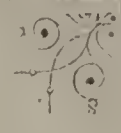


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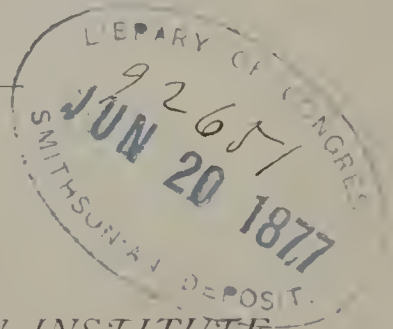
—OF THE—

PRECIOUS METALS USED IN COINAGE.

—BY—

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THE METALLURGY AND ASSAYING OF THE PRECIOUS
METALS USED IN COINAGE.¹

[Abstract of the first of a course of two lectures, delivered before the members of
the Franklin Institute.]

By ALEXANDER E. OUTERBRIDGE, JR., Assay Department,
U. S. Mint, Philadelphia.

ON GOLD.

The book of nature is a vast volume, from any part of which we may obtain wonderful sources of instruction and entertainment. Whether we contemplate the immensity of the vault of heaven with its innumerable suns revolving in their orbits, or whether we examine the tiniest blade of grass or the sting of the smallest bee, we find equally interesting subjects for study. It is one chapter, nay, rather one small page, of this great book, which I propose to open for you this evening, and my subject possesses one material advantage in its novelty in a lecture course.

The history of the precious metal which we call gold, carries us far back to the first records of the civilization of the human race. There is every probability that gold was the first metal known to man. Centuries before its use as a medium of exchange or unit of value, it was known and highly prized as an article of ornament. The ancient symbol of gold among the Egyptians was a circle, which typified to their minds the idea of perfection and divinity.

In the Old Testament we find very frequent mention of gold, and the vast amounts of precious metal used by King Solomon in the adornment of the Royal Palace and the Holy Temple excite our wonder and admiration.

The marvelous accounts related by the classic writers of the great quantities of gold possessed by the Oriental monarchs of antiquity must, of course, in some cases be accepted *cum grano salis*, and yet the recent archæological and treasure discoveries of General Di-Cessnola, in Cyprus, and of Dr. Schliemann at Mycenæ, are at

¹ As the lectures were not delivered from manuscript, this abstract for the JOURNAL has been prepared from memory, assisted by brief notes of headings. It has been found necessary, on account of limited space, to omit some portions, and to curtail others.

least partial confirmations of the stories related by Herodotus, Pliny, Homer, and other ancient authors. The beautiful collection of Etruscan and Phœnician golden ornaments—amulets, rings, fibulæ, etc., exhibited in the Castellani collection at the Centennial Exhibition, is a proof of the antiquity of the art of refining gold and working it into artistic forms of great beauty. Indeed the method of joining microscopical particles of gold, forming the ornamentation called “granulated work,” is a marvel to modern experts.

I wish you to pause with me for a moment to consider a phase in the history of the precious metals of absorbing interest—I allude to the search for that ever fleeting will-o-the-wisp, the Philosopher’s stone. Although we may laugh at the delusions under which the enthusiastic alchemists of the middle ages labored in their search for that *elixir-vitæ* which was to enable them to cure all ills, to prolong life to an indefinite period, and to transmute the ~~precious~~ metals into gold, we must not forget that we owe to their labors many valuable metallurgical discoveries. The older alchemists believed that the great secret was possessed by the Devil and could only be procured at the expense of the soul—while the more modern enthusiasts relied upon earthly means, and they accordingly triturated and boiled together the most heterogeneous compounds. Thus, in an old work, called the “Gold maker’s guide,” there appears this amusing recipe: “Take of the gall of a black tomcat, killed when the night approacheth, 1 part; of the brains of a night owl taken from out its head when the morning dawneth, 5 parts; mix in the hoof of an ass when the tide turneth; leave it until it doth breed maggots; place it on thy breast-bone when the moon shineth bright—and—thou wilt see a sight which the eye of mortal man ne’er beheld afore.” Again, “Hide and couple in a transparent denne, the Eagle and the Lyon, shut the doore close, so that their breath go not out, and strange ayre enter not in; at their meeting the eagle will tear in pieces and devoure the lyon and then be taken with a long sleepe.” The explanation of such riddles is simple enough when we have the key; for example, I have in my hand a glass vessel containing gold foil; this is typified by “the lion.” I now cast in “the eagle,” viz.: a little mercury; the mercury quickly forms an amalgam with the gold and becomes a sluggish or pasty mass, *i. e.* “is taken with a long sleepe.”

Numerous guides appeared from time to time, but, unfortunately, those which were written plainly never yielded a stone, while those

base

written enigmatically could not be understood.ⁱ This mysterious manner was not always owing to an intention to deceive—many philosophers believed it was wicked to reveal the secrets of nature to the vulgar people, and might even cause the death of the writer.ⁱⁱ So strong was the faith in the power of transmuting base metals into gold, that Henry VI of England issued a royal proclamation, in the year 1423, encouraging the art of gold making, in order to obtain means to pay the state debt. Edward IV, in 1476, accorded to a company “a four yeare privilege of making gold from quicksilver.”ⁱⁱⁱ

Our limited time will merely permit us to glance at these interesting by-paths in the history of the precious metals, and we are now prepared to investigate the

PHYSICAL AND CHEMICAL PROPERTIES OF GOLD.

You are all, doubtless, familiar with the rich orange-yellow color of gold, and yet but few of you have seen the royal metal in a state of purity. In this little porcelain saucer I have fastened with mucilage a number of granulations of chemically-pure gold. This gold is prepared with the most scrupulous care in the Assay Laboratory of the Mint, for test purposes, and is absolutely free from foreign substances.

By the aid of the improved form of megascope, devised by the Secretary of the Institute, Mr. J. B. Knight, I shall project the magnified image of these beautiful granules upon the screen. There, you see, they retain their natural brilliant lustre, golden color and

ⁱ In 1649 there appeared, “A master key to the opened heart of fatherly philosophy, and the “Childbed of the philosopher’s stone.”

In 1700, “Philosophical field sports and nymph catching,” and the “Brightly shining sun in the alchemical firmament of the German horizon,” “Chymical moonshine,” etc., etc.

ⁱⁱ Wilhelm von Schroeder, in 1684, wrote a book called “Necessary Instructions in the Art of Gold Making,” in which he says: “When philosophers speak openly, a deceit lies behind their words; while when they speak enigmatically, they may be depended upon.”

ⁱⁱⁱ The Danish ducats of 1647 were made of gold obtained, as it was believed, from artificial means, by the alchemist of Christian IV, named Caspar Harbach. So under the Emperor Ferdinand III, in 1648, a large medal was struck from artificially-prepared gold. In like manner the ducats struck under Landgrave Ernest Lewis, of Hesse Darmstadt, were of artificial gold, prepared, it was said, by the transmutation of lead.—*Reducer’s Manual*.

appearance of solidity.ⁱ So much for the color of gold by reflected light. Here is a sheet of gold-leaf, mounted on glass; it is partially transparent, and you might suppose that the transmitted light would also have the same orange-yellow color; let us see. I place the leaf in the oxy-hydrogen lantern, and the disc of light upon the screen is tinged a decided *bluish green*. This property of reflecting one color and transmitting another, is peculiar to gold. We are thus led, by a natural association of ideas, to the question, how thin is this sheet of gold-leaf?

The wonderful malleability and ductility of gold was a property well known to the ancients. Homer speaks of the art of gold beating, and Pliny mentions that an ounce of gold was beaten into 750 leaves, each leaf being about four fingers square. Gold leaves of extraordinary thinness have been found on the coffins of the Theban mummies. The rude specimens of gilding on the walls of the Peruvian temples, and the palace of Tippo-Sahib at Bungalore, prove its extensive application in ancient times. We also have biblical authority to the same effect.

