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THE MINERAL INDUSTRY,

ITS

STATISTICS, TECHNOLOGY AND TRADE,

IN THE

UNITED STATES AND OTHER COUNTRIES

TO THE END OF

1898.

EDITED BY

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GEMS AND PRECIOUS STONES.

The only features of interest in the mining of gems and precious stones in the United States in 1898 were connected with the production of ruby and turquoise, which are engaging considerable attention. Elsewhere in the world the main supply of diamonds continued to come from South Africa and ruby from Burma, while Persia remained the chief source of turquoise.

Amber.—Amber, the mineral succinite, is produced chiefly in Germany, where the production in 1896 was 440 metric tons, which was about 100 more than in 1895. The mines and business which were formerly in the hands of Stantien & Becker have now been taken over by the Prussian government. A small amount of amber is obtained from Myitkyina in the Hukong Valley of the Bhamo district of Upper Burma, where it is otained by mining at depths of 70 to 80 ft. Lumps weighing as much as 1,000 lb. are found sometimes.

Diamonds.—The De Beers Consolidated Mines, Ltd., reported for the year ended June 30, 1898, receipts of £3,647,874 13s. 11d., from diamonds sold, and an expenditure of £1,870,079, including amounts written off for depreciation of machinery, redemption of debentures, etc. Dividends amounting to £1,579,582 were paid and £748,488 6s. 7d. was carried forward. The average yield per load for the De Beers and Kimberley mines was 0·80 carat, worth 21s. 21d., or 26s. 62d. per carat; for the Premier mine the yield was 0·27 carat, worth 5s. 8·22d., or 20s. 9·3d. per carat. The price received for diamonds showed a slight decrease as compared with the previous year. The amount of blue ground and lumps on the floor, June 30, 1898, was 3,619,945 loads, including 729,039 at the Premier mine. At the annual meeting of the company at Kimberley, December 19, the Right Hon. C. J. Rhodes, quoting Gardner Williams, the general manager, as to the condition of the mines, said: "Although there was a falling off in the yield in 1898 this was due only to carelessness of the contractors in the mine in separating waste and blue gravel; and the fault has been remedied. At the De Beers mine an area of blue ground 730×200 ft., which should yield 1 carat per load is being dug on the 1,200-ft. level. Besides this there is almost an equal area in the west end of the mine which has been called poor heretofore, but will probably pay, and is to be tested thoroughly. The Wesselton mine is yielding nearly 32 carats per

100 loads and paying between £300,000 and £400,000 per annum. The position of the De Beers Co. is highly satisfactory. The net return for the six months ending December 31, 1898, was about £924,000. Expenses are from £150,000 to £160,000 per month, of which £100,000 is for mining and the remainder for sinking fund, interest and other charges. The company is receiving 20s. 8d. per carat for Kimberley and De Beers diamonds and 20s. 6d. for Wesselton, but will get a better price in 1899. The entire product is sold to the syndicate which controls the diamond-cutting industry. This syndicate imposes upon the company the condition of not putting diamonds unnecessarily upon the market, wherefore the company has no intention of increasing its output."

The production of De Beers Company in 1897-98 was 2,753,000 carats, from 3,260,000 loads (725 kg. per load) against 2,769,000 carats, from 3,011,000 loads in the previous year.

The De Beers Co. keeps a close watch upon all new discoveries of diamonds and considers that through its agents it has better opportunity than any outsider to secure control of new and valuable finds. During 1898 an examination was made of the Rivas mine in the Orange Free State, which proved to contain diamonds, but in too small quantities to make the undertaking attractive. Reports were also received as to the Schuller mine, near Pretoria, and its competition is not feared, although, it may be remarked, the feeling between Mr. Rhodes and the Transvaal government are not of a nature to permit close relations toward the investigation or acquisition of a rival diamond producer in the South African Republic.

The Jagersfontein mine, in the Orange Free State, produced in 1897-98 232,433 carats from 2,421,503 loads (725 kg.), against 220,212 (from 2,147,-427 loads) in 1896-97, and 205,000 (from 1,905,000 loads) in 1895-96. The Rivas diamond mine, in the Orange Free State, also made a small production in 1898.

