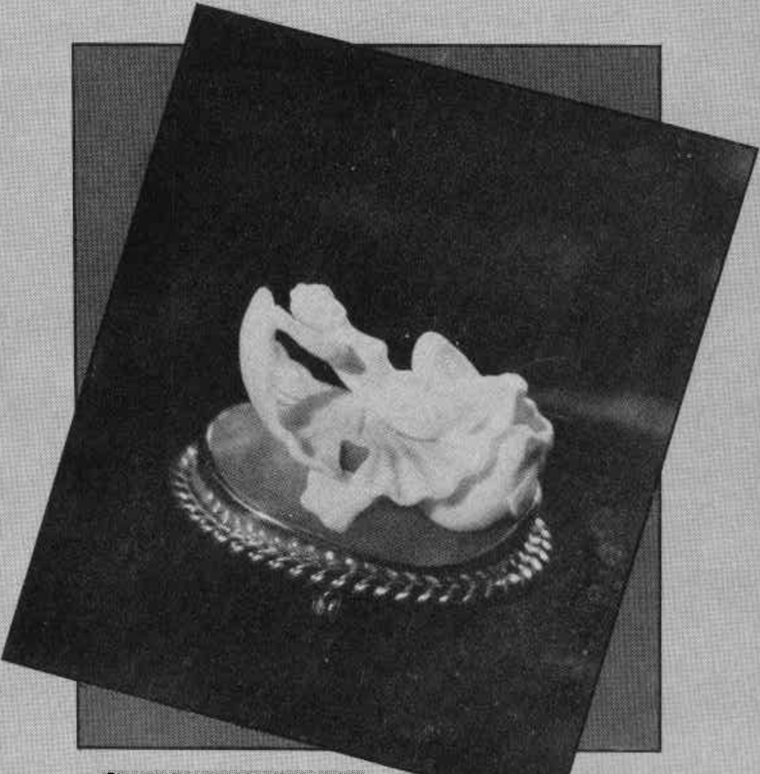
Gems and Gemology

SUMMER 1952



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GEMS & GEMOLOGY

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Richard T. Liddicoat, Jr.
Editor

On the Cover

Remarkable detail of fingers, toes, and hair braid can be clearly seen in the engraved figure shown on the cover. This shell cameo, which was purchased in New York City by Paul J. de la Reussille around 30 years ago, measures one and one sixteenth by three fourths inches, and is three fourths inches deep at its extreme point. Mounted in a yellow gold pin, it depicts the "Birth of Venus" with the goddess emerging from a shell supported by two dolphins. Shell, dolphins and Venus are white, while the base is a reddish brown.

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TWO NEW GEMSTONES
Taaffeite and Sinhalite

by

B. W. ANDERSON, B.Sc., F.G.A.

An interval of nearly 40 years separated the discovery of benitoite (1907) and the arrival of the next gem mineral, brazilianite, in 1945. It is thus rather remarkable that in the short period since then two more entirely new gem species have been added to the list.

A curious feature of these later discoveries was that each new mineral was found in the state of an already faceted gem, so that in both cases there was the strange necessity of carrying out all the determinative work, including X-ray and chemical analysis, on cut gemstones, or on minute fragments removed from these. In the case of taaffeite, as will be recounted below, this was a particularly tricky operation, as for several years the only stone available in the whole world was one small specimen weighing 1.419 carats.

Without further preamble let me proceed to describe in turn these two newcomers to the ranks of precious stones, and the manner in which they came to light.

TAAFFEITE

The name (pronounced "tarfite") given to this mineral, with its curious spelling, is derived from the family name of the gemologist who first drew attention to it. Count Edward Charles Richard Taaffe was born in Bohemia in 1898, and was descended from an old Catholic Irish family for many years exiled from their land. Best known to the outside world was his grandfather, Count Eduard Taaffe, eleventh Viscount Taaffe and Baron of Ballymote, who was a distinguished Austrian statesman.

Taaffe, now resident in Dublin, has for many years been a keen gemologist. I knew him first as a correspondent student of the Gemmological Association during the War, when I was an instructor. I used to enjoy his original, racy replies to the set questions, and soon became aware that, despite his paucity of apparatus and lack of academic scientific training, he was a gemologist of quite unusual skill. The very lack of apparatus probably helped to develop his faculty for acute observation with the Bausch and Lomb Greenough binocular microscope which was (and probably still is) his main testing instrument.

One day in October 1945 Count Taaffe called on Mr. Robert Dobbie, a jeweler friend, for the purpose of buying some of the stones broken from old jewelry, which were stowed away in various "junk boxes." The searching and sorting took several days, and each day 100 or so stones were taken home. These were a very mixed bag. Blue zircons, opals, garnets, citrines, amethysts, spinels, a few Siam rubies, and poor quality emeralds and sapphires.

At home, Taaffe thoroughly cleaned the stones (an important factor with him as a preliminary to inspection) and roughly sorted them according to color. The stone which eventually became known as taaffeite was put in the little box containing violet and lilac stones. Each stone was scrutinized under the microscope on white paper, with illumination from above provided by an adjustable table lamp with metal reflector. The specimen in question, which looked like a pale mauve spinel, puzzled him by showing small, but quite distinct, "doubling" of scratches and dust particles at the back of the stone. This was a remarkably acute piece of observation considering the power of the microscope was only 21x the stone less than one and one half carats, and the birefringence (as later established) less than .005.

Next followed density tests. The stone sank in methylene iodide, and no Clerici solution was available, so hydrostatic determinations were made with a pocket balance in which the tassel had to be held by hand while the weighing was in progress. The average of ten determinations was 3.62. As our final figure obtained in the laboratory proved to be 3.613, this also was evidence of good work under difficult conditions. No refractometer was available, but the low relief in methylene iodide showed that the refractive index must be near that of spinel. There remained the puzzle of the double refraction, which was confirmed by a test between crossed nicols, which showed normal extinction at 90°. Finally Count Taaffe decided to send the stone to me at the Laboratory, stating the results of his tests, and asking "could anomalous double refractions be so strong?".

I have given the above rather full account of the exact circumstances of Taaffe's discovery (derived from the even fuller record which he kindly sent me when the paper[1] was eventually written) because it seems to me of both human and scientific interest. The rest of the story can be told more briefly.

When we examined Taaffe's stone, we measured its indices as 1.717 and 1.721 (see later for more accurate data) and found that it gave a clear uniaxial interference figure through the table facet. Trial with a quarter-wave mica plate showed the stone to be optically negative. Taaffe's density estimate was found to be substantially correct, and the hardness was near that of spinel. The stone was a very pale mauve and the absorption spectrum was weak in consequence. Such bands as could be seen and measured, however, bore a strong resemblance to those typical of blue spinel. No fluorescence was visible under the ultraviolet light, but X-rays induced in the mineral quite a bright green luminescence—spinel of a similar color behaving in a like manner.

Thus, though its optical properties made it seem impossible that the stone could be spinel, we felt that there must be a close relationship between the two. Subsequent findings proved the correctness of this prognostication.

Count Taaffe generously permitted the removal of part of the stone for the X-ray and chemical work which necessarily followed. This was carried out at the skillful hands of Dr. Claringbull and Dr. Hey in the Mineral Department of the British Museum (Natural History). The mineral was found to be truly hexagonal in symmetry and gave a spectogram proving the presence of beryllium in addition to the expected magnesium and aluminum.

For various reasons there was a long delay before the required quantitative chemical analysis could be completed. In the meantime (October 1949) a second specimen of the mineral was found by C. J. Payne while carrying out a routine laboratory test on a case of 100 mixed colored stones submitted by a Hatton Garden merchant in the ordinary way of business.

This collection consisted mainly of green sapphires, though a Ceylon kornerupine was a pleasant enough early "find." There were also a number of small pale-colored spinels with refractive index 1.715. One stone, however, had an index near 1.720—enough difference to make an experienced gemologist sit up and take notice.

The birefringence was not clearly ascertainable on the refractometer available—our best instruments being at a Gemmological

Exhibition being held in the Goldsmiths' Hall, a mile or more away. However, with a polarizing microscope, Payne obtained a uniaxial negative interference figure of a size indicating a small birefringence, and he realized with mounting excitement that at long last a second "taaffeite" (already our pet name for the mineral in the Lab.) had been found.

When at last Dr. Hey was able to carry out the delicate process of a complete quantitative microanalysis—for which he had only 12 milligrams all told to work with for both the preliminary and final runs—the mineral proved to be a beryllium magnesium aluminate, intermediate in composition between spinel and chrysoberyl. Hence the relation to the spinel group so strongly indicated by its properties, was confirmed. What in the cubic mineral spinel is the direction of a trigonal axis in taaffeite has become hexagonal. The comparable direction in the orthorhombic chrysoberyl is pseudohexagonal in symmetry.

The properties of the two taaffeites are summarized below. At present, these remain the only specimens known to the writer, despite a continuing search by many competent gemologists among spinels of "likely" color. The original locality of the stones is unknown but suspected for various reasons to be the gem gravels of Ceylon, which for us has been a happy hunting ground.

The refractive indices quoted below are measured in sodium light on a Zeiss Abbe-Pulfrich refractometer. Density measurements involved the finding of blue spinel pebbles of fair size which exactly matched the rise and fall of each when suspended in Clerici solution. These spinel indicators were large enough to yield reliable values by subsequent hydrostatic weighing in ethylene dibromide.

Quantitative hardness figures were obtained for us by Dr. W. Stern, using a microindentation method.

PROPERTIES OF TAAFFEITE

(1) Stone discovered by Count Taaffe in 1945. Pale mauve, weighing originally 1.419 carats; present weight 0.56 carat.

(2) Stone discovered by C. J. Payne in 1949. Now in collection of B. W. Anderson. Even paler than (1) weighing 0.87 carat.

	R.I.	Bi.	S.G.	H
(1)	1.7230 - 1.7182	.00475	3.613	8
(2)	1.7208 - 1.7167	.00412	3.60	8

The dispersion of stone (1) was obtained on a table spectrometer by the minimum deviation method, and found to be approximately 0.019 for the B - G range, compared with 0.0205 for spinel of similar tint.