Experiments made in modern times have shown that a grain of gold can be beaten out so as to cover a space of 75 square inches, having a thickness or rather thinness of $\frac{1}{367650}$ part of an inch. While reflecting upon this remarkable fact, the thought suggested itself to me, that the film of metallic gold deposited by means of the galvanic battery must be far thinner. And as the art of gold plating is so extensively applied to a great variety of ornamental metal objects, it seemed an interesting query, how thick a film is required to produce a fine gold color? On inquiring into the subject I did not find that any careful notes had been recorded, and I was led to try some experiments with rather interesting results, although they are not yet finished. Here are two highly burnished plates of metal, looking like pure gold; they have a metallic surface of twenty square inches each; these plates were cut from a strip of copper which I had rolled down to a uniform thickness of $\frac{5}{1000}$ of an inch. They were boiled in alkali to remove grease, and accurately weighed on an assay balance of extreme sensitiveness.

A "gold blush" of sufficient depth to produce this fine gold color was then deposited by the battery; the strips were carefully washed

ⁱ Several gold coins, medals and ornaments were exhibited, and elicited the applause of the audience, both on account of their inherent beauty and the brilliancy of their reflection.

and dried without rubbing; they were then reweighed, and I found they had gained exactly one-tenth of a grain each. It is thus apparent that one grain of gold would cover a space of 200 square inches, when deposited by the battery, as compared with 75 square inches by beating.

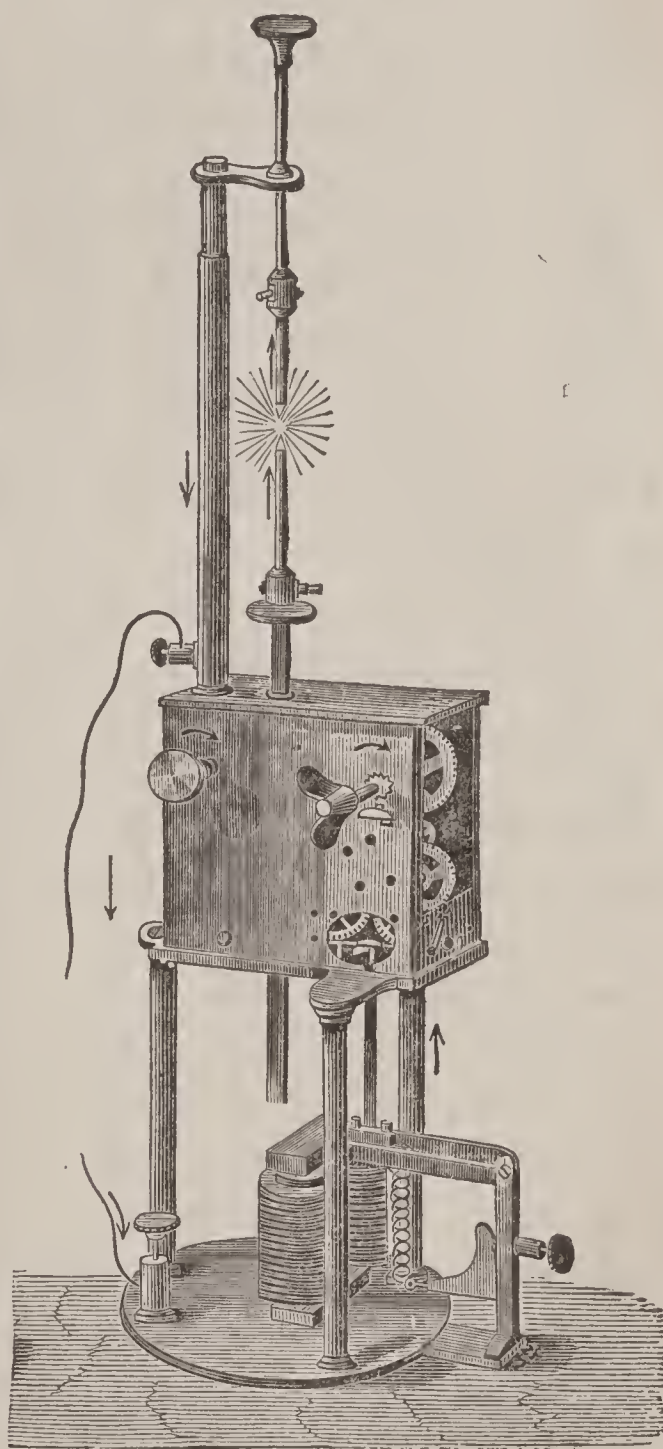
The film of gold appears evenly deposited, under the microscope, and it is more than $2\frac{1}{2}$ times thinner in the former case than in the latter, or $\frac{1}{980400}$ of an inch as compared with $\frac{1}{367650}$ of an inch.¹

It is stated, that when a cylindrical bar of silver is coated with gold and drawn into the fine wire used in embroidering housings, etc., one grain of gold will cover a length of 345.6 feet of wire.

Gold deserves its name of "noble metal" from its power of resisting the rusting and tarnishing action of the atmosphere, even when subjected to the severest trials. Kunckel kept a mass of gold in a molten state exposed to the atmosphere, for a period of nearly 30 weeks; at the end of that time it had not lost a single grain in weight.

Gold may be melted at a temperature of a little over 2000° F. in a wind furnace.

We may even cause gold to boil and vaporize by means of the intense heat of the electric arc. Here is an apparatus designed to produce an exceedingly powerful electric current. The copper wires



Electric Lamp.

¹ "A leaf of beaten gold occupies an average thickness of no more than one-fifth to one-eighth part of a single wave of light. By reducing the thickness of the leaf by solution in cyanide of potassium, I think 50 or even 100 might be included in a single progressive undulation of light."—Faraday's *Researches on the "Experimental Relations of Gold (and other metals) to Light."*—*Philos. Trans.*

conveying the current terminate in two sticks of carbon placed vertically one above the other in the focus of the condensing lens of this large lantern; when the points of carbon are brought in contact



Carbon
Points.

they become intensely hot, and on separating the poles, the current is carried across the hiatus, by the conductivity of the carbon particles. The lens projects the greatly magnified image of these incandescent poles upon the screen.ⁱ In the lower carbon is bored a small cavity into which I place a particle of gold, and you see its image just appearing upon the screen as a globule becoming white hot; ah! now it boils, and there darts forth an exquisitely beautiful tongue-like flame of *vapor of gold*, licking the carbon points, and there, upon the opposite electrode, are rapidly appearing small brightly shining beads of condensed vapor of gold, resembling sparkling dewdrops.ⁱⁱ

ling dewdrops.ⁱⁱ

Gold resists the solvent action of nearly all single acids, but a mixture of nitric and muriatic completely dissolves it as a perchloride; hence the alchemists gave the name of *aqua-regia* to this combination. Here are three glass vessels containing sulphuric, nitric and muriatic acids, with a piece of pure gold in each one, where it has remained for several hours, quite unchanged. I now pour the contents of the last mentioned vessels together, and our gold dissolves almost immediately.

Having in this manner obtained a solution of gold, we are prepared to test it with several characteristic re-agents. I place a few drops of the gold solution in this little tank containing distilled water, which you see reflected upon the screen; I now add a single drop of the solution of proto-sulphate of iron, and instantly a dark precipitate of metallic gold in fine division, rolls like angry thunder clouds over the canvas. This method of precipitation is used in the mint in the preparation of chemically-pure gold. I now add, to a fresh solution of gold, a drop of ammonia: a precipitate of

ⁱ The cut shows the carbon points inverted, as they appeared on the screen.