Upward of 10,000 carats of diamonds from the Schuller mine were exhibited in Johannesburg in December, which were described as small and of poor color. The mine is said to show two pipes, 2 furlongs apart, one 630 ft. in diameter, yielding 63 carats per 100 loads, and the other 550 ft. yielding 42 carats per 100. The mine, known also as the Rietfontein, and owned by Lewis & Marks, has been tested by drilling to a depth of 500 ft. The stones are usually covered with a reddish film, which is removed by boiling in acid. Previous to November the largest stone that had been found was of 57·75 carats. About a mile west, J. B. Robinson has a mine, called the Montrose, on which he is erecting machinery. About 5 miles north the Bynestpoort Exploration and Developing Syndicate has tested an alluvial stratum about 2·5 ft. thick, which is said to yield an average of 3·5 carats per load. The diamonds are not of very high quality the average produced being worth only 15 to 17s. per carat; a plant of 50 loads per day capacity is being erected It is not yet two years since the first diamond was discovered in the Pretoria district. The Transvaal government has already promulgated a new law, considered rather onerous, to regulate the new industry.

The total production of the Schuller diamond mines in 1898 was registered as 10,823 carats, valued at £9,192. This production was obtained from 15,000 loads of red soil, representing the top stratum about 2 or 3 ft. thick on the easternmost of the two pipes mentioned above. This quantity of gravel was treated by one machine, having a capacity of 300 to 500 loads per day, according to the nature of the gravel. Below the top stratum there is a stratum of yellow soil, 30 ft. thick, and below the latter is the blue ground of the pipe. Blue ground is now being "floored" preparatory to washing. The actual production of the mine in 1898 was larger than reported, a good many stones of the better class being known to have been stolen.

For a description of the practice in washing diamondiferous gravel in South Africa the reader is referred to the paper on "Progress in Ore Dressing and Gold Milling," by R. H. Richards, elsewhere in this volume. The diamondiferous rocks of Monastery, in the Orange Free State, 30 miles south of Winburg and 140 miles from the Jagersfontein mine, and those of Griqualand, were described by A. Lacroix in the *Bulletin de la Société Francaise de Minéralogie,* 1898, Vol. XXI., pp. 21–29.

An exploration party sent recently by the Portuguese government to the country lying between the Tembe and Umbeluzi Rivers, in Portuguese South Africa, has located diamondiferous ground over a large area. The announcement of this discovery caused considerable excitement at Lourenço Marques. Considerable interest was excited in 1898 by some new finds in the Nullagine district, situated at the headwaters of the Congoon River and not very far from the Pilbarra gold field in northwest Australia. Diamonds were first discovered in this district in 1891, in connection with the gold ores of Pilbarra. A small consignment was shipped in 1897. The diamonds are said to occur in a conglomerate in which the stratification resembles the South African banket reefs. Diamond fields have been located in the Province of Shantung, China, and it is said that they are worth development.

Although Brazil was once the most important diamond-producing country in the world, and the excellent quality of the stones makes them highly valuable, diamond mining has been comparatively neglected of late in that country, being carried on only by individuals or small associations working in a crude manner. The production at present is probably about 40,000 carats a year.* The larger part of the stones found in Brazil at the present time is cut in that country either at Diamantina, Gouvea, or Rio de Janeiro. A new company the (Boa Vista) has lately been organized in Paris with a capital of 2,000,000 fr. to carry on systematic mining on a large scale in the neighborhood of Diamantina. This company intends to exploit what is believed to be the original deposit from which the diamonds were washed into the Santa Maria River, an affluent of the Jequitinonha, the most famous of all the diamond rivers of Brazil.

Diamond Cutting.—About 50% of the world's production of diamonds goes to Belgium for cutting, the remainder being done chiefly in Amsterdam. The Belgian and Dutch cutters buy the rough stones in London, whither they are

* British Consular Report, Miscellaneous Series, No. 494, February, 1899.

shipped from South Africa. The value of the rough diamonds purchased by the Belgian cutters and the wages paid to their employees since 1893 have been as follows, the wages being given in brackets after the value of the rough stones: 1894, $7,750,000, ($772,000); 1895, $9,650,000 ($965,000); 1896, ($1,061,500); 1897, $10,615,000 ($1,061,50).