SINHALITE

The sinhalite story goes a long way back. For years many museums, private collectors, and dealers in colored stones have had in their collections specimens of this unrecognized species. The stones vary in color from pale yellowish to very dark brown. At their best they are golden or greenish brown. When these had not been scientifically tested they passed, plausibly enough, as chrysoberyl, zircon, tourmaline, or beryl. When tested, their density, refractive indices, and birefringence fitted closely enough to the values to be expected for intermediate members of the forsterite-fayalite series to enable them to pass as an iron-rich variety of olivine—i.e., as "brown peridot." Only the low value of the optic axial angle as reflected in the proximity of the value of the intermediate refractive index, (Beta) to the maximum (Gamma) index should have aroused suspicion in an acute observer. One such was Dr. A. F. Hallimond, who made an entry in a register of the Geological Survey concerning one of these stones originally entered as chrysoberyl which, on the basis of his examination, he altered to "chrysolite" with the significant remark "This stone is to be further examined"—but apparently it wasn't. This was in 1912.

In my own collection in the Laboratory there were a number of sinhalites, dating back twenty years or so—some obtained by gift, and some by purchase. They interested me greatly—I was always hoping to find examples which would fill the gap between the

3.34 density of green olivines and the 3.46 upwards found in these brown or yellowish stones. I never did, and I now know why.

My colleague, C. J. Payne, had made accurate measurements of all three refractive indices of green peridot from all available sources (St. John's Island, Congo, Arizona, Hawaii) and found them remarkably consistent and all optically positive. He was puzzled by the strongly negative character of the brown "olivines" measured.

Another point which worried us was the very pale color of some of these high-density stones, which seemed hardly consistent with the color to be expected in an iron-rich olivine. However, we did nothing; we had grown up with these stones and did not seriously question them. The moral to be drawn here (well instanced in the history of taaffeite recounted above) is *"never let anomalies pass by without investigating their cause, however slight they may seem."*

To Dr. George Switzer, of the U. S. National Museum, goes credit for proving quite definitely that some, at least, of these brown gemstones could not be classed as olivine. In June 1950 he took a scraping from the girdle of a typical specimen in his Museum's collection and obtained an X-ray powder photograph from this small sample which showed spacings quite obviously different from those of olivine. It so chanced that Mr. Kenneth Parkinson, gemologist and dealer in collectors' stones, had brought back several cut specimens of "brown peridot" from a recent visit to Ceylon, and offered some of them for sale. Switzer applied for one of these in order to continue his studies, and, on hearing that I had forestalled him in the purchase, wrote to me early in 1951 asking for particulars of the stone for comparison with that he had tested. Data on this and similar specimens in our possession were duly sent to him, together with the tentative offer of one of the smaller specimens for analysis, should this prove necessary.

Not long afterwards, Dr. Foshag (also of the U. S. National Museum) paid a visit to this country. While inspecting the Mineral Gallery in the British Museum (Natural History) in South Kensington he remarked to Dr. Claringbull, who was showing him around, that a brown gemstone in the collection which was labeled "olivine" might have been incorrectly determined. Thus challenged, Dr. Claringbull lost no time in investigating this possibility quickly and thoroughly. He had plenty of material at hand both in the Museum and outside it, though all of it was in the form of cut gemstones.

Mr. Robert Webster happened to have a pale yellowish broken specimen of the mineral in question, and with pieces taken from this, both X-ray and chemical analysis were possible. As in the case of taaffeite, the final quantitative chemical analysis was carried out by Dr. M. H. Hey on a microscale. Preliminary spectrum analysis showed the presence of magnesium, aluminum, and boron, but *no silicon.* The full analysis proved the mineral to be in essentials a borate of magnesium and aluminum, with the ideal formula $MgAlBO_4$. Two per cent of iron was also present in the specimen analyzed.

The mineral is orthorhombic (crystal class not yet determined) and its structure has much in common with that of peridot—a fact reflected in the similarity between their absorption spectra—a similarity, incidentally, which had helped to lull our suspicions in the past. The name sinhalite was chosen in reference to the native name for Ceylon, the only locality so far known for its occurrence.

The color of sinhalite varies from pale straw yellow, through golden brown and greenish brown, to dark brown. The best stones are extremely attractive, and resemble chrysoberyl closely in their appearance, though the luster is not so bright. The mineral is obviously not uncommon. A score of specimens graced the table when the paper was read before the Mineralogical Society in London[2], and many more have come to light since then. They are often quite large, several being more than 20 carats in weight: the largest so far seen was one of nearly 75 carats. This was sent to the Laboratory as part of a routine test, in a packet marked "Jargoon."

In addition to the cut stones, one or two rough pebbles of sinhalite have been recovered from lapidaries' samples of the Ceylon gem gravel by Dr. E. H. Rutland.

Gemologists must be on their guard, however, since pebbles of a true brown peridot exist in the Ceylon gravel, and these have a very similar appearance to sinhalite. Cut specimens of brown peridot also are not unknown—one such from the British Museum collection was tested by Dr. Claringbull in the confident expectation that it would turn out to be a sinhalite, but it gave a normal olivine powder pattern.

The two minerals, however, are fairly easily separated even when the color is similar, since the brown peridot has properties very similar to the ordinary green examples and thus has lower refractive indices than sinhalite and density only slightly greater than that of methylene iodide. Of the few brown peridots examined, none has been a very clear stone, whereas sinhalite is usually remarkably free from feathers or flaws. The inclusions so far seen have been for the most part negative crystals either needlelike or tabular, but not enough have been studied to warrant any statement on "typical" inclusions at this stage.

The dichroism of sinhalite is distinctly stronger than in peridot, giving two shades of brown and a greenish ray (corresponding to the Beta index). Where the stone is cut with this latter ray in evidence a greenish cast is imparted to the gem.

The birefringence is a little larger than in peridot—quite large enough to give a very distinct doubling of back facet edges when viewed with a lens through the crown of the stone. This distinguishes it at once from chrysoberyl and (to the practiced eye) from tourmaline. Zircon shows even greater doubling, but in this shade of brown is hardly dichroic at all.

On the refractometer the sinhalite indices are too high for peridot and the birefringence too strong for diopside. With loose stones, a trial in methylene iodide is useful. Sinhalite sinks rapidly, distinguishing it from tourmaline, diopside, beryl, or true brown peridot, though on this test alone confusion might arise with chrysoberyl.

PROPERTIES OF SINHALITE

Composition: Magnesium aluminum borate ($MgAlBO_4$); *Crystal System:* Orthorhombic; *Hardness:* 6½; *Color:* Pale yellow to dark brown, greenish brown; *Pleochroism:* Distinct. Pale brown, greenish brown, darker brown.

Dispersion for sinhalite is approximately 0.017 for the B - G range. Absorption bands are mainly in the blue, centered at 4930, 4750, 4630, and 4520A with general absorption of the violet. Peridot has a very similar spectrum, but lacks the 4630 band, and on the other hand shows (on photographs) bands at 3970 and 3850A, which are missing in sinhalite.

The refractive indices given below were obtained by C. J. Payne on an Abbe-Pulfrich refractometer in sodium light. The density determinations were made by the writer by hydrostatic weighing in ethylene dibromide.

		R.I.		Bi.	S.G.
Pale yellow sinhalite	1.6667	1.6966	1.7048	.0381	3.47
Brown sinhalite	1.6691	1.6988	1.7069	.0378	3.48
Dark brown sinhalite	1.6708	1.7000	1.7081	.0373	3.49
St. John's Is. peridot	1.6541	1.6721	1.6900	.0359	3.347
Burma green peridot	1.6525	1.6659	1.6870	.0345	3.330
Brown Ceylon peridot	1.6562	1.6719	1.6920	.0368	3.35

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[1] Anderson, Payne, and Claringbull, "Taaffeite, a new Beryllium Mineral, found as a Cut Gemstone," *Mineralogical Magazine*, London, December, 1951.
[2] Claringbull and Hey, "Sinhalite, a New Mineral," *ibid.*, June, 1952.

ENGRAVED GEMS Through 6,000 Years of Popularity

by

KAY SWINDLER

Jewelry is more than the gift of sentiment, and it has long since outgrown its early label of a "luxury item" available to only a privileged few. Through the civilized ages it has been an integral part of dress and the wise jeweler is quick to keep abreast of fashion trends and to profit from them.

In recent years there has been a gradually increasing interest in pieces of antique jewelry, or jewelry patterned after antique design. In line with this trend, a selection of scarab jewelry was introduced at the recent trade shows by several jewelry manufacturers. Through the use of many varieties of cryptocrystalline quartz, these colorful bracelets, necklaces, earrings, and pendants—reminiscent of the ancient days of the Pharaohs and the splendor which once was Rome's—could, if properly presented, become an important accessory item. In one of the wealthier communities on the West Coast, there has also been an increasing demand by men for large intaglio cuff links fashioned of sard.

A familiarity with the interesting history of carved and engraved gems—one of the oldest arts practiced by man—should prove a useful sales tool for the retail jeweler and we hope in our discussion of its evolution through 6,000 years of history to provide information which may be advantageously used.

HISTORY OF GEM ENGRAVING

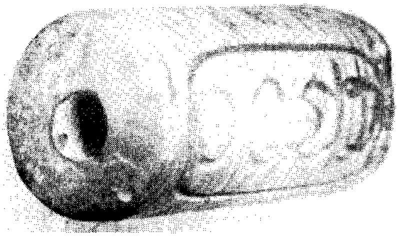
The earliest forerunner of the carved or engraved gemstone had a much more utilitarian use than as a means of personal adornment, although it was often beautifully and elaborately designed. It was introduced as a means of affixing a signature when the art of writing was the accomplishment of only a very few.

First form of the engraved gemstone was in all probability the cylinder which was individually designed for the owner and was used not only to sign important papers by impressing the intaglio inscription into wax or clay, but also to seal doors of private property. To the deeply superstitious and religious inhabitants of these ancient lands, unlawful violation of any sealed property would bring eternal damnation to the soul. For this reason, the sealed possession was as safely protected as it would be with the modern locks of today.

The first form of engraving and carving was intaglio and was introduced by the Sumerians in the Tigres-Euphrates Valley of Southern Mesopotamia about 3300 B.C. This method of affixing the signature was quickly copied by neighboring nations in Asia Minor and for 3,000 years seals were used in Babylon (modern Iraq), Syria, Hatti, (the Hittites), Assyria, and Persia (Iran). Cylinder seals remained popular until about the 4th century B.C. and several thousands still exist in collections today. The use of the cylinder seal also spread to Egypt but its popularity lasted only a short time and it was replaced by the sacred scarab seal.

