier, Liverpool.
E. Colman, Leamington Spa.
P. G. Cooper, London.
J. M. Crichton, London.
Miss G. Cross, Birmingham.
B. P. Davies, Gerrards Cross.
J. W. Dubois, Hong Kong.
P. J. Dungate, Loughton.
D. S. M. Field, Toronto.
Mrs. A. H. Greenhill, Belerno.
J. Hart, Glasgow.
A. D. Havenhill, Fresno, Calif.
F. Hessling, Birmingham.
Miss D. M. Janes, Margate.
M. Lipman, Johannesburg.
R. S. B. Lyon, Edinburgh.
I. Macdonald, Glasgow.
A. E. Middlesmiss, London.
N. C. Morrison, Jnr., Ingleswood, Calif.
M. J. O'Hara, Sydney.
D. G., Paterson, Edinburgh.
W. Pyke, Wolverhampton.
Miss E. B. Pyne, South Woodford.
Mrs. W. M. Rankine, Farnham.
B. Roulet, Basle.
A. Schilling, Stuttgart.
E. J. Soukup, San Diego, Calif.
Miss T. R. Spittle, Birmingham.
Mrs. E. Stern, London.
W. H. Summers, Burnham.
L. J. Van Ameringen, Leiden.
H. M. Vaughan, Ross-on-Wye.
J. O. E. Vince, Ipswich.
A. J. Walker, London.
R. A. Wells, New York.
D. K. Williams, Holland, U.S.A.
B. R. Worth, Leicester.
D. Wright, Weston-super-Mare.

PRELIMINARY

Qualified

Agnes C. Allison, Glasgow.
James Allison, Glasgow.
Ian J. Allum, Wellington.
Sture Andersson, Uppsala.
Kenneth A. Banks, Manchester.
Alan J. R. Bennett, Cheltenham.
Dennis C. Bentley, Epsom.
Charles E. Beresford, Birmingham.
Kjell Berggren, Angelholm.
Antonio C. Bonanno, Washington.
William G. Bone, London.
H. G. Bonning, Tonsberg.
James G. Boyd, Cambuslang.
F. Brinks, Leiden.
Cote Carlebjork, Enkoping.
Norman Catherall, Wallasey.
Sylvia D. M. Chiles, Coulsdon.
David R. Clarke, Sutton Coldfield.
Edwin W. Clifford, Cassington.
Walter G. Cook, Liverpool.
Michael S. D'Arcy, Whittlesey.
Kurt Decker, Lidingo.
J. C. Ebbestael, Oslo.
Carl-Eric Eriksson, Harnosand.
J. Felin, Oslo.
William F. Ferguson, Alexandria.
J. Flapper, Arnhem.
Kenneth W. Fortune, London.
M. A. Gam-Dede, New York.
Charles D. Goodwin, Trentham.
Davina E. Gordon, Ruislip.
Anthony C. Hackett, West Ewell.
David E. Haigh, Lincoln.
Peggy I. R. Hall, Edinburgh.
John S. Harris, Glasgow.
Asher D. Havenhill, Fresno, Calif.
August F. E. Herr, London.
John M. M. Hirshman, Plymouth.
Edwin S. Hodgson, Darlington.
Kenneth Hoskyns, Birmingham.
George F. Humphreys, London.
Roy E. H. Jeffreys, London.