ⁱⁱ The apparatus used for the development of the electric current was "Wallace's Duplex magneto-electric machine," and was kindly furnished for these lectures by the manufacturers, Messrs. Wallace & Sons of Ansonia, Conn. The shaft was revolved at about 1200 revolutions per minute by a steam engine placed at the back of the stage. The light produced was remarkably steady and intensely brilliant.

a very different character appears upon the screen. This is the substance known as *fulminating gold*, and is a dangerously explosive compound; fatal accidents have occurred from its careless or ignorant preparation. Again, I take a fresh solution which is somewhat acid; into the tank, I place a thin strip of tin, it is attacked by the acid; proto-chloride of tin is formed, which instantly unites with the gold, developing very pretty purple streamlets. This is the well known "purple of Cassius," about whose chemical composition there has been a great deal of discussion. The Cassius purple is largely used in the arts, in staining ruby glass, and giving to enamel the delicate rose-pink color.

SOURCES OF GOLD.

To say that gold is at once a *rare* metal, and yet that it is one of the most widely disseminated of the metallic elements, seems at first sight contradictory; and yet it is, in a sense, literally true. Gold is found in Europe, Asia, Africa and America; it was known, in the time of Herodotus, to exist in Russia in the Ural Mountains. The mines were afterwards re-discovered in 1743, during explorations ordered by Peter the Great. The gold and silver mines of Spain have been worked from the most remote periods; both Strabo and Pliny mention the abundance of the precious metals, and it is stated that Hannibal would have been unable to continue the war in Italy but for the discovery of many mines in Carthage. China and Japan, India, Ceylon, Sumatra, Borneo, the Celebes and Philippine Islands, all add a sheaf to the golden harvest. The mountains and streams of Africa all contain gold. The Transvaal Republic, in Southern Africa, promises vast wealth of native gold to the hardy explorer; some magnificent nuggets were brought to us recently by a prospector from this almost inaccessible region. Some of these nuggets were for a short time placed at the Centennial Exhibition.¹

It remains for our own country to have the honor of possessing the most extensive gold and silver producing regions of the world at the present day. California and Oregon, Idaho and Washington territories, Nevada and Colorado, Montana, Arizona and New Mex-

¹ A *fac-simile* of one of the largest nuggets ever found in Australia was exhibited to the audience. It was prepared at the Department of mines in Melbourne, and formed an attractive object in the Victorian Court of the late exhibition.

ico, all contribute their quota.ⁱ Even the Philadelphia bricks, of which our houses are built, contain gold securely locked within their walls, as was proved by the interesting investigations made in the mint some years since.ⁱⁱ Here is a speck of gold, barely visible to the naked eye, which was extracted at the assay laboratory from galena of Bucks Co., Pa., representing one part of gold in 6,220,000 parts of ore.

GEOLOGICAL POSITION.

Gold is found in nature in the form of dust, grains, nuggets, and associated with quartz, etc. "It was formerly supposed that productive gold veins were confined to the Silurian rocks, but the discovery of fossils of the Carboniferous period in California by Dr. Trask in 1854, the exploration of Professor Blake, and the subsequent discovery of secondary fossils in the main belt of gold bearing States, together with the discoveries in Hungary in 1861-62, proving that the rocks holding the gold belong to the latest geological periods, even as late as the Tertiary—all show the fallacy of the opinion that productive gold veins are associated chiefly with the older rocks."ⁱⁱⁱ

MINTING.

Gold is received at the mint in the form of native grains, dust, amalgam, photographers' waste, old jewelry, dentists' plate, etc., and often contains a great variety of base metals, destroying its ductility, and rendering it totally unfit for coin. It is necessary to eliminate these, and then to effect the removal of silver. We will follow in imagination the course of a deposit, consisting, let us suppose, of old coin and jewelry, as it is received at the mint counter.

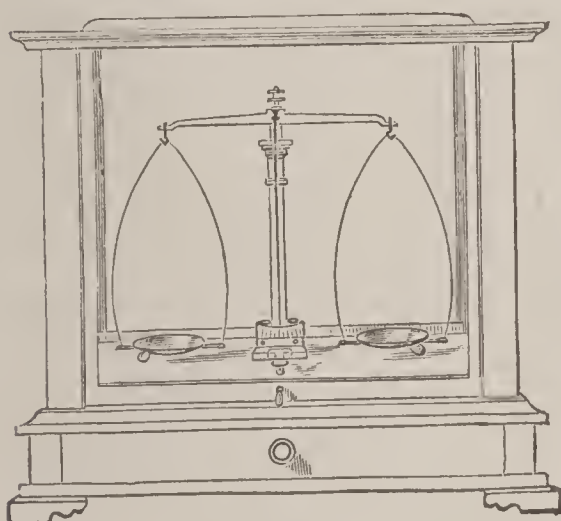
The metal is placed in a locked box, and carried to the "deposit

ⁱ According to the record of Wells, Fargo & Co., the sole carriers of the gold and silver product of the Pacific States, the total gold product of the mines west of the Missouri River, for the year 1876, was \$44,828,501. This exceeds the amount produced in any year since 1870. The highest yearly product was \$65,000,000 in 1853. The total gold produced since 1849 is \$1,858,400,745. The total stock of gold in the world, at the present time, has been estimated at \$5,540,000,000, with an annual loss by wear and tear of \$15,000,000. This is interesting, but can hardly be considered more reliable than a guess.

ⁱⁱ The report of these experiments, made by Profs. Eckfeldt and DuBois, states that the clay contains about forty cents' worth to the ton; that it is homogeneously diffused; and, from an estimate made of the extent of the clay bed, it was found that more gold lies under the paved portion of the city "than has yet been brought, according to the statistics, from California and Australia."

ⁱⁱⁱ Blake's Report on the Precious Metals at the Paris Exposition.

melting room;" here it is melted under a protective covering of borax, and constantly stirred, to render the mass homogeneous. It is then cast into a bar or "shoe" mould, and weighed; this is the weight at which the mint receives the deposit. A small chip is now cut off, for purposes of assay. A rigid analysis is made of this sample, and the result determines the value of the entire mass, by calculation to the fraction of a cent, and the depositor is paid accordingly. As the largest weight used by the assayer is the demi-gramme (about $7\frac{7}{10}$ grains Troy), and the deposit frequently represents thousands of dollars, it is evident that a very slight error in the assay would amount to a considerable sum total;¹ the assayer accordingly carries his actual analysis to the ten-thousandth degree, viz.: the twentieth part of a milligramme, or the $\frac{1}{1295}$ part of a Troy grain.



Assay Balance.



Muffle.

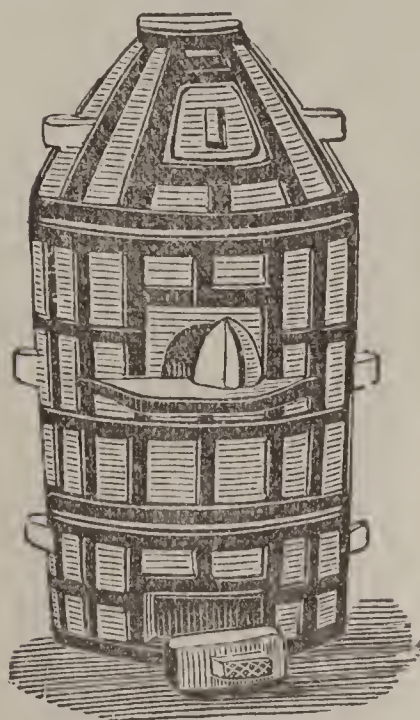
The fine assay balances will indicate even a smaller weight than this. The assayer rolls the sample into a thin ribbon, for convenience of cutting; the weight of half a gramme of this gold alloy is enclosed in an envelope of pure lead, and melted in the muffle of the assay furnace, in a small cupel made of pressed calcined bones. The lead rapidly oxidizes, and in this

condition is much more fluid than the simply melted precious metal; it therefore sinks into the pores of the cupel, carrying with it all the base metals originally combined in the alloy; the button of precious metal

remaining is weighed, and the proportion of base metal determined; another weighing of the sample is made as before, to which is added fine silver granulations in the proportion of about two parts of silver to one of gold. The alloy is cupelled as before, and the silvery button remaining is laminated, coiled into a "cornet," and boiled in nitric acid. The acid dissolves all the silver, leaving a roll of pure

¹ The average weight of one "melt" of gold ingots for coin, the fineness of which is determined by assaying a slip cut from the first and last ingot cast, is 4000 ounces Troy. The value is about \$75,000 in gold. Melts containing as much as 5500 ounces have been made, but it is found very difficult to render the metal homogeneous, owing to the difficulty of pushing the stirrer down to the bottom of the pot.

gold remaining; the gold cornet is then annealed and weighed; this weight is the proportion of gold; the difference between this and the first weight, is the proportion of silver.ⁱ The object of adding pure silver to the alloy is, in order that it may be present in excess; otherwise the atoms of gold cover up and protect the silver originally present in the alloy.