Carbonado, or bort, the black diamond which is used in diamond drills and for other abrasive purposes, is found commercially only in Brazil. The occurrence and industry there are described by H. W. Furniss, United States Consul at Bahia,* who reports that they are found in the interior of the State of Bahia, in a district which is reached, from Bahia by boat to St. Felix and thence by rail to Bandeira de Mello, the edge of the diamond region. The carbonado is always found near the gem diamonds, The most productive region is further up the Paraguaçu River, which is reached by a mule-back journey of two days. It is thought that diamonds and carbonado occur all through this section, but on account of the rude methods of mining only the bed of the Paraguacu and its tributary the San Antonio and the side of the Serra das Lavras Damantinas are worked. The carbons are found in a kind of gravel called "cascalho," which occurs in the river beds beneath the silt and on top of a stratum of clay; on the mountain sides beneath a stratum of rock and above the same stratum of clay; and in the surrounding country beneath several strata of earth. The carbons are obtained from the river beds by planting a pole in a place not more than 20 ft. deep, where the current is not too rapid, up and down which native divers work, removing all the gravel down to the clay by means of sacks. This work is carried on during the six months of the dry season, being abandoned necessarily at the beginning of the rains on account of the strong current and greater depth of the river. During the rainy weather the gravel previously got is washed and examined for carbons and diamonds. The land deposits are worked by short adits, the accumulation of gravel being washed during the rainy season. These are more productive, being more accessible, than the river bottoms. Carbons vary in size up to 975 carats, which was the weight of one discovered in 1894; it sold in Paris for 100,000 fr. The most useful are those weighing from 1 to 3 carats. Larger stones have to be broken, in which there is always a loss, since they have no cleavage planes. About two years ago there was a local combination to keep up prices, but this failed, and since then the price has been maintained solely by the large demand, small supply and laborious method of mining. The small supply is due to the crude methods. Frequently two men obtain only three or four carbons in six months' work. The carbons are bought by agents of the exporters in Bahia.

QUARTZ.—In THE MINERAL INDUSTRY, Vol. VI., p. 256, reference was made to the discovery of large quartz crystals in the Green Mountain mine, Chile Gulch, Calaveras County, Cal. During 1898 a sphere entirely free from flaws 5·5 in. in diameter was cut from one of these crystals by Tiffany & Co. This is the largest perfect sphere ever made from an American crystal. It is valued at $3,000.

* United States Consular Reports, December, 1898.

RUBY AND SAPPHIRE.—Gem mining was prosecuted actively in 1898 at the ruby mines of the American Prospecting & Mining Co., in Macon County, N. C. A good many inferior sapphires and rubies were found there, and one pigeon-blood ruby weighing five carats. The New Mine Sapphire Syndicate was organized to exploit sapphire-bearing gravel along Yogo Creek, Mont.

The world's chief supply of ruby continues to come from Burma, where the most important of the deposits (described in THE MINERAL INDUSTRY, Vol. V.) are worked by the Burma Ruby Mines Co. Ltd. In 1895 this company produced 56,108 carats, valued at 2,91,357 rupees. In 1896 the outturn yielded 6,87,-537 rupees, the expenses of the company being 4,31,892 rupees. In 1897 the yield was 8,02,452 and the expenses 6,78,934 rupees. Some excitement arose early in 1898 over the discovery of sapphires in the Muang Long district, on the right bank of the Me Yom River, in Siam.

Rubies have long been esteemed as the most valuable of all gem stones. At the present time rubies under half a carat in weight cost £4 to £10 a carat, while rubies of four carats fetch £400 to £450. Stones of greater weight than four carats are of such exceptional occurrence that they command fancy prices. The two most important rubies ever known in Europe were brought from Burma in 1875, one weighing 37 and the other 47 carats. The smaller stone, it is said, brought £10,000 and the larger one £20,000.

Artificial rubies were regularly on the market in London and Paris in 1898. Some gem experts said that they could not distinguish them from the natural stone; others, including Mr. Claremont, who is the contributor of a paper in this volume, said that there was no difficulty in making the distinction. The stones are made by a company known as the Maiche, Ltd., exploying a process invented by Louis Maiche, which claims to be making a profit of £37,000 per annum. If this be true it is obvious that a large number of the artificial gems, which are said to be beautiful, have already been marketed.

TURQUOISE.—A recent report of the British consul-general at Meshed, Persia, says that the turquoise mines near Nishapur in Khorassan are at present held by the Malik-ut-Tujjar (head of the merchants) of Khorassan at a yearly rental of 24,000 tumans (about $24,000). There is great uncertainty about the continuity of the contracts, which naturally prevents any good work or improvements in the mines. The production can only be estimated in a very vague way, as there are no records whatever.

There was considerable activity in turquoise mining in Arizona in 1898, an especially important development being made at Turquoise Mountain, in Mohave County, where ancient Aztec or Indian workings were reopened. According to a report by A. B. Frenzel, veins of turquoise showed from the commencement of operations, increasing in width as the work progressed. Near the surface the stone was of poor color and quality, but as depth was gained the rock became firm and the turquoise solid and of better color, giving evidence of permanency. There is said to be a good deal of stone here which can be worked up to advantage in mantelpieces, columns, bases for clocks and bronzes, pedestals, mosaics, etc. This material is the country rock intersected by veins of turquoise. The mines are 18 miles from Kingman.

The Identification of Gems.

By Leopold Claremont.