ENGRAVED GEMS IN EGYPT

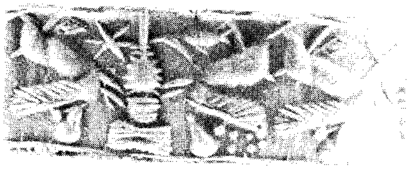
The scarab originated as an amulet-seal which was called Kheper after the creator—the sun god Khepera—whose symbol was the common beetle (kheper). It was of deep religious significance to the sun-worshipping Egyptians of the early dynasties. Personal symbols for signature to be impressed in wax or clay were inscribed on the broad oval base of the carved sacred scarab. For about 2,000 years each of seven million Egyptians had one or more of these scarabs, so it is understandable that a great many of them are still in existence.



- **Ancient Egyptian cylinder seal.**

As their predecessors, the cylinder seals, scarabs were cut intaglio and were drilled with a hole for hanging on a cord or thong, or for a swivel for mounting in a ring. These early ring-type seals were not worn on the hands, however.

From the 9th to the close of the 12th dynasty (about 2,000 B.C.) scarabs came into general vogue and reached their apex of popularity and perfection. Amethyst scarabs were common articles of jewelry in the Middle Kingdom. Others were fashioned in glazed steatite, obsidian, and crystal. When the harder stones were used, the scarab was often mounted in a band of gold, electrum, or silver with the metals also forming the base on which the inscription was engraved.



- **Clay impression of ancient seal.**

Scaraboids, whose backs were cameolike negro heads, or animal forms, instead of the regular beetle form of the sacred scarab, have been found among relics of the Middle Kingdom of Egypt. The base inscriptions of these are similar to the scarab seal.

Although, for some unknown reason, the scarab seal disappeared in Egypt about the 6th century B.C., through the trade routes its use spread to other countries and it remained the basic gem form until about two centuries later. Between 3,000 and 900 B.C. when culture flourished in the Mediterranean Islands, this form of seal was adopted by the inhabitants of Crete and Cyprus, as well as by the peoples on the mainland of the Western World.

EARLY GREEK ENGRAVING

Lacking religious importance to the early Greeks, the scarab form was nevertheless at first used by them in making signets or seals and they often imitated Egyptian models in blue pottery, glass, and the soft stones.

The gem cutters of the ancient Greek civilization did not borrow or copy and a sign of powerful folklore is found running through the decorations used by them. Animals predominate among designs on these ancient seals, with birds, fishes, trees, ships, vases, buildings, and geometric decorations also used. The cult element is also evident in this early art, with ceremonial dances and sacrificial scenes common. Gods and heroes were often used and humans in combat, riding in chariots, or in hunting scenes were good subject matter.

With the decay of Mycenaean culture, came the Dark Ages of Greece which extend down to the 7th century B.C.

Oriental forms began to appear on the seals or cylinders created during this time. Flat stones were often used with a bored handle. Rough cone shapes, or a flattened hemisphere shape were adopted. This probably developed later into the scaraboid form of the seal whose back showed only the cabochon. As the demand for rings increased in the 6th century, this hump was planed off and the flat ring stone—to be mounted in a frame of metal or to form the bezel of a ring or pendant—was developed. Geometrical designs were used, as were also a few animals and rudely drawn men.

ART OF THE IONIAN GREEKS

In the 7th century B.C. the immigrant Greeks of Ionia, which was a portion of the West Coast of Asia Minor, introduced a new Greek art. This tribe, which had a name for effeminacy and considerable wealth, were generally original in fashioning their seals although they were receptive to foreign ideas. Animals were popular as subject matter, as were the tales of mythology.

It is from this period that the mythical story of Prometheus had its origination. Pliny states that, "according to the fables of the poets," Prometheus was the first man to put a small piece of stone (from the rock to which he was chained in the Caucasus) into a piece of iron, and "placing it on his finger, had not only a ring, but also a gem-set ring." Pliny further credits this tale of Prometheus' ring as starting the fashion of wearing gem-set rings.

The Ionians were subdued by the Persians in the middle of the 6th century B.C.

From the 7th to the 6th century B.C., the art of gem engraving grew rapidly. The wheel was now used for cutting harder stones and carnelian, chalcedony, banded agate, and sardonyx were commonly known. Less common were green jasper and rock crystal.

During the period from 600 to 480 B.C.—known as Archaic Greek—the subjects began to show more motion and had lost much of their stiff Egyptian form. The scope of Archaic subjects was large. Heroes and gods in action were used as were natural animal forms with the Sphinx most common. Figures, though not portraits, were often seen, and there was a whole cycle of demons and the lower gods.

There were few inscriptions on the gems of this period. One which reads "I am the seal of Thyrsis; open me not," is the most pretentious. Several authentic artists' signatures have been found from this period. It is in this period that the noted gem engraver, Theodorus of Samos (560-522 B.C.) is believed to have lived. It is Theodorus who is credited with engraving the famous gem of Polycrates which was thrown into the sea and recovered from the belly of the fish. This is, of course, only one of the many variants of the ring-fish stories. Several writers have claimed that the ring of Polycrates was an emerald. Pliny, although he questions that the ring deposited in the temple of Concord by the Empress Augusta is Polycrates' ring, describes it as a sardonyx.

As the demand for seals increased Solon (638-556 B.C.), who had seen the evils of seal counterfeiting while traveling in Egypt, sponsored a law forbidding an artist to keep copies of signets he had cut.

ETRUSCAN SCARABS

The finest Etruscan (northern Italy) seals of the 6th and 5th centuries B.C. are in the form of the scarab. During the early part of this period the seals used by the Etruscans were undoubtedly made by Greek artists. By the 5th century B.C., however, they had learned to make their own seals. Generally, the intaglio of the seal was poor but the scarab was worked out by them with great care. The stone most commonly used by the Etruscans was the carnelian. Banded agate and sardonyx were not uncommon. The Etruscan was mostly an imitator and he filled the entire available space on the seal with carving.

The Etruscans seem to have had a special taste for scenes of violence—fighting, bloodshed, and death. Pictures were largely used as subject matter and most of them showed action. Although the designs may have been drawn from the hero element, it is possible that they depicted domestic scenes in the life of the owner. The myth of Prometheus bound on the rock was often pictured. Inscriptions were common.

In the 4th century, style lost all trace of severity and inscriptions are generally lacking.

Forgeries during the early 19th century were especially directed toward these Etruscan scarabs.

PURE GREEK GEMS

The best period of pure Greek art was from 480 to 400 B.C., but, unfortunately, few examples from this period exist today. The school of Attic art shows a much higher artistic merit, with more subtle accuracy in interpreting the subject matter. The scarab now begins to fall into the background and the scaraboid is adopted as the growing style for seals.

Seals are of considerable size and thickness with the curvature on the back apt to be pronounced. Several — produced around the time of Alexander the Great — show a convex face and back.

Stones which were set solid in rings have also been found from around the period of 400 B.C. From that date on, ring stones outnumber the scaraboid forms. A few cylinder seals have been found from the period between 450 and 400 B.C.

In Asia Minor and the islands, particularly, chalcedony predominated as the popular material used. Next came carnelian, banded agate, and sardonyx, with some rock crystal. Sard and lapis lazuli were rarely used, while glass pastes were abundant.

In the period between 450 and 400, when the best engraved gems ever known were produced, there was perfect freedom of artistic style, plus breadth and largeness of conception with pure beauty expressed. Foreshortening was now attempted by the artists.

Gods, demons, and heroes were replaced by purely human subjects. Portraits on gems first appeared in the 5th century, but only two or three authentic ones survive today. Symbolic designs were now rarely used. Gems bearing inscriptions increased in this period.

Xenophon the Greek states (400-401 B.C.) that rings set with an intaglio were worn by many of his fellow soldiers. At that time, in Greece, ring wearing other

- Impressions of ancient seals.

than that of a signet was considered effeminate.

Although Pyrogoteles was the only artist permitted to engrave the portrait of Alexander, no signed portrait of the great general has ever been recovered. This is probably due to the fact that no one would dare place his name on the image of the divine Alexander.

HELLENISTIC PERIOD

In Greece proper, ring stones with the picture side strongly convex became the characteristic form during the Hellenistic Period (300 to 100 B.C.). Although it does not predominate, chalcedony was commonly used. The fashionable stones at this time were the Syrian garnet or hyacinth. For the first time, beryl appears in an engraved ringstone. Amethyst again came into favor and topaz was used in the very finest work. Peridot and aquamarine occurred rarely while carnelian, agate, and sardonyx remained common among the materials used by the gem engravers. Pastes were now used in various colors—green, yellow, brownish, and sometimes violet.

Usually only one figure was used on the gemstone. Gods were still used as subject matter but heroes were rare and large numbers of portraits were now used as signets. Faces were generally beardless and the bust form was characteristic of these early portrait seals. Commonest form of inscription from this period was the name of the owner.

MIDDLE ITALIAN GEMS

The Romans probably began to use signets as early as the middle of the 3rd century B.C. Rising Roman influence soon demanded the gem form as we know it today and the scarab seal passed from popularity.

Pictures from hero sagas, warriors, and minor deities were used. Cult pictures and magical subjects were also popular. The purely national theme of Remus and Romulus with the wolf has frequently been forged.

Ancient tradition, heroism, and deep religious feeling indicate the early ideals of the Roman Republic. Later, scenes or devices commemorative of personal or family history and conquest appear. Sulla's signet of the captured and bound King Jugurtha is a fine example.

It is believed that most historical scenes from this period may be regarded as forgeries.

Soon luck-bringing symbols on rings began to be used, most of the inscriptions on them referring to the owner's name.

Dark sards were most popular. Glass pastes were used, gray chalcedony and carnelian were not rare, and amethyst was occasionally engraved.

In the last century before the Christian era, the Etruscan and Greek influenced signets of the early Roman period began to blend. Subject matter was now taken from paintings. Representations of students, philosophers, and similar subjects increased. The deep religious feeling expressed earlier retrograded into desire for pleasure, alternating with periods of depression and gloom. Toward the end of the period portraiture had made big strides and a distinct Italian style was evident.

GREEK-ROMAN GEMS

It is from the period of the Early Roman Empire that we have most of the gems existing today. Not only was the wearing of rings a passion with the Romans of this time, but a mania for collecting gems also swept the land.

The most common stone used for engraving was the carnelian, but for the best work of the gem engravers such stones as garnet, aquamarine, beryl, topaz, peridot, and — more rarely — emerald and sapphire were used. Endless portraits appear at this time but after the time of Augustus the quality of this work is greatly inferior.