Assay Furnace.

Numerous checks are employed to correct variations, and so accurate are these devices that two samples taken from the bar will frequently be found, after passing through the various chemical and mechanical operations of hammering and rolling, melting, fluxing and dissolving (providing the original melting rendered the mass homogeneous), to show a deviation in the assay of not more than one-thousandth part of a single grain. The methods of refining gold adopted in the mints

are so closely associated with silver, that the two will be incorporated in the abstract of the second lecture.ⁱⁱ

ⁱ Strictly speaking, the gold cornet is not absolutely pure, but contains a small "sur-charge" of silver. The weight of the sur-charge varies according to the temperature of the furnace and other causes. This slight but important variation is determined by means of "proof assays" of chemically-pure gold, which are invariably made side by side with the others, and the proper correction is made for each. The boiling in nitric acid was formerly effected in separate glass flasks, but a great improvement has been made, in comparatively recent years, whereby the cornets are all subjected to the same acid and the same heat. A small platinum basket, perforated with holes, is made to contain a set of sixteen platinum thimbles. One cornet is placed in each, and the basket is immersed in nitric acid contained in a small platinum still. The boiling is effected by a Bunsen burner. When the silver is dissolved, the cornets are washed, dried and annealed in the basket. It is necessary to know, approximately, the amount of silver originally in the alloy; otherwise, if too great an excess is added, one of the cornets may break up, and, becoming diffused through the acid, small particles will attach themselves to the other assays and ruin the whole set. This is a misfortune that rarely happens to a careful assayer.

ⁱⁱ Through the courtesy of the chief assayer, the lecturer was enabled to illustrate his descriptions by the aid of apparatus in daily use in the mint. *Fac-similes* of gold bars, ingots for coin, native grains and nuggets, were shown, prepared in plaster of Paris, and covered with gold-leaf. Large oil paintings, showing the geological structure of the gold regions of California, and the methods of washing, were kindly lent by Professor Booth.

THE METALLURGY AND ASSAYING OF THE PRECIOUS METALS USED IN COINAGE.

[Abstract of the Second Lecture delivered before the Members of the Franklin Institute.]

By ALEXANDER E. OUTERBRIDGE, JR., Assay Department,
U. S. Mint, Philadelphia.

ON SILVER.

In my last lecture I traced the history of gold from its earliest mention in the Bible, in the marvelous accounts of the early classic authors, and of the alchemical writers of the middle ages, down to the production of the present day.

Silver was likewise known from the most ancient historic period, and even antedates gold as a medium of exchange. Its frequent mention in Scripture proves its familiar employment among the Jews. The shekel was a silver coin, and as it is very interesting, not only historically, but as revealing the state of coinage in the time of Simon Maccabæus, whose reign began 143 B. C., we will project its image upon the screen by means of the megascope.

On the reverse side you see the budding rod of Aaron, with the legend *Jerushalaim ha-kedoshah* in the Samaritan character, which is, translated, Jerusalem the holy. On the obverse is the pot of manna, with the words *Shekel of Israel*. This is one of the rarest and most remarkable coins in the mint cabinet.¹

SHEKEL



OF SIMON MACCABÆUS.

¹ Several curious old silver coins were used in illustration; among the most interesting were the stater, or 4 drachms of Athens, 2100 years old, showing the sacred owl. The stater of Alexander the Great, B. C. 336—323, showing the head of A. as Hercules with the lion's skin. A silver coin of Sapor, one of the Magian or fire worshiping kings of Persia, preceding the rise of Mohammed, A. D. 300. Denarius of Tiberius, A. D. 14—37, this was the *penny* of the New Testament. A silver coin struck in the time of the Roman Emperor Vespasian, A. D. 69—79, to commemorate the destruction of Jerusalem, with a figure of a weeping woman. And, finally, proof coins of our own mint, for 1877. The slow growth of art and gradual development of mechanical improvements in coinage, were very rapidly demonstrated in this manner.

PHYSICAL AND CHEMICAL PROPERTIES.

We are at once impressed with the brilliant lustre and pure white color of the virgin metal. This property is beautifully shown by the little *granule* of chemically-pure silver reflected on the screen, and magnified to the size of half a ton.

In its malleability and ductility, silver ranks second only to gold. Here is a book of silver leaves. They are so light that they float about on the surface of water, and if I hold some of them over the ascending current of warm air from the register on the floor, they are wafted through the room like thistles in the breeze.

Silver dissolves readily in nitric and in concentrated boiling sulphuric acids. Both of these solvents are used in the mints for the refining of the metal. A great number of re-agents precipitate silver from its solution. We will merely consider a few of the most characteristic and important. This tall jar contains salt water, and here is a silver quarter dissolved in acid; they both form clear solutions. By pouring the silver into the salt we obtain a white, flocculent cloud, falling like a miniature snow shower. The fickle chlorine gas, which was before united with the sodium, forming common salt, has changed partners with the nitric acid, and we have as a result, chloride of silver precipitated and nitrate of soda in solution. This test is of great value in the analysis of silver, and is an exceedingly delicate one, as I shall now endeavor to show you. I am holding in the forceps a tiny particle of silver which weighs just one-hundredth part of a single grain. I put it into a test tube containing a few drops of nitric acid, and it is immediately dissolved. The little glass tank in the lantern, reflected on the screen, contains a common sea-water bath, sufficiently enlarged to make a pretty formidable wave. I now add our drop of nitrate of silver, and I think you can all notice a cloud, the size of a man's hand, forming upon the screen.

Silver melts and volatilizes at a much lower temperature than gold; I place a particle of it on the lower carbon electrode, and you all see the superb emerald-green flame it produces, which is even more beautiful and brilliant than was the vapor of gold.

SOURCES IN NATURE.

Silver is found in the metallic state nearly pure, sometimes in enormous masses, weighing several hundredweight; but it is more frequently combined with other elements, such as sulphur, antimony,

lead, arsenic, etc. The process of extraction from the ore is, therefore, much more complicated than is the case with gold. It is also found over a wider range of geological periods. It occurs in true veins in the older crystalline and metamorphic rocks, in calcareous rocks, and even in the carboniferous period. The large colored geological chart of the world, together with the paintings, will serve to give you a pictorial impression of the natural distribution of the precious metals, and the means adopted for their separation.

My friend, Mr. J. A. Clay, whose valuable cabinet of minerals some of you may have seen, has kindly placed at my disposal his gold and silver specimens; many of these are quite rare, and the megascope will enable you all to appreciate their beauty. Perhaps one of the most remarkable of these is the ruby silver, enclosed in a transparent crystal of quartz.

The most famous mines of the old world are to be found at Kongsberg, in Norway, and at Sala, in Sweden. The silver mines of Spain have been worked from the most remote period by the Phœnicians, Romans and Moors in turn. In fact nearly all the countries of Europe have added their quota to swell the general stock in existence, both of silver and gold.