It often happens that a dealer in gems, who has gained his experience by constantly handling large quantities of precious stones in the rough and cut states, is able to settle in a few moments some important question of dispute which it would take a clever mineralogist as many hours to decide, and it is surprising to what a degree of keenness the senses can be educated by the continual concentration of the faculties upon minute details, enabling one not only to discriminate between gems of different kinds, but to pick out, say, from a parcel of cut diamonds weighing several thousands of carats, a single stone which owes its origin to a different mine from the remainder of the parcel. It is, however, impossible to overestimate the value of the methods of testing precious stones which have been placed at our disposal by the science of mineralogy, by the application of which the keen judgment of the expert should be indorsed and made doubly sure.

Before applying any test at all, the gem to be examined—unless it be a turquoise or an opal--should first be carefully studied with a view to discovering if possible the form in which it crystallized, since many gems which somewhat resemble each other in many other respects occur in forms appertaining to different systems of crystallography. Unfortunately it is not always possible to discover more than a trace of the natural geometric formation, owing to the fact that precious stones are frequently found in more or less broken or waterworn fragments, which, especially in the case of highly modified forms, renders them not easily recognizable. At the same time careful note should be made of the fracture, indications of cleavage, and direction and nature of striæ, all of which help in the diagnosis.

Specific Gravity.—The specific gravity and the hardness should then be tested, after which the optical properties, which form a study in themselves. Following will be found a list of some of the gem stones, with their respective specific gravity, viz.: Diamond, 3·5; ruby, asteria and sapphire (blue, yellow, purple and green), 4·0; chrysoberyl, alexandrite, cymophane and catseye, 3·7; spinel, ceylonite and "Balas ruby," 3·6; topaz, 3·5; emerald, beryl and aquamarine, 2·7; jargoon, jacenth, hyacinth and zircon, 4·6; pyrope and almandine garnet, 4·2; essonite, 3·66; tourmaline, 3·1; amethyst, cairngorm and rock crystal, 2·6; chrysolite, peridot and olivine, 3·3; turquoise, 2·7; opal, 2·2; hiddenite and spodumene, 3·2; iolite, 2·6; phenakite, 2·9.

All the mechanical methods formerly used for taking the specific gravity of precious stones by means of balances, etc., are too laborious and troublesome to be of much assistance, and cannot be compared with the simple method of immersing the doubtful stone in different liquids of known degrees of density. A liquid suitable for this purpose is methylene iodide, which can easily be diluted by the addition of benzine, thereby diminishing the density, and hence by a careful adjustment of their relative proportions the specific gravity can be regulated to a nicety, so that the density of even the most minute stone can be ascertained in a few moments; for instance, if it be desired to discover if a certain doubtful gem is chrysoberyl or beryl, all that is necessary is to place it in a tube of methylene iodide together with a small fragment known to be beryl, to serve as an index. If it be beryl (2·7) it will float, if it be chrysoberyl (3·6) it will sink immediately. In the former case, if the fluid be diluted and stirred until the index is exactly suspended, the doubtful gem will also neither float nor sink, but remain poised beside it. The great drawback to this method is that many of the gem stones are heavier than methylene iodide.

Another liquid used for determining the specific gravity of precious stones, and one which I find most convenient, is known as "Sonstadt's solution." It consists of a solution of mercuric iodide and potassium iodide, and should be made up in several different vessels to different degrees of density, in which the gems will either float or sink, according to their relative weight, viz.: Solution A=3·17, solution B=2·9, solution C=2·67, and solution D=2·63. In solution A, spodumene, diamond, diopside, topaz, spinel, peridot, zircon, chrysoberyl, garnet, ruby, sapphire (and all other varieties of corundum gems) sink; and tourmaline, phenakite, turquoise, labradorite, beryl, emerald, quartz, iolite and adularia float. In solution B, tourmaline, turquoise and phenakite, which float in A, sink. In solution C, labradorite, beryl and emerald sink; and in D, quartz and iolite sink, but adularia floats. "Sonstadt's solution" should be handled with great care, as it is highly corrosive and very poisonous. It will be seen that this solution also is not sufficiently dense to float some of the heavier stones, but this difficulty has been removed by the discovery of a colorless solid compound which melts, at a fairly low temperature, to a clear liquid five times as dense as water, and therefore sufficiently dense to float all known precious stones. This compound is a double nitrate of silver and thallium, and possesses the remarkable property of mixing in any desired proportions with warm water, so that by dilution the specific gravity can be easily regulated.