GREEKS INTRODUCE CAMEOS

It was the Greeks who introduced the cameo cut, with satyrlike heads replacing the sacred beetle of the Egyptians.

The cameo is commonly a gem engraved from two differently colored layers, especially from onyx, the upper layer being used for the figure while the lower layer serves as a background for the design. The cameo is actually a miniature bas-relief sculpture and, unlike the intaglio, cannot be used to give an impression in relief. They were created, accordingly, largely for ornamentation purposes.

Early cameos in low relief first appeared on the "plaque," or a flattened oblong gem, which was drilled for hanging on a thong. This form remained popular to Roman times.

Early cameos were large because the artisans could not work effectively in the small spaces now made possible by modern power tools and, except on cylinders, only a limited number of figures were cut. Statuelike poses, usually in repose, were favored with the face of the cameo usually convex since the ancients hated angles. Uniformity of shape—oval or round—was rare in gems from the classic periods. Designs were deeply cut with irregularities showing on the back of the gemstone.

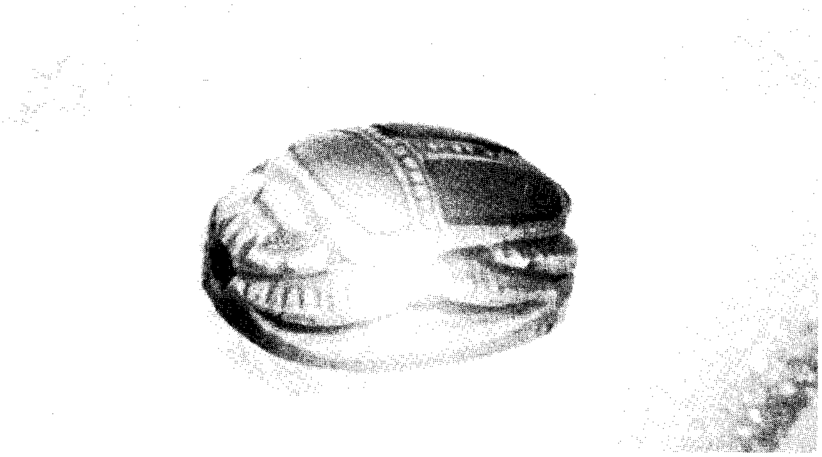
By the 3rd century B.C. cameos had become relatively common since Indian layer stones were then available to Greek lapidaries.

ENGRAVED GEMS IN ROMAN TIMES

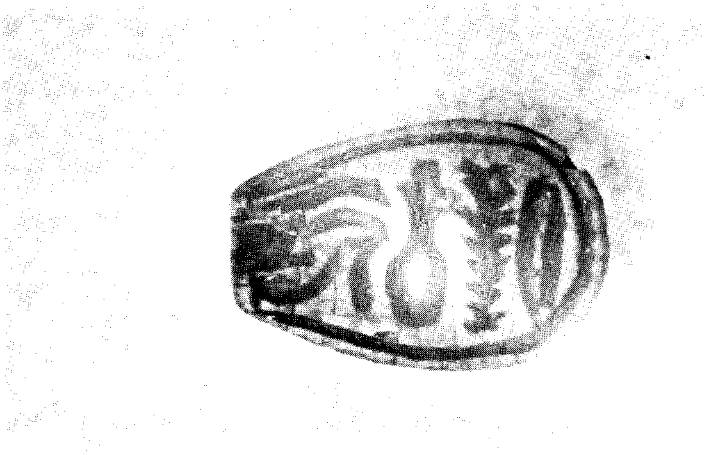
Characteristic gems of this period were cut by Greeks as a rule, but were influenced by the Romans. Seneca is the first Roman to speak of cameos (to be specific a ring set with the head of Tiberius), intaglios having preceded them by thousands of years. Cameos were never as popular in Rome as intaglios which were not only beautiful but also had their practical use as signets. Later, however, cameos became popular for portraiture with some Roman cameos as large as 10 to 12 inches square. Some of these are still in fine collections today.

From the time of the great Roman general the Elder Africanus (237-183 B.C.), the use of engraved gems (intaglio) spread among the Romans. This was in part due to the fine sardonyxs and other quartz gems which had just become available in quantity from India.

By the time of Julius Caesar, the use of engraved gems was a passion, and the Roman general himself was an enthusiastic collector. Upon the conquest of King Mithridates by Pompey (66 B.C.), the use of pearls and precious stones became general and gem engraving flourished in Rome.



- **Ancient Egyptian scarab.**



- **Engraved base of ancient scarab.**

Pliny describes in detail some of the signets used in the Roman period. Augustus, he tells us, had successively in his lifetime three signets—a Sphinx, a portrait of Alexander the Great, and his own. The latter is said to have been an excellent likeness of the emperor which, according to Pliny, later emperors used as a seal. This seal is said to have been engraved by Dioscurides, the famed gem engraver of Rome. It is believed that it was the signet by Pyrogoteles, with the bust of Alexander engraved upon it, that Augustus—when prostrated with fever (23 B.C.) – handed to Marcus Vipanius Agrippa as a sign that he should succeed him as emperor.

Pliny also tells us that Maecenas' signet was a frog and that those who received papers sealed with this signet were always terrified for they knew without breaking the seal that it meant duties or taxes levied against them. When away from Rome (during the civil wars which he waged against M. Antonius) Augustus always left a duplicate seal with Maecenas so he could act as the Emperor's representative (sort of an old-time power of attorney).

During the reign of Claudius (41-54 A.D.) no one was permitted to wear a ring bearing the likeness of the Emperor. This order, however, was rescinded by Vespasian (ruled 69-79 A.D.).

Large Roman cameos reflect the later imperial taste for the elaborate and showy. With the decline of the empire, and the adoption of cheap ostentation which had replaced its earlier splendor, the quality of engraved gems deteriorated and the art passed into unimportance although the art of gem engraving did not wholly die. Truly, the history of Rome can be read on the designs of her engraved gems.

FAMOUS ANCIENT GEM ENGRAVERS

Gem engravers were called *dactylioglyph* from two Greek words meaning "to engrave finger rings." The first Greek gem engraver known as a personality was Mnearchus, the father of Pythagoras, who was engraving gems at Samos before 570 B.C. According to Herodotus, Theodorus of Samos, architect and sculptor, was one of the earliest gem engravers known.

Pliny says Alexander the Great expressly forbade all others to engrave his image in precious stones except Pyrogoteles who was doubtless the leading gem engraver of his time and the only one, Pliny claims, who could engrave the emerald. Although we have a number of fine gem portraits of Alexander, we cannot say that any one of them is the work of Pyrogoteles since he signed none of his masterpieces. It is interesting to note that Pyrogoteles used tools similar to those in use today.

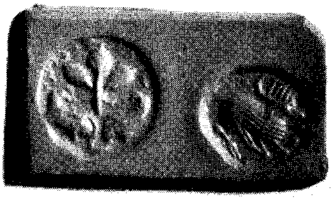
Dioscurides was the foremost gem engraver of the Augustan age, a cutter of both cameos and intaglios. However, the gem portraits of Augustus which are supposed to be signed by Dioscurides are evident forgeries, but we have a number of other engraved gems signed by him which are authentic. Carnelian and amethyst were his favorite materials. Born a Greek, Dioscurides is believed to have come to Rome from Aegae in Cilicia, Asia Minor. His three sons were also gem engravers.

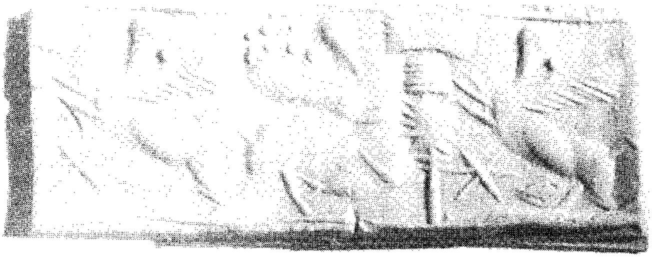
MATERIALS USED

All stones known to the ancient world were used for engraving although the softer stones were preferred such as hematite, jasper, chalcedony, quartz, and lapis lazuli. Because of its comparative softness, and because the layers of color often lend themselves to attractive design, chalcedony was probably the most universally used for engraving, as it is today.

Greek and Roman literature, even with such students and recorders as Theoprastus (died 27 B.C.) and Pliny (died 79 A.D.) do not help much in correctly listing all stones used by the ancients. Until a comparatively recent time wholly unrelated stones were grouped together by color, or through rough estimates of hardness. Only since the publication of Herbert and Lou Hoover's translation of Agricola's *De re metallica* and Dr. Sydney Ball's *Roman Book on Precious Stones*, have modern mineralogists had much of a key to the identity of stones mentioned by early recorders of gemstone history. The many ancient carved gemstones still in existence have also given a good indication of materials most generally used.

In the Mesopotamian area before the 2nd millenium, hematite was most commonly used with jaspers and chalcedonies favored later. The Assyrians preferred rock crystal,





Designs on Ancient Seals

agate, and carnelian after the 14th century B.C. In Egypt, scarabs of amethyst dominated the 12th dynasty; green feldspar, green basalt and jasper the 13th; carnelian and glass the 18th; red and green jasper and rock crystal the 19th; and lapis lazuli, the 20th.

Among the Greeks, the cryptocrystalline quartz varieties — sard, plasma, jasper, and agate — were favored. During the Hellenistic period of the 3rd century B.C., sardonyx (where layers could be given a polychrome effect) and glass pastes were favorite materials. Rock crystal and amethyst were most frequently used of the crystalline varieties. At times, Greek gem cutters also used harder stones like garnet and beryl. Roman lapidaries preferred sard, plasma, jasper, amethyst, garnet, aquamarine, topaz, lapis lazuli, and sardonyx for fashioning cameos.

Because of their hardness ruby, sapphire, and diamond were seldom used for carving although a few intaglios fashioned of these materials have been found. The emerald was perhaps so seldom used because of its hardness, and the fact that it fractured easily.