Mexico formerly produced two-thirds of the product of the whole world. You all remember the famous cake of silver that attracted so much attention in the Mexican Court at the Centennial Exhibition. This cake was afterwards cut up by steam shears, and brought to the mint. It weighed about 4000 pounds, contained $\frac{960}{1000}$ of pure silver, and was worth \$68,149.

The famous mines of Potosi, in Bolivia, were discovered in 1545, and were estimated by Humboldt to have produced \$1,150,000,000 worth of silver.

Coming now to the United States we find here the greatest mines of the world. Nevada and Colorado are treasure houses of apparently inexhaustible wealth. The presence of veins of silver throughout the territory of Nevada was comparatively unknown until 1859, when the Comstock vein was discovered. "The region was then regarded as an irredeemable wilderness, a land of deserts and death, over which the early pioneers had passed as rapidly as possible in the tide of emigration to the gold regions of California. The scene has changed, Nevada from a comparatively unknown portion of Utah became first a territory and then a state in the Union. The valleys and deserts resound with the shrill whistle of engines and falling of

stamps. The little valleys are brought into cultivation; graded roads are made over apparently impassable mountains; mails arrive and depart daily, and the telegraph connects the business centres with those on the Pacific and Atlantic coasts. All this has resulted chiefly from the discovery of the celebrated Comstock lode, which has already added nearly \$80,000,000 in value to the bullion of the world.”¹

In 1876, the Consolidated Virginia mine alone is reported to have yielded 145,666 tons of ore, the value of which was \$16,661,940. Colorado yields at the present time a daily average of \$15,000 in silver, and \$10,000 in gold. The mines of Utah yield a daily average of \$12,000 in silver.

REDUCTION OF ORES.

The ancient method of extracting silver from its ores was exceedingly crude, requiring a period of several months in the operation. In the old Mexican process, the ore was ground to a fine powder in circular paved pits or mills called *arrastras*, by means of large stones attached to a shaft drawn round by mules (resembling the manner in which clay is still mixed in some of our brick yards); water was added and the argentiferous mud was piled into heaps and left exposed for a considerable time to the action of the atmosphere. It was then mixed with common salt and copper pyrites called *magistral* by driving mules backward and forward over the mass. Mercury was added which combined with the silver to form amalgam and the dross washed away.

The excess of mercury was removed by squeezing the amalgam in canvas or chamois skin bags. This method is said to have been

¹ “From the Comstock the explorations extended in all directions, and resulted in the discovery of gold and silver bearing veins in most of the principal mountain ranges that traverse the great basin in a general north and south direction. First the metal was traced southward to Esmeralda, Mono, Coso, Walker’s River, Owen’s River, and the slate range near the southern end of the Sierra Nevada. Eastward the Humboldt mines, Reese River, Goose Creek, Egan Cañon, and Utah Mines, were reached in succession, and the discoveries have been extended eastward to the ranges of the Rocky Mountains, where the prospectors met those of Colorado. Northward in connection with the gold prospectors of Oregon, the precious metals were traced into Idaho, Montana, and British Columbia, and southward, veins have been discovered along the ranges reaching into Arizona, extending the silver region to Sonora, thus connecting the whole with the great metalliferous belt of the Mexican plateau; and with the discoveries of the extreme north, proving a continuous zone of mineral wealth through North America, from Panama to the Arctic Sea.”—*Prof. Blake’s Report upon the Precious Metals.*

invented in the year 1557 by a miner named Bartholomew de Medina. Nearly all the modern improvements, are merely mechanical modifications of detail, but the advantages of machinery are so great that as much can now be accomplished in a few hours as formerly required several months.

The usual method at present adopted is to roast the silver ores containing sulphur with from six to twelve per cent. of common salt. About 1000 lbs. of ore constitute a charge. The heat volatilizes the sulphur and the chlorine unites with the silver. After the ore has swelled into a spongy condition it is thoroughly sifted and placed in barrels holding 1000 lbs. each, mercury is added and the barrels are revolved for about 20 hours. Modifications of this process are adopted in some cases, to shorten the time; the mercury is sometimes delivered in a fine spray while the ore is kept hot. In order to separate the mercury the amalgam is dried, rolled into balls, and placed in hermetically-sealed retorts. The mercury is driven over and condensed, and the silver is cast into bars (called *pigs*) for shipment. Efforts have been made to effect the removal of the silver without the aid of mercury, and several methods of solution and precipitation have been devised. Ziervogel's process is exceedingly ingenious. The *matt*, consisting of sulphurets of silver, copper and iron, is roasted. The copper and iron first change to sulphates and then to oxyds. The sulphuret of silver also subsequently becomes sulphate, and if the heat were continued would be reduced to the metallic state; as this is not desired, the roasting is discontinued, and the silver is found as a *soluble sulphate*, which is then dissolved in hot water. The silver is precipitated by means of copper plates. The principal objection to this method of reduction is that the presence of certain impurities, such as antimony or arsenic, cause the formation of insoluble salts, which retain a portion of the silver.

Von Paterra's process consists in converting the silver into a chloride by roasting with salt. It is then dissolved in a cold dilute solution of hyposulphite of soda. It is next precipitated in the form of sulphide by the addition of polysulphide of sodium, and finally reduced to the metallic state by melting in a furnace while exposed to the atmosphere.

All the processes of solution are comparatively modern, and possess advantages in several ways over the old amalgamation methods.

MINTING.

Silver bullion is received at the mint in the form of bars, pigs, doré silver, old plate and coin. We have even received, in former days, whole altars of silver from Mexico, and Saints innumerable, which were ruthlessly cast into the fiery furnace.

The bullion is frequently rendered exceedingly "short" or brittle by the admixture of base metals. These, of course, require to be eliminated in order to render the metal fit for coinage, and the process is technically called "toughening." The metal is melted in a sand pot with an oxidizing agent, such as nitre, together with a protective covering of borax. The oxygen of the nitrate of potash combines with the base metals, forming volatile oxides; these are partially dissipated and partially dissolved in the borax. The precious metal is then cast into bars, and still another process, known as "parting," is required to separate the silver from the gold. For this purpose the silver deposits containing gold, and the gold deposits containing silver, are melted together so as to make the relative proportions about two pounds of silver to one of gold; formerly three parts of silver were considered necessary; hence the old name, "inquartation." The metal is broken up into *granulations* by pouring it from the melting pot into ice-water; these are placed in large porcelain jars having a capacity of 50 gallons each. Nitric acid is added and steam heat applied for several hours. The silver is converted into a soluble nitrate, and the gold settles to the bottom in the form of brown powder.

By means of a large gold siphon the solution of silver is transferred to a wooden vat containing salt water, having a capacity of 1200 gallons. The precipitated chloride of silver is collected on filters, washed, and reduced to the metallic state by means of granulated zinc and dilute sulphuric acid. Here is another instance of the base inconstancy of the pungent chlorine; having first deserted the sodium for the silver, it already sighs for new elements to conquer, and takes to itself the metal zinc, leaving the silver without a partner. The silver does not now present the beautiful appearance of the virgin metal, but requires purification by the "tryall by fire." It is accordingly pressed into large cakes, dried in an oven at a moderate heat, and melted in large crucibles. It is then cast into fine bars for stamping, or the requisite proportion of $\frac{1}{10}$ of copper is added for coin ingots.

In most of the foreign mints, as well as at the assay office in New York, the parting is effected by means of concentrated boiling sulphuric acid in cast iron kettles. The silver and copper are converted into soluble sulphates, while the gold remains untouched. Sulphurous acid gas is largely developed; this is sometimes conducted into leaden chambers and condensed into sulphuric acid. The silver is then reduced to the metallic state by means of copper plates. The sulphate of copper formed is crystallized in flat pans or vats, and becomes a valuable product. The advantages of this method are in the cheapness of sulphuric acid as compared with nitric, and in the fact that all the copper originally in the alloy is recovered in the form of blue stone, while in the nitric acid process it is lost in the solution of nitrate of soda.