Preparation of Specific Gravity Solutions.—Sonstadt's solution is easily prepared by making a saturated solution of potassium iodide in distilled water and adding to it mercuric iodide until no more is dissolved. Portions of the dense fluid thus obtained may then be diluted with water till they have the specific gravity required. Three fluid ounces (or say 100 c.c.) is a convenient minimum quantity for each solution, and assuming that four are to be prepared, take 360 c.c. of distilled water and add 415 g. of potassium iodide, and 567 g. of mercuric iodide, which should be previously powdered and mixed together. Allow to stand for some days, shaking at frequent intervals; then filter the liquid to remove any suspended particles, and ascertain if the specific gravity exceeds 3 by dropping in a gem, such as chrysoberyl, of about that density, which should float. If it does not, small portions of potassium iodide and mercuric iodide previously mixed and powdered in a mortar must be added till the required gravity has been attained. The whole bulk of liquid is then divided into four portions, each of which must be separately adjusted to the particular density required. This is a somewhat tedious and troublesome process, especially if any great degree of accuracy is desired; but since gems of the same nature may vary somewhat widely in density, an error not exceeding ·005 may be disregarded. The most accurate way of adjusting the solution is by means of a Sprengel tube, or a specific gravity bottle, preferably the former, on account of the high coefficient of expansion of the liquid and its great weight, which makes it desirable to work with a smaller quantity of material than most pyknometers are made to hold. Having ascertained the density, and assuming that it is too great, the proportion of water which must be added to get the density wanted may be calculated with approximate accuracy by means of the following formula:

Let x=the number of parts by volume of the liquid which must be added to reduce the gravity to the required extent. Let s'= the specific gravity of the solution, and let s''=the specific gravity to which it is wished to reduce it. Then $x=(s''-1)\div(s'-s'')$.

Having diluted in accordance with the above calculation, take the density once more. After one or perhaps two further adjustments the gravity required will be obtained with all necessary exactness. However, instead of directly ascertaining the specific gravity of the solutions, they may be adjusted with all reasonable accuracy by dropping in gems of known specific gravity, and adding water, as in the case of the silver-thallium compound about to be described. If the gems of the right density for each solution are at hand, this is a much quicker method than that previously described, but it generally necessitates taking the gravity of a large number of stones before suitable ones can be found.

Sonstadt's solution, though not so subject to loss by evaporation as the silver-thallium preparation, and not acted upon by organic matter under the influence of light, nevertheless slowly changes in density by keeping, however well stoppered the bottles in which it is kept may be. It is therefore desirable to have some rapid means of ascertaining whether it is up to strength. For this purpose a pair of gems may be kept in each solution, one which just floats and one which just sinks when the respective solution is at its correct strength. If no such gems are available any maker of scientific apparatus will, if supplied with solutions of correct gravity, prepare glass bulbs weighted with mercury for use instead of the stones. By careful adjustment it is possible to make them so that they neither sink nor float, but remain in almost any position in which they may be placed when the liquid is at the right temperature; but of course any considerable departure from the temperature at which the densities have been adjusted will determine the sinking or floating of the bulb.

The double thallium-silver nitrate may be made from the nitrates of silver and of thallium, both of which can now be purchased in sufficiently pure condition. For actual working purposes one fluid ounce of each solution is a sufficiently large quantity, but if expense is no great object more than this should be prepared, as the liquids rapidly lose water owing to the high temperature (70–100° C.) at which they have to be employed, and the density continually increases, but of course less rapidly with a large than with a small bulk.

Assuming that two solutions of about 60 c.c. each are to be made, having a density of 4·0 and 3·5 respectively, weigh out carefully 170 g. of silver nitrate and 265 g. of thallium nitrate, dissolve separately in distilled water, mix the two solutions in a porcelain basin and evaporate on a water bath, keeping the liquid protected as much as possible from both light and dust. The concentration should be continued until a stone (*e.g.*, a topaz or a garnet) having a carefully determined sp. gr. of 3·5, or a very little below, just floats. A little more than half the total volume should be set aside and the remainder further evaporated until a gem, such as a jargoon, with an observed density of 4 or a trifle below, rises to the surface.

Since so high a temperature has to be employed it is absolutely necessary to frequently test the density of the liquids, and this is best done by keeping in them a pair of gems as recommended for Sonstadt's solution. For convenience in working the latter is best kept in very wide-mouthed stoppered bottles, with no constriction at the neck. A pair of steel or ebonite forceps may be used to remove the gems, and a spare bottle containing distilled water should always be at hand in which to dip both gems and forceps after they have been withdrawn from the solution. Of course both should be wiped dry before being immersed in a fresh solution, otherwise the latter would be diluted and so altered in density by the adherent moisture. The water containing the washings should of course be used over and over again, as it can be filtered and evaporated down to the right density to replenish the solutions when they require it.