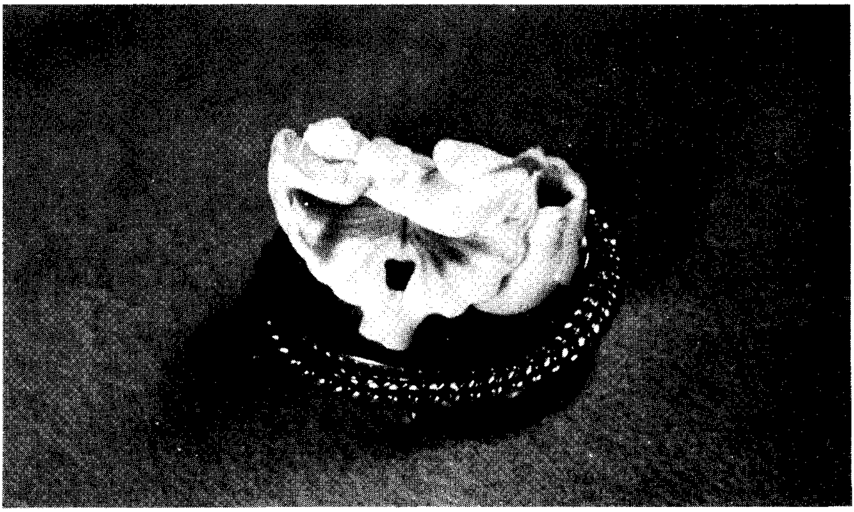
SHELL CAMEOS

Cameos carved from pink conch shells, or from shells of various pearl-bearing molluscs and other marine fish, have been used for centuries. Some of the shell cameos of the 19th century represent some of the finest gemstone engraving known. Since cameos carved from the pink conch shell are almost invariably carved of a solid color, they are sometimes mistaken for pink coral cameos. Pink shell cameos have a tendency to fade to white, or a very light pink, and some have probably been dyed to restore the pink color. Shell cameos with a brown background are usually considered more desirable. Obviously, shell cameos are less expensive than those carved from gemstones, but they are also less durable.

Various other materials have been used at times for carving and engraving. Amber, because of its softness and easy working, has been carved by gem cutters of many early civilizations. Coral cameos have also enjoyed intermittent popularity but are seen infrequently in the trade today.

(To be continued)

- **Another view of shell cameo shown on cover.**



Some Unusual Composite Stones

by

ROBERT WEBSTER, F.G.A.

Maybe doublets are not so very important. But from experience of routine testing and teaching, it is generally the slightly unusual rather than the rare stone which will "trip-up" the student, and even at times the expert. Knowledge as to what may be encountered in this ever-expanding science of ours must always be of value. This, then, is my simple apology for penning these few words.

Recently there came into the writer's hands several stones which merit description and comment. These stones, seven in number, were found in a stone dealer's stock. They were in a stone packet simply and unexpressively labeled "doublets."

On examination, one stone was found to be a simple garnet top and glass base doublet made with the colored glass to represent a peridot. This stone gave a refractive index for the garnet top of 1.795 and for the glass base, 1.64. There was the usual layer of bubbles in one plane at the layer of fusion between the garnet and glass, a large bubble in the glass base, and a patch of crossed needles in the garnet top. Beyond these few notes the stone requires no further comment. The other six stones, however, were found to belong to two different types of composite stones.

Three of these stones consisted of a crown of rock crystal cemented to a base of colored glass, and were of interest mainly through their color and appearance. The stones were oval in outline, cut with a brilliant-cut crown, and a zircon-cut base. They were respectively sapphire blue, purple, and yellow in color and each weighed a little less than five carats. In all these stones the crown gave the refractive indices for quartz and the glass base a value of 1.51.

The blue stone had a density of 2.61, exhibited the typical absorption spectrum of cobalt and showed clearly the colorless crown and colored base when the stone was immersed in a cup of water. Under low-power magnification there was no bubble layer at the junction of the two parts but a few large bubbles were seen in the glass base. When irradiated with long-wave ultraviolet light, the characteristic fluorescence of the cement layer was clearly seen as a bright line around the girdle of the stone.

The purple stone had a density of 2.56, showed a faint cobalt absorption spectrum with a fainter band in the blue. Bubbles and swirl marks (so common in purple colored glasses) were seen in the base. Similarly to the blue stone, the cement layer showed up strongly under ultraviolet light. The manifest danger, with this stone is that, in haste, measurement of refractive index might lead to an identification as an amethyst—a stone which this "fake" so closely resembled.

The yellow stone had an appearance very much like the yellow synthetic spinel which exhibits such a strong yellow-green fluorescence under ultraviolet light. Indeed, this doublet also showed a strong and similar colored glow. However, examination of this fluorescent light with a hand spectroscope showed that the fluorescence spectrum was discrete (banded or fluted) which indicated a uranium coloration of the glass. The glow was sufficiently intense to illuminate the whole stone and mask the glow from the cement layer. As in the case of the other two stones, the glass base showed swirl marks and gas bubbles and no layer of bubbles was seen in the plane of joining of the rock crystal and glass. The density was found to be 2.55.

All these three stones, when immersed table facet down in a cell of liquid, were found to show extinction at 90° when examined between crossed nicols.

The remaining three stones were found to consist of two pieces of rock crystal with a colored layer between them. In other words, they were similar to the well-known *soudé emeralds* (which in American parlance are generally called *triplets*). The first of these stones was essentially a *soudé* emerald of the modern type which owes its green color to a thin layer of material of unknown composition which has, maybe, been sintered to the two slabs of rock crystal from which the complete stone has been cut. The density of this emerald-cut specimen weighing 4.38 carats was found to be 2.77, a value higher than might be expected, but about the usual values found for the modern *soudeés*. It is conjectured that this high density may be due to the fact that an organo-metallic dye (possibly containing copper) may be employed to color the "frit" used in "soldering" the two pieces of quartz. The stone was found to show green through the emerald color filter and was inert under ultraviolet light.

The second specimen, an oblong cushion-shaped stone weighing 7.45 carats, was unusual in that its appearance in daylight resembled a synthetic fancy corundum which is made to imitate alexandrite. Indeed, this slaty-green color with reddish reflection turned to purple when seen under artificial light—exactly like the synthetic "alexandrite-like" corundum. The absorption spectrum of the stone showed the cobalt lines strongly and a very intense band in the blue-violet, with a weak line in the blue. The density was found to be 2.62, a value which compares favorably with the values of the old type *soudeés* which owed their green color to a gelatine (?) film (which often went "bad," turning to a yellow color). It may be useful to mention that this old type of *soudé* often showed red through the emerald filter. When irradiated with long-wave ultraviolet light, the stone appeared to glow with a purplish haze, but it could be seen that it was the cement layer which was fluorescing and that the glow was diffusing through the colorless crown and base.

The last of these stones was an oval mixed-cut, sapphire-blue stone weighing 4.27 carats. This stone also showed a color change in artificial light, becoming a purple color. The absorption spectrum in this case was again the three bands due to cobalt, but no lines were seen in the blue part of the spectrum. The density was 2.62, the same as for the "alexandrite" and, likewise, no bubble layer was observed in either of these two color-change stones.

When examined between crossed nicols with the table facet down, there was no extinction on rotation of the stage but a more or less continuous *light* field. However, when the stone was turned sideways and similarly viewed, so that both the crown and pavilion were in the field at the same time, on rotating the stage it was seen that each separate part extinguished at different angles, but each at every 90°. This proved that the two pieces of rock crystal did not have the same optical orientation.

In conclusion, the writer's thanks are due to Messrs. George Lindley and Company (London) Ltd. for presenting the specimens.

OCCURRENCE— Mining and Recovery of DIAMONDS

Part II

by

A. ROYDEN HARRISON

EDITOR'S NOTE: This is the second installment of a paper read at the Diamond Drilling Symposium, April 21 to 23, 1952. under the auspices of the Chemical, Metallurgical & Mining Society of South Africa, Johannesburg. Photographs which were used in Part I were not selected by the author but were from the photographic files of the Gemological Institute. Apology is hereby made for the incorrect captioning of the illustration on page 158 of the Spring Issue of GEMS & GEMOLOGY. Operations at the "Big Hole" ceased in 1903 and the mine has never been reopened.

GOLD COAST ACTIVITY

The diamond deposits of the Gold Coast consist of shallow gravels in beds and flats of streams, about 65 miles northwest of Accra. About eight miles are worked at a time. The gravels are from two to five feet thick and are covered by two to ten feet of clay or sand overburden. The formations in this area are steeply dipping, metamorphosed, igneous and sedimentary rocks of pre-Cambrian age, with intrusive granites nearby.

Overburden is removed almost entirely by excavator and deposited in mined-out sections. The gravel is loaded by excavator into one-ton trucks and brought to the washing plants. These are similar to those in Angola and Sierra Leone.

The average size of the diamonds is 20 to 22 stones per carat. Gravels yield 2.5 to 3 carats per cubic m. or 60 to 75 carats per 100 loads.

Other diamond deposits on the Gold Coast are worked by African leaseholders. Production from these sources increased considerably during 1951. Size of diamonds and the gem content is similar to that obtained in the area just described.

On Sierra Leone and Gold Coast concessions the working system is to have a qualified mining engineer in charge of each section, consisting of a Diesel power plant, washing plant, and mine. Usually no other European is employed on a section, except for training purposes. All foremen, mechanics, and artisans are skilled and trained Africans, who are also trained as surveyors. The ratio of Europeans to Africans is about one to 100.

FRENCH WEST AFRICA

The deposits of French West and Equatorial Africa are all alluvial. They are similar to one or other of the deposits already described and are mined by the same opencast methods. The deposits vary considerably in respect of grade and also in the quality and percentage of gem diamonds.

ALLUVIAL DEPOSITS IN SOUTH AFRICA

The alluvial deposits of the Union of South Africa may be classified as those of the interior, and the marine beach or terrace deposits on the West Coast.

Interior deposits extend from the vicinity of Premier Mine, through the Western Transvaal, to the Orange River in the Northern Cape. Some occur along existing rivers, but the majority are in the channels and flood plains of ancient river systems. In some cases there is no overburden, in others a considerable thickness. Generally speaking, the gravels are shallow and not thick, but in the Western Transvaal payable gravels have been found persisting to considerable depth in sink holes in the dolomites.

After removal of the overburden, if any, the gravels are mined, usually by hand, and concentrated in a small rotary washing pan, similar to, but smaller than, those in use at most of the pipe mines. Concentrates from the washing pan are gravitated by hand in sieves without further concentration and are then hand-sorted. Production from these deposits reached its peak in the late 1920's, but has waned steadily to about 100,000 carats per year.