The most recent improvement in refining which seems to combine the three valuable concomitants, of cheapness, simplicity and dispatch, is the *chlorine process* devised by Professor F. Bowyer Miller, of the Sydney Mint, Australia. A current of chlorine gas is passed through the metal while in a molten state; the gas combines with avidity with all the metals except gold, converting the base metals—such as lead, zinc, tin, antimony, etc.—into volatile chlorides, which escape up the chimney. The chlorides of silver and copper being comparatively non-volatile, are retained by a protective covering of melted borax, and, being lighter than the molten gold, they float upon its surface. The pot is then removed from the fire, the gold quickly “sets,” and the combined chloride of silver and copper is poured into moulds.

Extended tests of his process were made by Professor Miller at our mint, a few years since, which proved entirely successful. The gold was found to be as nearly pure as by the other methods in use, and the chloride of silver may be reduced in the ordinary way. This ingenious method was devised for the especial purpose of recovering the silver in the native gold of Australia, which often amounts to as much as 14 per cent., but which was formerly lost to the colony, owing to the too great expense of acids in that country.

ASSAYING.

In my first lecture I gave you a brief outline of the method of assaying gold by cupellation. Silver was also formerly assayed in the same way, but it was long known that the result was not quite

accurate, owing to the partial volatility of the metal. Experiments were instituted by the French government, which resulted in the beautiful "volumetric process" devised by Gay Lussac. This is one of the most accurate methods known to chemical science, and so complete was Gay Lussac's original description, that but little room has been left for any improvements, and many thousands of dollars' worth of silver are rapidly and accurately assayed every day in the mint in this way. The rationale of Gay Lussac's method is quite easy to understand, viz., *a given proportion of chlorine will precipitate a definite amount of pure silver.*

We prepare two solutions of common salt water (chloride of sodium), one is known as the "normal solution," the other as the "decimal solution," one begins and the other finishes the assay. Here is a pipette holding just one hundred grammes of the normal solution, which is made of such a strength that it will precipitate exactly one gramme of pure silver. In this bottle, I have a piece of a silver coin of a definite weight, dissolved in nitric acid, and when the pipette charge of normal salt water is added to it, you see the dense white precipitate which permeates the whole liquid. I now agitate the bottle rapidly for a few moments and the precipitate falls to the bottom, leaving a clear solution above. Is any silver still unprecipitated? Let us see. Here is a glass tube with graduated divisions, each division marks one-hundredth the capacity of the large pipette, and here is a solution of salt just one-tenth the strength of the other. I allow the charge of decimal salt water contained in one division of the glass tube to flow over the surface of the silver solution in the bottle, and a cloud is forming on the top. Now, as this charge of salt is $\frac{1}{10}$ the strength and $\frac{1}{100}$ the volume of the normal solution before added, I know that I have precipitated just $\frac{1}{1000}$ as much silver, or one milligramme. The bottle is again agitated until, after four decimal charges have been added, only a very faint *shadow of a cloud* appears, and I am now sure that all the silver is precipitated. A simple rule-of-three sum, gives us the proportion of fine silver in the original weight of alloy.¹ It is not necessary to weigh the precipitate, and even the

¹ The gramme with its decimals is universally adopted by assayers for accurate scientific work, the jewelers' "carat" having been entirely discarded within the last half century. Twenty-four carats represent purity, or 1000 fine. 18 carats mean two-thirds fine or 750-thousandths. Our "standard" for both gold and silver coin is 900 parts of precious metal, and 100 parts of copper; in other words it is nine-tenths fine.

calculation is saved by using Gay Lussac's tables. But perhaps you may think that the strength of the salt solution must vary with changes in the temperature; so it does, but this and other minor sources of error are corrected by testing the strength of the solution every day by means of a "proof assay," made of chemically-pure silver.¹

SPECTRUM ANALYSIS.

Most of you are, no doubt, familiar with the principles of the captivating study of spectrum analysis. You know that a beam of white light from the sun, or from this powerful electric lamp, is a very complex thing indeed. It is composed of a number of different and distinct rates of vibration of the luminiferous ether, which may reveal themselves to our physical sense of sight as a band of beautiful colors (as in the rainbow), but which are ordinarily so blended together upon the retina that we fail to distinguish the component elements; just as when we listen to a symphony played by a fine orchestra, we appreciate the combined harmonies while we lose the sound of the individual instruments. By inserting this prism in the path of the beam of white light coming from the electric lamp, we can sift out the primary rays, and now we have upon the screen a palette of the purest rainbow colors, spread by nature's own artistic hand, and shading into each other with an exquisite blending far surpassing the fondest dreams of a Titian or a Turner.

What would be the effect if, in place of this brilliant *chromatic symphony*, we could produce a *luminous solo* by means of a light of a single color?

There is a fundamental mono-chromatic note in the spectrum, which I wish to have as familiar, to your eye, as our national tune is to

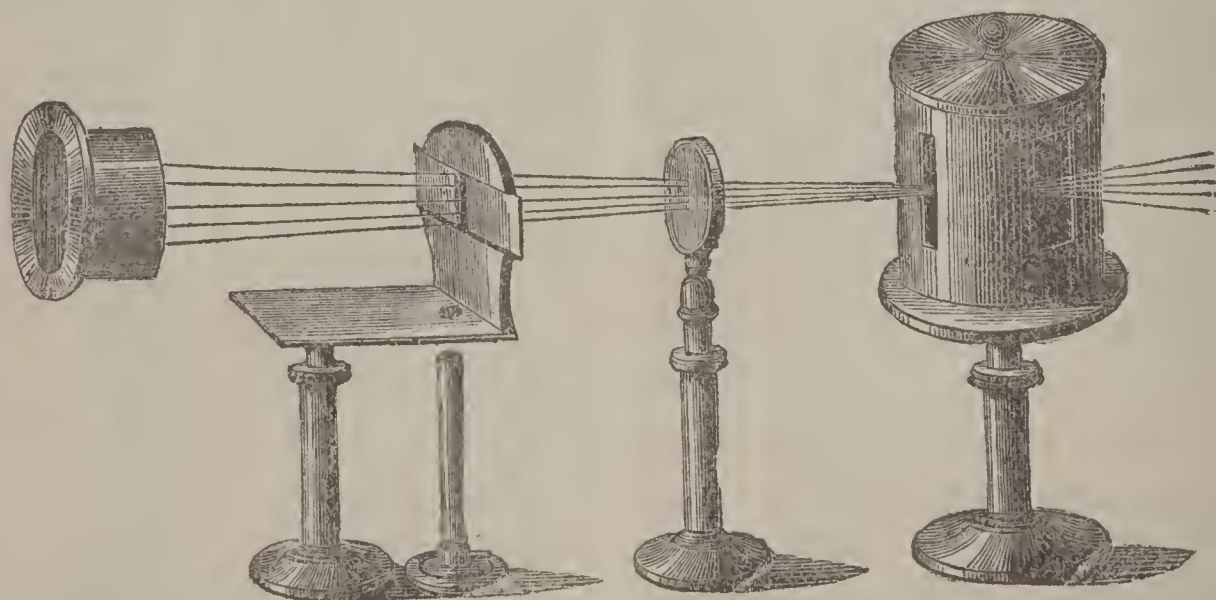


STAND, WITH TWO PRISMS.