The silver-thallium solution is best kept in little flasks with wide and short necks, kept covered by a watch glass. When not in use each flask with its watch glass should be put into a wide-mouthed stoppered bottle with a little cotton wool at the bottom to prevent it shaking about. Before use the flasks and contents must be warmed to a temperature a little over 70° C., until the crystals have entirely dissolved, and the clear liquid must be made homogeneous by gently shaking the flask so as to impart, without splashing, a circular motion to its contents. The heating is best carried out in a small hot air or water oven with a false bottom, on which the flasks can rest, and two glass doors on opposite sides, so that the solutions are easily seen. For greater convenience there should be circular holes (with copper lids) in the top, sufficiently wide to admit a flask with the watch glass resting on it. When the solutions are quite clear and homogeneous the gems may be introduced through the top of the oven, removing the little lid and then the watch glass, the latter always being replaced immediately. As a cold stone dropped into a solution is liable to cool it down and to become coated over with crystals, it is as well to let the gems to be examined remain in, or on the top of, the oven a little while before they are tested. A pair of steel forceps should be used, and the coating of silver-thallium nitrate should be rinsed off the forceps and gems, as in the case of Sonstadt's solution. This is best done in warm water contained in a small flask similar to that in which the solutions are held. On account of its greater cost the washings are of course even more worth keeping than in the case of Sonstadt's solution. Great care must be taken to avoid getting the liquid on the hands, since no washing will remove the black stains it produces.

Hardness.—By the hardness of precious stones is meant the degree which they possess of resisting abrasion. Many of the hardest minerals cannot be scratched, although they can be easily broken, fractured or chipped. Emeralds, diamonds and jargoons, for instance, have often been injured by a blow or a fall. This quality of hardness forms another very valuable means of identifying precious stones, which, however, must be applied with discretion and care. There are 10 convenient standards of hardness used by mineralogists, to which specimens under examination may be compared, as follows: Diamond 10, sapphire 9, topaz 8, quartz 7, feldspar 6, apatite 5, fluorite 4, calcite 3, rock salt 2, talc 1. Small pieces of these minerals cut into points and suitably mounted in handles are applied in succession to the doubtful gem, with the object of attempting to scratch it.

When the gem neither scratches nor is scratched by any member of the scale the two stones may be considered of the same hardness. When it is scratched by the harder and scratches the softer of two test stones a good idea of its position between them may be gained by drawing all three stones with slight pressure across the surface of a fine, clean, hard file, and carefully noticing the different degrees of resistance to abrasion and the sounds produced. It requires some practice to acquire the delicacy of touch necessary to successfully perform this operation. The tools used in the process of cutting and polishing precious gems enable experienced gem cutters to appreciate the quality of hardness to a nicety, and thus dispense altogether with the system of scratching specimens with test stones. The following list shows the relative position of various gems in the scale of hardness: Diamond 10, sapphire 9·0, ruby 8·8, chrysoberyl 8.5, spinel 8·0, aquamarine 8·0, topaz 8·0, zircon 7·8, emerald 7·8, tourmaline 7·5, phenakite 7·5, iolite 7·3, almandine garnet 7·3, essonite 7·0, amethyst 7·0, peridot 6·3, adularia 6·3, green garnet 6·0, opal 6·0, turquoise 6·0, lapis lazuli 5·2.

Optical Properties.—These form most valuable means of identifying precious stones, and there are several scientific methods of a more or less practical nature which can be applied with the utmost advantage in this connection. These tests depend in the main part upon the refraction, single and double, and the absorption of light during its passage through the gems under examination. It will be obvious that the natural broken and scratched surface of a rough stone is very detrimental to the successful use of some of the instruments about to be described; therefore it is in connection with the discrimination of cut and polished gems that they are introduced into this paper.

Refraction.—The extent to which light is refracted by a translucent precious stone is a characteristic property most useful in determination. In the case of a facetted gem there is no need whatever to cut the stone into a prism, as was formerly supposed to be necessary, which, if the stone were of value, would be absolute madness. It is always possible to find two of the facets forming a convenient angle, and after carefully painting over the remainder of the gem to trace the ray of light passing through these facets, and thus to measure by means of the goniometer, not only the refraction, but the double refraction of the gem, no matter how great its refractive power. The little instrument known as the reflectometer is also useful for the purpose. It consists of a hemispherical glass lens viewed by an eyepiece containing a graduated scale.

It only requires to be pressed against the gem upon which has been previously placed a drop of liquid possessing a higher refractive power than itself, such as monobromonapthalene. On looking into the eyepiece a shadow is seen over half the field of view, and its edge crosses the scale at a point which gives the exact refractive index of the stone. This method, however, is only useful to examine gems of low refractive power.