Marine beach deposits stretch from the Orange River southwards for some 200 miles and northwards into South-West Africa for an even greater distance. Diamonds may have been carried down from the interior by ancient river systems to the sea, and were redeposited by wave action on beaches subsequently elevated to their present position.

South of the Orange River the best-known workings are the Government-operated State Alluvial Diggings. Here, very rich deposits were discovered some 80 feet above sea level in a terraced beach, in which the 'goatshorn oyster' (*Ostrea prismatica*) is present. Sand overburden and semicemented calcareous limestone immediately above the diamondiferous gravels is 100 feet deep in places.

The overburden is removed by mechanical excavators and disposed of in a barren area. The diamondiferous gravel is removed by hand or excavator and brought to a central treatment plant and concentrated in jigs. The concentrates are gravitated mechanically in sieves and then hand-sorted.

At Kleinzee, some 100 miles south of the State Alluvial Diggings, operations are on a smaller scale. The overburden seldom exceeds 15 feet and is usually mined together with the gravels, which are concentrated in rotary pans, then gravitated and hand-sorted.

SOUTH-WEST AFRICA

Kimberlite pipes discovered in South-West Africa have proved barren, thus diamond mining is confined to coastal alluvial deposits, which may be a continuation of deposits south of the Orange River.

The diamond size decreases fairly rapidly proceeding north from the Orange River, perhaps due to the two and one half knot northerly drift of the Benguela current. Like the deposits to the south of the Orange River, the diamond quality is consistently good, averaging 95 per cent to 98 per cent gem. The average thickness of sand overburden is about 25 feet but sometimes up to 70 feet. Diamonds occur in well-defined horizons at various elevations above sea level.

Terraces are determined by prospecting trenches, which are put down to bedrock, the overburden is removed by rotary bucket excavators, together with mobile stacking conveyors. The gravels are excavated and loaded into one cubic m. trucks by mechanical excavators, or by hand. At present, about six million tons of gravel and sand are handled each year.

Here, as in the deposits south of the Orange River, richest diamond concentrations are usually found in gullies, potholes, and crevices in the bedrock. This is, therefore, swept clean. Some 35 per cent of production is picked up in this final sweeping operation.

Gravel trucks are brought to field screening plants, where about 80 per cent of the gravel is screened out as undersize sand and pumped to the sea. The remaining 20 per cent is brought to a heavy media separation plant.

About 97 per cent of the feed is floated off and the remaining three per cent, i.e. concentrates, is washed for the recovery of ferro-silicon, and then passed to tube mills. These remove softer fractions, such as schist and marine shells, and the clean concentrates are then classified into several sizes. All plus 6 mm. concentrates pass over continuous grease belts, while the smaller sizes are concentrated further in an electrostatic separator. Hand-picking of diamonds from the concentrates in either case is simple.

Here, as on most alluvial fields, the diamonds are not water-repellent because they are coated with a microscopic film of salts which renders their surface hydrophylic, and it is therefore necessary to condition the diamonds by immersion and light milling in a dilute solution of whale acid, or fish oil, and caustic soda. This enables them to adhere to a greasy surface. This treatment should be carried on only long enough to condition the diamonds, otherwise the gangue will also become water-repellent and adhere to the grease. The electrostatic and the continuous moving grease belt processes were developed by Diamond Research Laboratory in Johannesburg.

The popular belief that diamonds could easily be picked up on the beaches of the South-West African and Namaqualand coasts by any individual, if only he were permitted to enter the field, is readily dispelled by the fact that for every one part of diamonds recovered 45 million parts of overburden and gravel must be removed or treated, i.e. ten tons of material are handled to recover one carat of diamonds. Compared with other diamond mines, the yield is extremely low.

RELATIVE YIELD OF DIAMOND MINES

Locale	Yield Quoted	Yield per 100 Loads	1 Part Diamond in X Million Parts
Panna	10 ct. per 100 loads	10	36.3
Premier	17 ct. per 100 loads	17	21.3
Angola	0.71 ct. per cub. m.	32.16	11.3
Tanganyika	20 ct. per 100 loads	20	18.1
Sierra Leone	2 to 2.5 per cub. yard	118.52 to 148.15	3.1 to 2.4
Gold Coast	2.5 to 3 ct. per cub. m.	113.23 to 135.87	3.2 to 2.7
South-West Africa	7.9 ct. per 100 loads	7.9	45.9

100 loads 160,000 lb. 160,000 x 453.6 x 5 362,880,000 ct.
100 loads 1,600 cub. ft. 45.29 cub. m. 59.26 cub. yards

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1. (1 load = 1,600 lb. or 0.8 short ton).

WEIGHT ESTIMATION of CABOCHONS

with Accompanying Chart and Formula with Derivation

by

JAMES SMALL

Tables for estimation of the weight of common styles of faceted stones have been available to jewelers and appraisers for many years. For some time the author has felt that such tables for weight estimation of cabochons would, likewise, prove useful. This article contains a formula by which the carat weight of cabochon-cut gemstones may be estimated with a surprisingly low probable error. It is applicable to low, medium, high, and double cabochons and, with modification, to hollow cabochons. The formula utilizes the principal measurements of the stone in millimeters, and the specific gravity of the material from which the cabochon is formed. Measurements may be made with any millimeter scale such as the Boley gauge; dial millimeter micrometer, such as the Leveridge Gauge; or a millimeter screw micrometer.

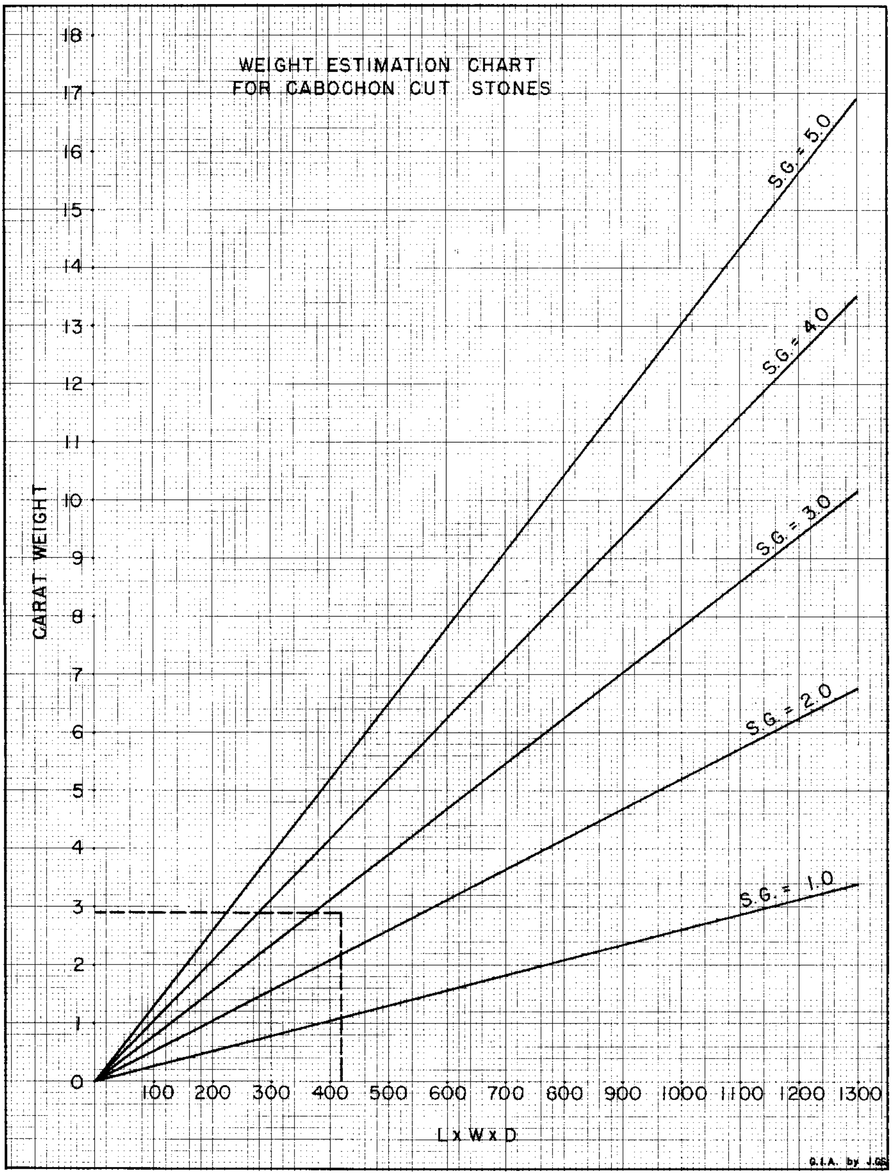
In the formula, the abbreviations used include *L* for length; *W* for width; *D* for depth; *SG* for specific gravity; and *C* for the estimated carat weight of the cabochon. The formula may be stated as follows:

$C = L \times W \times D \times .0026 \times SG$

To illustrate the use of the formula, the following example is given: A medium cabochon of amethyst quartz was measured and the following dimensions determined: L = 10.4 mm; W = 5.3 mm; D = 4.0 mm; SG of quartz = 2.65. Substituting these values in the formula we get:

$C = 10.4 \times 5.3 \times 4.0 \times .0026 \times 2.65$ or $C = 1.52$ carats.

By using this formula it is a simple matter to estimate closely the weight of a stone which will fit into a mounting of certain dimensions. As an example of the variation of weight between cabochons of various species which would fit into a mounting of the following dimensions: 15 mm x 10 mm, and which would accommodate a stone 5.1 mm deep. A simple system could be set up



L x W x D x .0026 = 15 x 10 x 5.1 x .0026 = 2.00

	Amber	Quartz	Tourmaline	Jadeite	Sapphire
SG	1.08	2.65	3.06	3.34	4.00
LWD .0026	2.00	2.00	2.00	2.00	2.00
Carat Weight	2.16	5.30	6.12	6.68	8.00

in which L x W x D could be determined and the product multiplied by the S.G.s of the various species being considered as possible replacement stones. If amber, quartz, tourmaline, jadeite, or sapphire were considered as replacement stones for this particular mounting, a table similar to the one at bottom of page 192 could be set up.

This formula lends itself nicely to solution by graph or chart. It was set up so that the only step necessary was the multiplication of the dimensions of the stone. Its weight may then be readily determined from the chart, depending upon the S.G. of the stone in question. An example of the solution of a problem using a chart rather than a formula follows: What is the carat weight of a quartz cabochon in which L = 10 mm, W = 7 mm, D = 6 mm? We proceed as follows: (See chart page 192.)