¹ Mercury is the only foreign element liable to cause an error in the humid assay. Its presence, even in minute quantity, may be detected by a peculiar haziness in the liquid. A mere trace will prevent the blackening of the chloride of silver in strong sunlight. I believe that this is a fact not generally known.

your ear, for it is the key-note to the whole study of spectroscopic analysis. I therefore place in the electric arc a particle of sodium; this metal is capable of vibrating, when vaporized, at only *one note of color*, and hence you now see upon the screen a single band of intensely yellow light. Please to fix the position of this yellow line in your memory. It is called the "D" line, and is regarded by spectroscopists as a sort of *tuning fork* by which the positions of all the other notes in the chromatic scale are compared. I shall now vaporize a particle of pure gold and pass its light through the prism, ah! there it has *written its signature* upon the screen, in lines of brilliantly colored light, which nature never counterfeits.

Next we will call for the autograph of silver, and you see the beautiful green lines so characteristic of this metal. Then comes



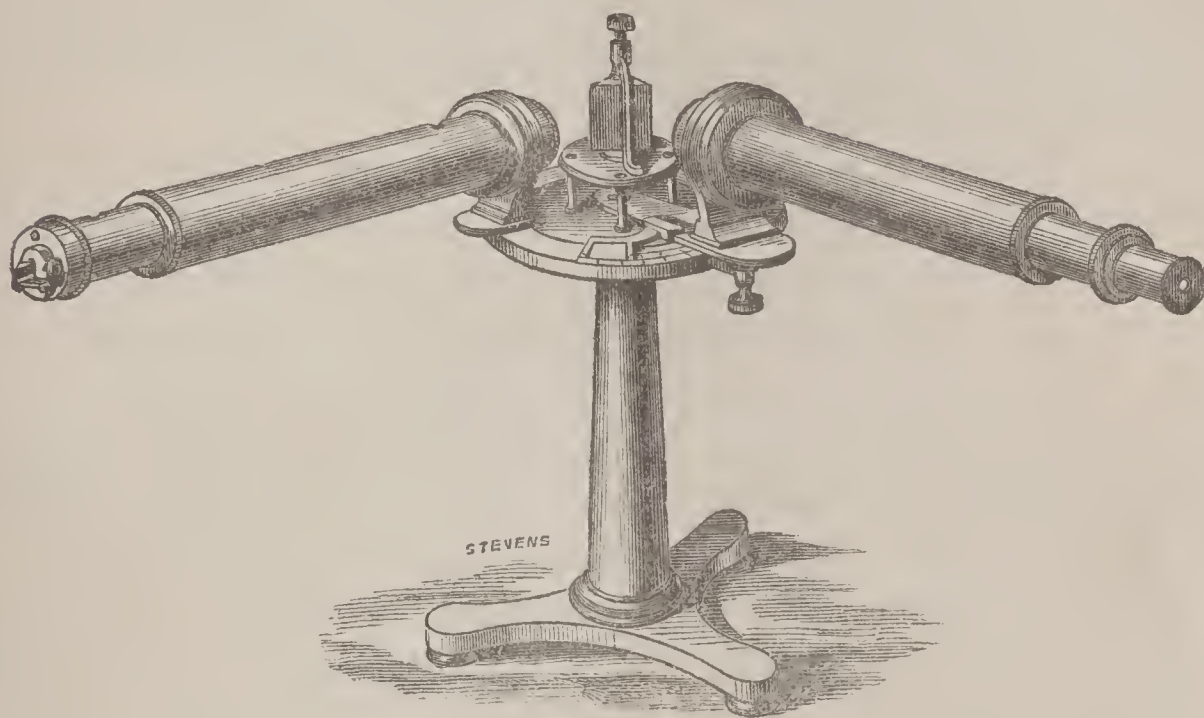
APPARATUS FOR PROJECTION OF SPECTRA.

copper, determined to outshine the others in its bold chirography; and, finally, when we vaporize an alloy of all three metals, we have the signatures of each written without confusion, and endorsed by the infallible authority of nature herself.¹

We have thus seen that the terrestrial elements (even when alloyed together), in the state of incandescent vapor, write their own distinctive autographs in the spectroscope, whereby each one may be easily recognized. But, you may ask, can these signatures also tell us the relative proportions in which the metals are combined? "Ay, there's the rub." This is the great problem that scientists are trying to solve to-day, and which I hope, and almost believe, we will

¹ By plugging the metal firmly into the cavity in the lower carbon, and filing it down to a cone, thus forcing the current to pass constantly from the molten globule, an uninterrupted spectrum was obtained in each experiment.

yet see accomplished. A step in this direction, which seemed to promise hope of success, was made some time ago by Mr. J. Norman Lockyer, the English astronomer. You know that when powerful electric sparks (from an induction coil) are passed between two terminal points of metal to be examined, a small portion of the metal is vaporized; its spectrum is then examined through an instrument of this kind.



SPECTROSCOPE.

Mr. Lockyer noticed while studying these luminous autographs, that when he separated the metallic electrodes, causing the spark to leap a greater distance through the air, the spectral lines no longer continued to cross the entire field of vision, but certain of them broke in the middle; and upon further increasing the distance between the electrodes, the hiatuses in the spectral lines increased proportionately, but unequally with different alloys. Upon this discovery Mr. Lockyer based the theory of a possible quantitative analysis.

The spectroscope was known to be marvelously sensitive to the impression of these autographs, and it therefore appeared plain that could such a method of analysis be reduced to a practical basis, its value would be immense in assaying metals used in coinage. For although the present modes of assaying precious metals have been brought to great perfection, yet the process is slow and tedious, requiring many chemical operations and great delicacy of manipulation; and “there is something captivating in the idea of a determination, as it were, by a flash of lightning, or in the twinkling of an eye, what proportion of gold or silver is present in any bar or coin.”

It was with the hope of reducing this beautiful theory to practice that I undertook, with the approbation of the chief assayer of the mint, an extended investigation in the assay laboratory, a portion of the work being performed at the University of Pennsylvania with the excellent apparatus and appliances afforded in the new college building. As the result of this investigation was published in the form of a report to the assayer, in the *Proceedings of the American Philosophical Society*, and afterwards as an article for the JOURNAL OF THE FRANKLIN INSTITUTE, it is unnecessary to do more than allude to a few of the experiments.

Various grades of alloys of gold, silver, and copper, were prepared, and their exact composition determined by careful assays. A special apparatus which you see upon the table, was constructed to hold the metal slips when under examination. Its peculiarity consisted in an automatic combination of accurately proportioned screws acting in opposite directions, by means of which a single motion of the hand sufficed to cause the upper and lower electrodes to approach or recede from the central line of contact in *an equal degree*. Its object was to admit of the electrodes being separated to any desired extent, while preserving the line of vision through the spectroscope directed to the centre of the spark. I found that while a decided difference in the spectral lines could be observed between alloys of comparatively wide variation, I was unable to detect any appreciable distinction between those varying but slightly in their composition. Several curious and unexpected anomalies were noticed in the course of this investigation, but the principal source of difficulty appeared to be owing to the infinitesimal amount of metal vaporized by the spark. I found, for instance, that when small electrodes were accurately weighed upon the delicate assay balance a thousand sparks might be passed between these points, each spark producing a brilliant spectrum of the metal, and yet the total loss in weight was only one-thousandth part of a grain; that is to say, each spark vaporized one-millionth part of a grain! Now, as I have already shown you, it is necessary to determine assays of the precious metals to the one-ten thousandth part of the normal assay weight, and it is hardly conceivable that a discrimination to the one-ten thousandth part of the *spark* assay weight or the *one-ten billionth* of a grain is practically possible. Even if it were so, the present state of metallurgy is not sufficiently perfected to enable us to mix the alloy so homogeneously

that we could safely assume that a test on such an atomic scale would correctly represent the value of a large deposit.

While there are several apparent paradoxes which have not as yet been explained, judging by former experiences in which even more mysterious problems have been resolved by study, we are surely warranted in anticipating, that when a larger number of observations, to be made, perhaps, by many experimenters, shall have been collated, the true scent may suddenly be struck, which shall discover the desideratum of quantitative spectroscopic analysis of metallic alloys.