The results of the measurements of the indices (for the yellow ray) of refraction of a few transparent gems are here given: Diamond 2·75, jargoon 1·95, ruby 1·779, white sapphire 1·75, phenakite 1·675, topaz 1·621, aquamarine 1·598, rock crystal 1·547.

Pleiochroism, or the property possessed by colored, doubly refractive gems of appearing of different colors, and different degrees of density of color, when viewed in different directions of the crystal, is most easily recognized by the dichroiscope, although the effect is often observable to the unaided eye. The instrument consists of a cylinder 2 in. long and 1 in. in diameter, containing a cleaved crystal of Iceland spar. When the instrument is held to the eye two images of the square opening of the eyepiece are to be seen, which appear of different colors, or of identically the same color, according to the nature of the precious stone.

If a gem under examination with the dichroiscope shows two images of the square opening of the instrument identical in color, no matter in which direction it is viewed, the stone is singly refractive and may be a garnet, spinel or diamond, but cannot be a ruby, sapphire, topaz, chrysoberyl, aquamarine, emerald, or any other doubly refractive gem, all of which show twin colors of distinctly different hues from each other when viewed at right angles to the principal axis of the crystal.

This is a very convenient and easy means of distinguishing gems occurring in the cubic form from those belonging to the other systems of crystallization, and is also a test which can be quickly applied to a doubtful specimen, either in the rough or cut state, enabling one often at a glance to decide between gems of the greatest value and others which are comparatively worthless. The characteristic twin colors of a few doubly refractive gems will prove of interest, the prime or natural color being mentioned first and the twin colors immediately following in parentheses: Ruby, red (crimson and carmine); sapphire, blue (dull green and blue); tourmaline, green (chartreuse green and bluish green); tourmaline, brown (dark orange and greenish yellow); tourmaline, red (salmon and rose pink); tourmaline, brownish red (mahogany brown and red); tourmaline, blue (green and blue); emerald, green (yellowish green and bluish green); peridot, green (brownish yellow and sea green); topaz, yellow (sherry yellow and pink); aquamarine, green (straw and grayish blue); chrysoberyl, yellow (golden yellow and greenish yellow); iolite, violet (drab and blue).

The so-called interference figures seen on looking through a doubly refractive translucent stone, by means of a polarizing microscope, are very characteristic, and this method deserves to be used as a test for precious stones much more than it is at present. It is necessary to look through the stones in one given direction (parallel to the principal axis), and as there sometimes exists a great difficulty in finding the exact direction in a cut and polished gem, which might possibly be from one projecting angle to another, this test is not often applied. This difficulty, due to refraction, may, however, be surmounted by immersing the gem in some liquid having nearly the same refractive power as itself, such as oil or glycerine, contained in a spherical glass bottle, whereby the stone may be easily held in almost any position, and the interference figure can always be seen.

The spectroscope may be brought into use in distinguishing gem stones, as there are two gems which give different absorption bands across the spectrum, namely, jargoon and almandine garnet or carbuncle, and the effect can be seen even with a pocket instrument.

Electrical Manifestations.—If a crystal of tourmaline be warmed it is electrified, one end becoming positive and the other negative. Advantage has been taken of this fact to make a very pretty test for the stone. If a mixture of powdered red lead and sulphur be blown through a sieve the particles become electrified by mutual friction, and if it then be shaken over a tourmaline which is being warmed the positively electrified end of the crystal attracts the negatively electrified yellow sulphur and the negatively electrified end of the crystal attracts the positively electrified red lead; thus one end of the stone becomes red and the other yellow. This ingenious test can of course be applied either to a rough crystal of tourmaline or to a cut and polished gem mounted as a jewel.

Color.—In the discrimination of gems it is always advisable to apply as many different tests as possible to every doubtful gem, and to be guided by the results of them all, thus avoiding the possibility of being misled by any slight error which might occur by the application of a single test. It is unwise to place much reliance on the color of the precious stone with regard to its identity, since there is no property of gems so unreliable and variable as this. The color of a precious stone is nevertheless of the greatest importance in regard to its market value, as even a slight variation in depth or tone often makes the difference between an immensely valuable and a common quality gem. The color of the ruby most highly prized is described as "pigeon blood," that of the sapphire "royal blue" or "cornflower" blue. The finest emeralds are spoken of as of "velvety green" richness, and fine white diamonds are termed "blue white," while a fine alexandrite should be pistachio green by daylight and a rich raspberry red by artificial light. Although every gem has a certain tone of color which is most highly prized, specimens occurring exactly of the desired tint are extremely rare; consequently those stones which present an appearance most nearly approaching it are of corresponding value.