L x W x D = 420. At 420 on the L x W x D line (the horizontal line) of the chart erect a perpendicular line to a point which would correspond to S.G. 2.65. This point will be 65/100 of the distance between S.G. 2.0 and S.G. 3.0. At this point, draw a line parallel to the horizontal lines until it intersects the *carat weight* column on the left side of the chart. Read your answer at this point. This problem is solved graphically (see dotted line) on the printed chart and the correct answer is 2.90 carats.

A modification of this chart would be one in which S.G. lines of particular species were placed in one chart rather than S.G.s 1.0, 2.0, 3.0, 4.0, and 5.0. For example, a chart could be made showing S.G. lines for quartz (2.65), tourmaline (3.06), topaz (3.53), and corundum (4.0). Such a chart would speed the solution of the problem and eliminate errors in interpolation. The user could design a chart for those species in which he was particularly interested.

DERIVATION OF THE FORMULA

For gemologists interested in the manner in which this formula was worked out, the derivation is as follows:

Since a cabochon has the symmetry of a portion of an ellipsoid, the volume of a cabochon should be equal to the volume of a section of an ellipsoid.

LOW CABOCHON

FIG. I

Where a, b, and c are the lengths of semiaxis, the volume of an ellipsoid is expressed as: Volume $\frac{4\pi\ a\ b\ c}{3}$ In terms of our equation, $a = \frac{L}{2}$; $b = \frac{W}{2}$; and $c = \frac{D}{2}$. Substitution

$$\textit{Volume}\ (\text{ellipsoid})\ \frac{4\pi \frac{L}{2} \times \frac{W}{2} \times \frac{D}{2}}{3} = \frac{\pi\ L\ W\ D}{6}$$

If a cabochon is considered an ellipsoid sawed through the center, L and W remain the same, but D becomes one half of the ellipsoid depth. Thus, the volume of each cabochon would be one half that of the ellipsoid.

MEDIUM CABOCHON

FIG. 2

In solving the problem by the above formula, the answer will be in terms of cubic millimeters. For our purpose, the formula should give us an answer in terms of weight rather than a space measurement of volume. Therefore, the formula must be adjusted so that the answer will be in carat weight instead of cubic millimeters.

By definition: 1 carat = 1/5 gram = 200 milligrams. Assume that the material comprising the cabochon is water (S.G. = 1.0). Since 1 cubic centimeter of water weighs 1 gram, then: 1 cubic centimeter = 1000 cubic millimeters = 1 gram = 1000 milligrams = 5 carats or: 1 cubic millimeter = 1 milligram = $\frac{1}{200}$ carats, or: 1 cubic millimeter = $\frac{1}{200}$ carats.

Our formula then must be modified by multiplying by $\frac{1}{200}$. C (when S.G. = 1) = $\frac{\pi\ L\ W\ D}{6} \times \frac{1}{200} = \frac{\pi\ L\ W\ D}{1200}$.

However, the material in the cabochon is not water, but a gem material. Specific Gravity has been defined as the weight of a substance compared to the weight of an equal volume of water. We can further modify one formula by multiplying it by the S.G. of the gem material.

$$C = \frac{\pi \, L \, W \, D}{1200} \text{ x S.G.} = \frac{\pi \, L \, W \, D \text{ x S.G.}}{1200}$$

The answer then will be in terms of carat weight for a specific gem material.

Since $\pi = 3.1416$, the formula can be simplified by changing the fraction $\frac{\pi}{1200}$ to $\frac{3.1416}{1200}$ and solving. $\frac{3.1416}{1200} = .0026$.

The formula can now be restated in this final form: C = L x W x D x .0026 x S.G.

In the derivation of this formula, it was assumed that a cabochon is a section of an ellipsoid and, therefore, the formula should be satisfactory for all types of cabochons.

HIGH CABOCHON

FIG. 3

If ellipsoid A in *Figure 1* were sawed in half, each half would be a cabochon. B in *Figure 1* represents a low cabochon of this type.

If ellipsoid A in *Figure 2* were sawed in half, each half would be a cabochon. B in *Figure 2* represents a medium cabochon of this type.

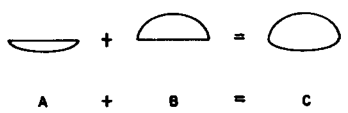
If ellipsoid A in *Figure 3* were sawed in half (through its shorter medial axis as shown), each half would be a cabochon. B in *Figure 3* represents a high cabochon of this type.

A double cabochon is really two cabochons in which L and W are equal. Thus the weight of a double cabochon may be determined by this formula, for the weight is proportional to the depth.

.0026 x $S.G._A$ + L_B x W_B x D_B x .0026 x $S.G._B$. But: $C_A + C_B = C$; $L_A = L_B$; $W_A = W_B$; and the S.G. is the same for both parts ($S.G._A = S.G._B$). Substituting: C = L W D_A x .0026 x S.G. + L W D_B x .0026 x S.G. Factoring: C = D_A + D_B (L W x .0026 x S.G.) But: $D_A + D_B = D$ (the total depth of the cabochon). Therefore: C = L W D x .0026 x S.G.

The formula can be used in its present form for double cabochons with no modifications.

Example: A special case in which the double cabochon is developed until it becomes a sphere. As in the previous example consider this as two cabochons (in this case each cabochon will be a hemisphere). C_A = L_A x W_A x D_A x .0026 x $S.G._A$; C_B = L_A x W_A D_A x .0026 x $S.G._B$. Add: $C_A + C_B$ = L_A x W_A x D_A x .0026 x $S.G._A$ + L_B x W_B x D_B x .0026 x $S.G._B$. But: $C_A + C_B = C$; $L_A = L_B$; $W_A = W_B$; $S.G._A = S.G._B$; $D_A = D_B = \frac{Ds}{2}$ (that is, ½ the total depth of sphere).



DOUBLE CABOCHON

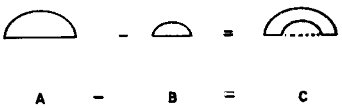
FIG. 4

The formula is valid for the usual type of double cabochon, as well as for the special case of a sphere, and is valid for any intermediate case.

A hollow cabochon can be said to be a large cabochon with a smaller cabochon hollowed from it. Cabochon A — Cabochon B = Cabochon C. The solution of this problem is a little more involved. To solve this type of problem, assume that the external Cabochon A has been reduced by the weight of a smaller solid Cabochon B. Therefore, solve by formula for Cabochon A using the external dimensions of the cabochon.—(the D measurement here will be from the crown to the girdle line.) For Cabochon B, the internal measurements will have to be used. In this case, the D measurement will be the D measurement of cabochon A minus the thickness of Cabochon A.

After solving, the carat weight of A minus the carat weight of B will equal the carat weight of the hollow cabochon.

Satisfactory results were obtained by comparing the results of weighing stones on a diamond balance with those results obtained after measuring stones and comparing their weight by the formula. The error was less than ten per cent. A few stones did exceed this percentage, but they were badly nicked on the girdle. The formula worked equally well for all types of cabochons.



HOLLOW CABOCHON

FIG. 5

While examining a box of cabochons labeled "amethyst," one stone caused a little difficulty. The diamond balance weight of this stone was found to be 5.79 carats. When computed by formula the computed weight was found to be 4.62 carats, an error of 20 per cent. All weighings, measurements, and calculations were rechecked and the same carat weights and errors presented themselves. This error was inconsistent with that of other stones previously run so it was assumed that the error lay other than in the formula. The stone in question was tested and determined to be tourmaline and not amethyst as labeled. When computed, using the S.G. of tourmaline, the stone was found to have a weight within the allowable percentage of error.

Gemological Digests

TWO NEW HONORARY MEMBERS ADDED TO EDUCATIONAL ADVISORY BOARD OF G.I.A.

Recently elected as honorary members of the Educational Advisory Board of the Gemological Institute of America were Prof. Dr. K. Schlossmacher of Idar-Oberstein, Germany, and Dr. Roland S. Young, Johannesburg, South Africa.

Dr. Young has, since 1947, been Director of Research of the Diamond Research Laboratory in Johannesburg. Readers of *Gems & Gemology* will recall his article on the work of this laboratory in the Fall 1950 issue. He has contributed a number of papers to technical publications and is the author of the American Chemical Society's monograph on "Cobalt."

Dr. Prof. K. Schlossmacher

Dr. Roland S. Young

Dr. Schlossmacher, an outstanding mineralogist, is well known to gemologists throughout the world for his Revision of Max Bauer's *Edelsteinkunde* (1932). From 1926, until the close of World War II, he was professor of mineralogy at the University of Konigsburg. At the suggestion of the Association of German Jewelers, he founded the Gemological Institute of Germany many years ago. He has been particularly interested in synthetics and has conducted many scientific research projects in past years. In 1948 he was appointed Director of the Gemological Institute of Idar-Oberstein, which post he now holds, and where he is attempting to rebuild the gem industry in Germany and to continue his work in the interest of gemological science. He is also currently working on a revised edition of *Edelsteinkunde* by Bauer, under whom he studied.

Gemological Digests

Digested by Richard T. Liddicoat, Jr., from an article appearing in April 1952 edition of the government publication, Mineral Trade Notes, written by Thomas Murdock, U. S. Consul, Elizabethville, Belgian Congo.

The only diamond producing company operating in Angola is the Companhia de Diamantes de Angola (better known as Diamang). This company replaced, in 1917, the original company formed to exploit Angolan deposits. Originally, the Belgian company, "Forminiere" (well known for its mining of Belgian Congo mineral wealth), together with Guggenheim and Ryan interests of the U.S.A., were important stockholders but the company is now said to be 80 per cent Portuguese owned.

The deposits in Angola are an extension of those in Tschikapa area of the Belgian Congo. They are on the other side of the Kasai River which forms a boundary between Angola and the Belgian Congo. Since the first diamond was found in the region on November 4, 1907, Angola has produced more than 15 million carats of diamonds. In the decade from 1941 to 1950, average production was approximately 775,000 carats annually—an average of about seven per cent of the world's total output during that period. Diamang concessions cover an area of approximately 14,000 square kilometers in a region 7° to 9° South Latitude, and 20° to 22° East Longitude. The deposits are along the tributaries of the Kasai River flowing north. The Tschikapa and Luachimo Valley deposits have been worked for many years and are practically exhausted. At the present time most of the 38 mines are located at Chiumbi and Luembe basins.