Archibald V. King, Edinburgh.
Peter N. Kingwill, London.
Ronald M. Kirk, Rutherglen.
Robert Klippel, Sherman Oaks, Calif.
Geoffrey W. Laney, Walton-on-Thames.
A. L. Larsen, Drammen.
Angus D. Lauder, Edinburgh.
Hugh Leiper, Austin, U.S.A.
Emily C. Lewis, London.
William Longbottom, Hull.
Hector M. MacLeod, Glasgow.
Patrick R. Mallory, Bath.
John A. Maxwell, London.
C. S. Mendis, Colombo.
Frank Molyneaux, London.
John Morgan-Smith, London.
William A. Muir, Wilmslow.
John Mulvey, Glasgow.
Bernard Muscat, Johannesburg.
Barbara J. Nilson, Birkenhead.
M. J. O'Hara, Sydney.
Anthony T. Ould, Plymouth.
Edna P. Padbury, Birmingham.
Norman H. E. Parker, London.
E. C. Parrott, Washington.
Sarah A. Peplow, Stourbridge.
Alan W. Peters, Birmingham.
Brian L. Peters, Camberley.
Walter Petersson, Linkoping.
Frants Pettersen, Oslo.
Elsie Pitcher, Birmingham.
Frederick D. W. Pollard, London.
Kenneth Ratcliffe, Buxton.
Adi Redman, Johannesburg.
Bernard Roulet, Sweden.
Harry P. Samuel, Birmingham.
J. J. Schoo, Arnhem.
Achim Schilling, Stuttgart.
Brian L. Selwood, Bushey.
Walter Semple, Baillieston.
Julian S. Sherrard, London.
Brian Simpson, Swansea.
Cora A. Smith, Grays.
C. W. Smith, Baltimore.
Lawson B. Smith, Birmingham.
Alan W. Y. Stewart, Hampton-in-Arden.
George W. Stewart, Glasgow.
Graham C. W. Street, Sutton.
Antony K. Swann, Sutton Coldfield.
Elizabeth Tapper, Birmingham.
Brian G. Toms, Plymouth.
Leslie H. Tye, Bromley.
John T. Tyerman, Harrogate.
Milos Vainer, London.
Yngue Wahlberg, Gavle.
Arthur G. Wardell, Edinburgh.
Gunnar Werner, Goteborg.
Donald K. Williams, Holland, U.S.A.

BRITISH MUSEUM (NATURAL HISTORY) LECTURES

LECTURES IN THE MINERAL GALLERY, BRITISH MUSEUM (NATURAL HISTORY) ON SATURDAYS AT 3 P.M.

Oct.	22nd	Lead and its minerals	Dr. M. H. Hey
	29th	Chalcedony	Dr. A. A. Moss
Nov.	5th	How to find minerals in Britain	Miss J. M. Sweet
	12th	Submarine volcanoes—methods of detection	Dr. J. D. H. Wiseman
	19th	Uranium minerals	Dr. G. F. Claringbull
	26th	Rocks from the Antarctic	Mr. S. E. Ellis
Dec.	3rd	Geological thermometers	Dr. G. H. Francis
	10th	Silicate minerals	Dr. A. A. Moss
	17th	The great Siberian meteorite	Dr. M. H. Hey

(*This programme is subject to alteration without notice*)

CURATOR

The Council of the Association has appointed Mr. G. M. Sprague, F.G.A., to be Curator of the Association gem collection in place of the late Sir James Walton.

DIAMOND CORPORATION GIFT TO THE GEMOLOGICAL INSTITUTE OF AMERICA

The Gemological Institute of America is proud to announce that the Diamond Corporation has just presented to the Institute the Oppenheimer Student Collection of over 1,500 carats of rough diamonds. This generous gift was authorized for educational purposes by Sir Ernest Oppenheimer, Chairman of the Board of the Diamond Corporation, Ltd., of London and the Union of South Africa. The Collection has an importance to jewelers throughout the industry for it will be used for the expansion of the Institute's diamond grading and evaluation training.

Included in the Collection is a wide range of shapes, sizes and qualities, representing colors from collection to eighth (color grades employed by the Diamond Trading Company), clarity grades from glassies to fifth spotted, and crystal shapes from symmetrical octahedra to distorted macles. Individual crystals range in weight from over 23 carats to stones several to the carat. Among the stones included are macles of 23·06, 22·23, 19·48 and 15·68 carats and octahedra of 15·99, 13·14, 10·50 and 10·43 carats, as well as several others from 6 to 9 carats each. There are several hundred carats of bort crystals.

The Collection was first loaned to the Institute a number of years ago for demonstration purposes. By giving the Collection to the G.I.A., the Diamond Corporation has made it possible to have some of the stones cut to increase the number of diamonds available for class appraisal work. This will provide over two hundred additional stones in sizes from about ·20 to 2·50 carats. This cutting will be done according to specifications drawn up to duplicate the general range of cutting proportions and qualities now represented in the stones offered to the retailer by all types of diamond sources. In other words, various makes from ideal to spread, to those with symmetry faults, poor angles, and various other proportion and finish irregularities, will be represented so that Diamond Evaluation and regular Resident Class students will appraise a complete cross section of what is available in the market.