Turquoise.—In the foregoing remarks I have been concerned almost entirely with methods of identifying gems which occur in nature in crystalline form, but there are two precious stones which are cryptocrystalline or amorphous, namely, turquoise and opal.

Calliate, or the true turquoise, is a sky-blue opaque colloid stone, consisting of aluminum phosphate and hydrate associated with a hydrated phosphate of copper, and containing small quantities of phosphate of iron and manganese.

Its hardness is 6, and sp. gr. 2·7, which, however, must not be taken with the specific gravity solutions, since the stones may change color. The color of the turquoise is due to the presence of copper phosphate. Powdered turquoise becomes dark-blue when moistened with strong ammonia.

There are two other substances which somewhat resemble the true turquoise; one is odontolite, a fossil bone or ivory colored with phosphate of iron, which is more opaque than turquoise and much softer; also its bony structure can always be seen under the microscope. There is also the mineral known as variscite, sometimes called callais or callainite, which has a hardness of 4, sp. gr. of 2·55, and is bluish green in color.

Opal.—Among the various mineral species known as opal there is only one kind of value as a gem. This is the variety called "precious opal," a beautiful translucent gem, which by transmitted light appears milky and cloudy, but by reflected light exhibits most brilliant prismatic colors reflected in patches of orange, red, blue and green. In composition opal consists essentially of silica, differing from rock crystal in being vitreous and containing combined water. Its sp. gr. is 2·2; hardness, 5·5 to 6. There is really no stone which resembles in any way the precious opal, and any specimen of fair quality can be easily recognized by its fiery play of colors.

The common and valueless variety of opal, which does not exhibit the prismatic colors, occurs in tints of pinkish brown and yellow, and often shows agatoid and dentritic markings. Hydrophane is a variety which readily absorbs moisture, and though not naturally transparent, becomes so (and sometimes prismatic) on being immersed in water. It is of little or no value. Cachalong is the name given to these specimens of hydrophane which adhere to the tongue.

Nomenclature of Gems.—Many of the difficulties frequently experienced in distinguishing precious stones are due to the nomenclature of gems being so very faulty and confusing; for instance, a diamond is always called a diamond, no matter in what color it occurs, be it green, red, blue or yellow, but corundum has a different name for every color in which it is found. When red it is called ruby; the blue variety is called sapphire; the green, oriental emerald; the yellow, oriental topaz; the purple, oriental amethyst; and the asteroid variety is known as asteria. In the beryl family of gems the bright green is called emerald; the blue, aquamarine; while only the sage green is known as beryl. The variety of chrysoberyl which has the property of changing from green by daylight to red by artificial light is called alexandrite, and the cats-eye is another variety of the same stone possessing a brilliant shimmering white line when cut *en cabochon*.

All the many different kinds of zircon, or jargoon, receive the same name with the exception of the red one, which is called jacinth. Indicolite and rubellite are the blue and red varieties respectively of the tourmaline. Olivine is called peridot when it occurs green and chrysolite when it occurs yellow, but the topaz is always called a topaz, no matter if it be blue, white, pink or yellow. Spinels occur in every imaginable shade of color; the bright red ones are called Balas rubies, and the others are known as red, blue, green and purple spinels, as the case may be. Amethyst is a purple form of quartz crystal, which also occurs yellow, being known then as cairngorm or Scotch topaz.

It should be borne in mind also that the same name has become associated with several absolutely distinct gems. No less than three different gem stones are known as topaz: (1) There is the "Oriental" topaz (corundum), (2) the true topaz, and (3) the Scotch topaz (yellow crystal); they can, however, be distinguished by their hardness and specific gravity. The beautiful golden-red stone called essonite is frequently misnamed jacinth, which is the correct designation of jargoons of the same color.

There are two or three varieties of quartz which, when properly cut and polished, display a ray of light somewhat resembling the true catseye. Although not approaching that costly and exquisite gem in luster or beauty of coloring, they have become known by the name of quartz catseyes. The emerald, amethyst and topaz must not be confounded with the Oriental emerald, Oriental amethyst and Oriental topaz, which are varieties of corundum, and are not infrequently known as "fancy sapphires."

It is greatly to be regretted that ignorance and the desire of irresponsible venders of gems to deceive the unwary has caused absolutely fictitious and misleading names to be indiscriminately applied to certain stones, such as "Parisian diamonds," "Cape ruby," "Rhine stone," "Cornish diamonds," "Evening emerald," "Chinese catseye," "Brazilian sapphire," etc.