Apparently all of the diamonds were once in the upper portions of the Karroo formation which is Carboniferous to Jurassic in age. Since the pipe mines of the Union of South Africa are of later than the Jurassic, the diamonds in the Karroo formation had an earlier primary source. The discovery of chrome-diopside in the gravels—a common constituent of kimberlite—has led to the belief that the primary source for these alluvial diamonds was kimberlite.

Beds found in Angolan valleys are generally of three types and are to be found in most valleys in the following order: The lower deposit is gravel which is covered by a sand which, in turn, is overlaid by mud. Terrace gravels are quite thick, often exceeding 10 meters. These older gravels contain more angular fragments than do the valley gravels and, in a number of them, implements of an ancient civilization have been found. The fact that, with certain exceptions and short reversals of trend, the diamonds get smaller from south to north and that there is a gentle slope to the north, has led to a belief held in Angola that the diamonds were derived from a single primary source, the age of which is suggested by the position of the diamond-bearing beds found in place near the top of the Karroo formation.

Through the 1944 operations the production amounted to .22 carats per cu. meter, including the overburden removed. The gravel itself produced .79 carats per meter in 1945 but has dropped off slowly, but steadily, to .52 carats per cu. meter in 1950. The prospecting completed in three recent years (1947 through 1949) has indicated, by sampling, a diamond content of 1.01, 1.12, and .82 carats per cu. meter for the average of the prospecting operations in those three years. The quality of stones produced compares to that of South-West Africa, but the stones are smaller, averaging four and one half to the carat. Production consists largely of what the author calls "water white" stones with a fairly high percentage of fancy colors.

Most of the crystals are octahedra, but a fair number of dodecahedra are also found.

Proved reserves of the Angola Diamond Fields are not disclosed but general belief indicates about 10 million carats, with expected reserves of several times that figure. Otherwise, present plans for the construction of a heavy media separation plant and a 6M HP hydroelectric plant would not have been made. The equipment used presently in Diamang operations includes eleven mechanical excavators used mostly for stripping overburden. These have made possible the removal of thicker overburden and increased production potential. Mobile steam boilers which burn wood supply the power for field concentration units, gravel haulage by endless rope, and for pumping water. The gravel is hauled in steel cars to field washing plants. Jig concentrates are taken to the final plant in 31-liter flasks.

Three different sets of grease tables are used for the various sizes of concentrates. The jig concentrates are trammed to a single entrance in a small flat car and emptied into a rotary trommel which separates the concentrates in sizes of 1+ to 3 mm, 3+ to 5 mm, and greater than 5 mm. The largest material is handled in a locked-in space where European employees remove diamonds from the grease table which consists of two 4-tray sections. The materials which go over the table are cleaned and dried and then go to magnetic separators. Magnetic materials are rejected and nonmagnetic are passed over the grease tables once more. The rejected material is ground to 100 mesh and flushed down the drain.

It is reported that a normal day's run is 4.2 cu. meters of jig concentrates which average about 500 carats per cu. meter, so the recovery is approximately 2,000 carats per day. Field concentrating units have a ratio of concentration of about 1 to 1,000. Figures given in the article indicate that the product is at least 30 per cent industrial quality. In all probability, the figure is much higher than this.

After the diamonds have been removed from the grease tables they are sent to Tschikapa by automobile and thence to Leopoldville and London by air. There are no export duties on the stones and average net profit per carat during the period of 1946 through 1950 was approximately 100 *escudos*[1]. Estimated sale price of the stones is 324 *escudos*, indicating a production cost of approximately 224 *escudos* per carat.

The entire production is delivered to the Diamond Corporation in London with the gemstones marketed by Diamond Trading Company and the industrial diamonds by Industrial Distributors, Ltd. At the present time five per cent of the net profits go to the legal reserve fund, ten per cent to shareholders (among whom the government is represented with a five per cent holding), and ten per cent to "managing bodies" such as the board of directors, Anglo-American Corporation, selling agents, etc. After these distributions the balance is divided equally between the colonial government and the shareholders.

The consular officer who reported on the Diamang operation in Angola was very favorably impressed, stating that it is "without doubt Angola's outstanding industrial enterprise." With plans calling for construction of the heavy media separation plant and power plant necessary for its operation, plus additional excavators, the reviewer considers a production double the present 700,000 carats per year quite possible and an annual 2,000,000 carat output within the next few years not beyond the realm of possibility.

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[1] American evaluation of an escudo is approximately three and one half cents.

THE STORY OF WATCHES, *by T. Cameron Cuss, McGibbon & Kee Ltd., London publishers, Philosophical Library, Inc., 15 East 40th Street, New York 16, American publishers, 172 pages plus index. Price $7.50. Reviewed by Joseph A. Phillips.*

This unique book should be read by everyone connected with watch retailing or repairing. Mr. Cuss has done a superb job of gathering together all of the important historical developments related to portable timepieces down to the present day mass produced watch. While doing this the author displays a sense of humor which often characterizes a person who has had to face the public from behind a watch repair counter and it is evident that his sympathies are with all watchmakers whose art is so seldom appreciated by the layman. The author is the head of a London watchmaking firm founded in 1788 and reveals a background rich in horological experience by his more than adequate coverage of this intriguing subject.

Some of the chapters are confined to such specialized subjects as "The Escapement," "Fashion in Cases," etc., making it a valuable reference book. The illustrations are adequate and are well reproduced.

The author's clearcut style of writing should make the subject interesting even to laymen who have never removed the back from a watch, and the many, many bits of interesting information about the watchmaking artists of the past should prove valuable to every watch salesman and watchmaker in the jewelry trade. Included is a bibliography of previous books which the author considers good sources of information for those persons interested in further reading on the subject.

INDIAN SILVERSMITHING, *by W. Ben Hunt, Bruce Publishing Company, 157 pp. including 48 plates of sketches, 70 photographs and, in addition, four color plates. Price $4.75. Reviewed by James Small.*

W. Ben Hunt's background as a professional commercial artist, craftsman, lecturer, author of many books on crafts, well-known Boy Scout leader and advisor, and contributor on handicraft projects to professional and scouting magazines qualifies him to author a book of this type. He has used his experience and knowledge to the fullest advantage in the presentation of this book on Indian craftsmanship in silver.

The subject matter is presented in a pleasant, easily followed style. The tools necessary for the work are well described. Simple tools, such as the Indians themselves use, are discussed as is the fabrication of simple tools from available scrap materials.

Techniques of silver craftsmanship are given in a logical manner so that the reader can progress from the simple to more complex work by doing examples of each type of work as a project.

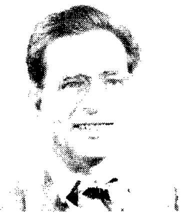
Navajo and Pueblo motifs are discussed as well as shown in excellent photographs and drawings from Mr. Hunt's sketch book. These were made from outstanding examples of Indian jewelry in museums, private collections, and pieces Mr. Hunt saw on reservations and elsewhere during the time spent with the Indian craftsmen while learning their craft from them. Jewelry described is both ethnic and functional.

The few pages on turquoise and its substitutes are not entirely accurate from a gemological standpoint. However, the Indian method of fashioning turquoise as cabochons is interesting and enlightening—for a fine cabochon can be made with the most basic equipment.

The book is directed to those people who are attracted to silver work and simple cabochon stonesetting as a hobby. It is also directed to those who appreciate Indian jewelry and desire to duplicate it. With this book as a foundation, the hobbyist should be able to design and make these pieces described as well as new pieces using the Indian motif and symbolism.

Characteristics of Indian-made jewelry as opposed to mass produced jewelry of similar nature are mentioned. These hints might prove valuable to the retailer who plans to carry such merchandise.

Contributors in this Issue

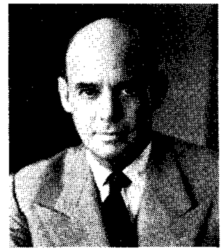


JAMES G. SMALL, B.Sc., F.G.A., attended the University of Nevada after his discharge from military service in World War II, during which time he had served in Alaska with an Anti-Aircraft Division of the U.S. Army. After graduation from the University in 1948, where he majored in geology, he studied the courses of the G.I.A. and came to the institute as an instructor in 1949. He was awarded the Fellowship Diploma of the Gemmological Association of Great Britain, with distinction, in 1951.

B. W. ANDERSON, B.Sc., F.G.A., whose report of two newly discovered minerals is in this issue, is no newcomer to the readers of GEMS & GEMOLOGY. He is also the author of the well-known *Gem Testing,* now in its 4th edition, and is known for his many articles on subjects of gemological interest published in technical journals in England and on the continent. Since its inception in 1925, he has headed the precious stone laboratory of the London Chamber of Commerce and conducted much important research especially along the lines of spectroscopy. In addition to his work at the London Laboratory, he is Senior Lecturer in Gemology at Chelsea Polytechnic, London.

ROBERT WEBSTER, F.G.A., is also well known to gemologists in this country and abroad, and is associated with B. W. Anderson at the London Gemological Laboratory. Gemologists of this country know him well for his excellent *Gemologists Compendium* and his earlier book, *Practical Gemology.*

He has been connected with the jewelry industry in England since 1914, with time out for service in World War I. In 1934 he was awarded the Fellowship Diploma of the Gemmological Association of Great Britain and is one of only two who have been awarded the Research Diploma by that organization.



A. ROYDEN HARRISON, Consulting Engineer of the Anglo-American Corporation of South Africa, Ltd., Johannesburg, consulting engineers and geologists retained by the Consolidated Diamond Mines of South-West Africa, Ltd., is well qualified to give authoritative information on diamond conditions in all parts of the world. His article in this, and the last, issue of GEMS & GEMOLOGY, contains most valuable figures on diamond production and the yield of individual mines, as well as describes in an excellent way the diamond mining procedures. Mr. Harrison was born in Aliwal North, Cape Province, in the Union of South Africa in 1902. After working at DeBeers and on the Copperbelt in Northern Rhodesia, he went to the Camborne School of Mines, Cornwall, in 1922. After graduating in 1926, he returned to Rhokana Corporation, Ltd., one of the largest copper mines in Northern Rhodesia, and in 1939 was appointed General Manager. In 1943, Mr. Harrison was awarded the O.B.E. and became a member of the Legislative Council of Northern Rhodesia the following year. He has held his present post in Johannesburg since 1946.