According to Richard T. Liddicoat, Jr., Director of the Institute, "This forward-looking and generous act by the Diamond Corporation will make it possible for the Institute to increase the number of its popular Diamond Evaluation Classes and to make them available in more cities throughout the country. We can only regard this gift of the Oppenheimer Student Collection as an endorsement of the effectiveness of the G.I.A. diamond training program."

LETTER TO THE EDITOR

Dear Sir,

I read with great interest Mr. J. R. H. Chisholm's notes in *Journal of Gemmology* 1955, Vol. V (2) pp. 77-79 (Apr.) with regard to the determination of specific gravity using heavy liquids. He reported on some tests with antimony tribromide which were originally suggested by J. Swimmer in *Ind. Diamond Rev.*, 1953, Vol. XIII, p. 255. Antimony tribromide which melts at 96·6 deg. C. and gives a liquid of about 3·6 was suggested for separating alumina from diamond. Ultimately its use for determining the specific gravity of a topaz crystal did not prove successful. Mr. J. Swimmer of National Biochemical Co., to whom Mr. Chisholm's notes were submitted, commented on this :

" As far as I can see everything Mr. Chisholm says about the use of antimony tribromide is true and it really is not suitable for use by the gemmologist. Also, as stated in my original article, it is not especially suitable for work with diamond powders but it will work where Clerici solution fails, owing to the fact that Clerici aqueous solution does not wet fine diamond and its common contaminants properly for separation work. Antimony tribromide's low price is another key factor in its use for routine work. Also the tendency to solidify is an advantage for powder separation because after the separation has been made hot and the mass allowed to solidify the sink and float can be separated by cutting the solid bar in two for removal of the respective fractions. Benzene (benzol) can be used to remove the last traces of antimony tribromide after most of it has been removed by heat. Most of these pros and cons on antimony tribromide are academic because it is of limited usefulness at best and we do not use it.

We recommend our MI-GEE methylene iodide being from $\frac{1}{2}$ to $\frac{1}{4}$ as toxic as carbon tetrachloride.

We also have a heavy liquid which is tailored for work with diamond powders being of 3·6 gravity at room temperatures of 70 deg. F. It is a solution of chemicals in methylene iodide of our own manufacture and the subject of patent applications. It is very useful for diamond powder work and may not be too good for gemmology but has more merit there than antimony tribromide. Its improved wetting power of minerals over aqueous solutions leads us to believe that it will have definite fields of usefulness."

I hope that this detailed explanation will clarify the position.

London. P. GRODZINSKI.

JOURNAL OF GEMMOLOGY

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Vol. 1, Nos. 1, 2, 3, 4, 5 and 6.

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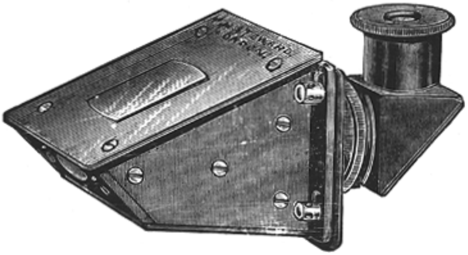

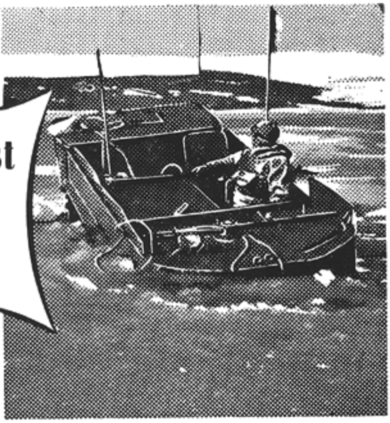

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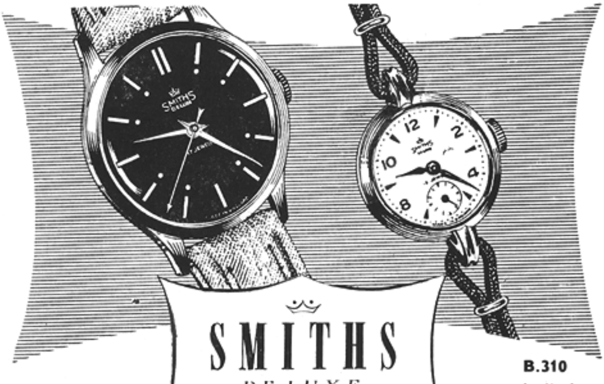

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