CALORIFIC INTENSITY OF SOLAR RAYS.

NOTE OF M. A. CROVA.

“In previous communications,ⁱ I have indicated the methods of observation and of calculation, which I have adopted in my researches. It was interesting to inquire what are, at different epochs of the year, the quantities of heat received during a day by the horizontal surface of the soil; these determinations may excite an interest in the study of the phenomena of vegetation, and furnish facts for the study of the propagation of solar heat in the earth. With this aim, I have calculated the observations made during two normal days, during which the sun shone without interruption, days remarkable for the continuity of the atmospheric diathermaney, and chosen as near as possible, the one to the winter solstice, the other to the summer solstice.

“I have already givenⁱⁱ the measurements of calorific intensity in the solar rays, made at Montpellier during the 4th of January, 1876. This series was remarkable for the clearness of the sky and the general symmetry of the hourly curve of calorific intensities. The total quantity of heat received during the whole day, normally to the direction of the solar rays, upon a surface of 1 sq. centimetre, could be obtained by integrating the hourly curve, but it is more simple and equally precise to trace the hourly curve of the calories from sunrise till sunset, and to *weigh* the area of the curve thus obtained. If the paper is of uniform thickness, the weight of this area, compared with the weight of the rectangle in which it is inscribed, will give the

ⁱ *Comptes Rendus*, lxxxi, p. 1205, and lxxxii, pp. 81 and 375.

ⁱⁱ *Memoires de l'Acad. des Sciences et Lettres de Montpellier*, 1876, p. 61.

total value of the calories received in this interval, normally to the sun's rays; by previously weighing rectangles of different surfaces, from the paper which I used, I assured myself of the proportionality of their surfaces to their weights.

“On the other hand, I traced upon the same paper the curve which gives, for each observation, the product of the calorific intensity of solar radiation by the cosine of the sun's zenith distance at the middle of the observation; the weight of this curve measures the total heat received by 1 sq. centimetre of the horizontal surface of the soil, from the moment of sunrise till that of sunset.

“I made a complete series of observations on the 11th of July, 1876, near the shore of Palavas, 12 kilometres from Montpellier; this day was remarkable for the clearness of the sky, and the steadiness of a light northwest wind that weakened the disturbing influence of the sea breeze, which was not perceptible at the surface of the ground. The horizon being free in all directions, I was able to measure, without interruption, from sunrise to sunset, by means of two actinometers carefully compared and simultaneously observed, the calorific intensity of the direct radiation, and that of the part which was transmitted through a layer of water 1 centimetre thick.

“The observations of July 11th show the want of symmetry peculiar to summer days; after weighing the hourly curves of the morning and evening calories, and doing the same for the curves of the products of calorific intensities by the cosine of sun's zenith distance, I calculated the total value of the quantities of heat received during this day, normally to the solar rays and by the horizontal surface of the soil, upon an area of 1 sq. centimetre. The results of these measurements for the two days are as follows:

“JANUARY 4TH, 1876.

	Heat received on 1 sq. centimetre.	
	Normally.	On the surface of the soil.
1. From sunrise till noon,	264·4	78·9
2. From noon till sunset,	270·6	82·3
3. From sunrise till sunset,	535·0	161·2

“The calories received normally varied between 0 and 1·29, in 9 hours of exposure.

“The calories received on the earth's surface varied between 0 and 0·53, in 9 hours of exposure.

“The heat received on the earth's surface, is ·301 of the normal heat.

“JULY 11TH, 1876.

	Heat received on 1 sq. centimetre.	
	Normally.	On the surface of the soil.
1. From sunrise till noon,	451·5	293·5
2. From noon till sunset,	424·9	280·6
3. From sunrise till sunset,	876·4	574·1

“The calories received normally varied between 0 and 1·21, in 15 hours of exposure.

“The calories received on the earth’s surface varied between 0 and 1·10, in 15 hours of exposure.

“The heat received on the earth’s surface, is ·655 of the normal heat.

“The heat received normally on Jan. 4th, is ·610 of that received on July 11th.

“The heat received on the earth’s surface on Jan. 4th, is ·281 of that received on July 11th.

“These results give a precise measure of the irregularities produced, in summer and in winter, by the obliquity of the solar rays, and by the duration of the sun’s appearance above the horizon, between the absolute values of the intensity of solar radiation, and between the ratios of the quantity of heat sent directly, to that which is received upon the horizontal surface of the soil.”—*Comptes Rendus*, March 12th, 1877. C.

Academy of Natural Sciences.—Part III of the Proceedings, for 1876, contains: Self-fertilization in *Mentzelia ornata*, *Meehan*; Direct Growth Force in Roots, *Id.*; Interpretation of varying forms, *Id.*; On the Marine Faunal Regions of the North Pacific; An Introductory Note to the Report on Alaskan Hydroids, by Mr. Clark, *Dall*; Report on the Hydroids collected on the coast of Alaska and the Aleutian Islands, by W. H. Dall, U. S. Coast Survey, and party, from 1871 to 1874, inclusive, *Clark*; On the Extension of the Seminal Products in Limpets, with some remarks on the Phyllogeny of the *Docoglossa*, *Dall*; Descriptions of some vertebrate remains from the Fort Union Beds of Montana, *Cope*; On Conglomerate No. XII, *Young*; The Australians, *Pickering*; On Sonomaite, *Goldsmith*; Explorations in S. America, *Cope*; On Boussingaultite and other minerals from Sonoma County, *Goldsmith*; Report on Insects introduced

by means of the International Exhibition, announcing "with moderate certainty, that no evil results will occur to our agricultural interests, from any introduction of foreign insects, by means of the Centennial Exhibits," *Le Conte*, chairman; Notes on a Cirripede of the California Miocene, with remarks on Fossil Shells, *Conrad*; Notes on American Cretaceous Fossils, with descriptions of some new species, *Gabb*; On Ozocerite, *Leidy*; On Hyraceum, *Id.*; On Itacolumite, describing specimens "reported to be from Mariposa Co., Cal., which are interesting and worthy of note by reason of the new locality, and as showing the peculiarities of this kind of sandstone in a marked degree," *Blake*; Mineralogical Notes, *Willcox*; Impurities in Drinking Water, stating that "during the last eight years, whenever the Schuylkill has been covered with ice, he observed that the water supplied by the city possessed a disagreeable odor and taste like chlorine," *Id.*; On Excrescences and Eccentric Wood Growths in the Trunks of Trees, showing that "there was no reason why cells, predestined, under ordinary circumstances, to be merely bark cells, in their change from wood cells should not occasionally retain enough of growth force to carry on a feeble wood constructing system of their own," *Meehan*; Pickeringite from Colorado, *Goldsmith*; Epsomite on Brick Walls, accounting for the whitish incrustation at the beginning of winter, *Id.*; Notes on Fishes from the Isthmus of Panama, *Gill*; On some Extinct Reptiles and Batrachia from the Judith River and Fox Hills Beds of Montana, *Cope*; Our Sidereal System, and the Direction and Distance to its centre, *Ennis*. C.

Prize for a method of Detecting Adulterations of Butter.—

The bureau of the Leipzig Pharmaceutical Union, offers a prize of 300 marks for the discovery of a sure and practical method for the detection of adulteration of butter by other fatty substances. Professors Dr. Heintz, in Halle, and Dr. Knop, in Leipzig, have consented to act with Herr Kohlmann as judges in awarding the prize. Each competing essay is to be provided with a motto and accompanied by a sealed note, containing the motto on the outside and the author's name on the inside, and both are to be forwarded to Herr Kohlmann, Apothecary, in Leipzig-Reudnitz, before September 30th, 1877.—*Dingler's Polyt. Jour.*, 223, 2, Jan., 1877. C.

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