bath, the concentration of the solvent, the richness in wolffersite of the electrolyte, etc.

With a view to extracting them later, the precious metals will be found in the mother-liquor of crystallization of the electrolyte at the end of the operation.

To sum up, and it is one of the main points which the authors have striven to make, by the application of the process just described, we obtain direct from the raw ore a metal chemically pure.

The above explanation being given, for a better comprehension of the system we shall now enter upon some of the details of the manufacture of the electrolyzer.

The ore, if it be poor, is first stamped, then separated by the methods in ordinary use, either upon the round table or the endless platform, and later subjected to mechanical enrichment. It must be borne in mind that nothing would be gained by enriching it too much, the solvent taking it upon itself to leave the excess inert.

The rich or enriched ore is now passed through a granulator, which reduces it to bits small enough to assist the dissolution. The electrolyzer consists of an elongated wooden trough, with upright sides and ends, lined throughout with cement to protect the wood from attack by the alkalis and at the same time to give assurance of perfect solidity and stanchness.

This trough is divided into two unequal parts by a porous diaphragm, already described, of which the edges are sunken in the cement.

In the larger or cathodic compartment there is an electrode of carbon or of some metal, in fact, a good conductor of electricity, such as copper, for example, upon which to deposit the antimony. The anode, on the contrary, must be of carbon and not of a metal, which would run the risk of combining with the sulphur. The two electrodes are now brought as closely together as practicable, so as to overcome as far as possible the resistance offered by the bath; they should be suspended some distance from the bottom to be well clear of the settlings, upon arms of cast-glass, extending out at right angles from the vertical walls and screwed into the wood; two other similar glass arms should be provided which shall sustain a perforated stoneware pot containing the granulated ore.

This pot should be placed at the higher part so that the heavier liquid which forms from the dissolution of the ore may tend to descend and be replaced by the thinner and lighter liquid.

In the anode compartment must be placed a saturated solution of sodium sulphide Na_2S ; in the cathodic division a diluted solution of soda.

Thus made up the electrolyzer constitutes an element which may be multiplied as often as required to produce the desired quantity of antimony; these elements may be grouped either in series or in parallel by the aid of suitable connections in a manner to make the best use of the source of the current. The anode is furnished with a cavity or hollow, which is filled with mercury, in which a staple soldered to the copper cathode is inserted. The battery is mounted upon skids, with oil insulators, while the skids are insulated with glass.

We have seen that in the course of the electrolysis the sodium sulphide for the most part acts only as a solvent; it should not become exhausted. Meanwhile, it changes in time by contact with the air (though the passage of the current seems to retard this change somewhat), by the foreign substances introduced during the manipulation, etc. It is sufficient to remark that, as is always the case with concentrated solutions, a slight evaporation will allow of the recovery by crystallization of the major part of the product.

As was intimated above, the mother-lyes are retained for the possible extraction from them of the precious metals which they are almost sure to contain. When the deposit of antimony is deemed sufficient the cathodes are withdrawn and placed upon a little car running beside the batteries and taken to the melting furnace.

It is to be understood that the melting has no chemical significance; it is simply to run the metal in molds, in the usual ingots, to place it upon the market.—La Revue des Produits Chimiques.

ELECTRIC PECULIARITIES OF THE DIAMOND.

SPECIFIC gravity, hardness, and quantitative composition with oxygen have hitherto been held as the necessary requisites for the certain identification of the peculiar properties of the diamond.

Very recently a Mr. A. Artoin, of Turin, proposed that a number of electric phenomena, of which some appear quite characteristic, be added to the distinguishing features above referred to, as in a measure complementary and of equal importance.

The specific electrical resistance of the diamond is about the same as that of ordinary glass; it lies, according to the values calculated by Artoin, somewhere between 0.2 and 1.3×10^{12} .

Worthy of note is it, that graphite, the allotropic form of carbon, in which the diamond is transformed under very high temperatures, possesses 10^{15} times as great a conductivity. Subjected to the Roentgen rays, the conductivity of the diamond is increased twofold, only to be reduced to its original capacity immediately upon the removal of the beam. Like ice the diamond also possesses a dielectric constant, which is much greater than would be expected from its exponent of refraction (relatively here, the dielectric constant K = the square of the exponent of refraction N^2). Theoretically, it ought to be 7; in reality, however, it lies somewhere between 10 and 17. This may be taken to indicate that the diamond, as is the case with ice, retains the dielectric constant of a former fluid state after it has become solidified. Meanwhile, it is possible that certain hydrocarbons, such as CH_2 and CH_4 , are present in small quantities in the diamond, and to them is ascribable the augmentation in the dielectric constant.

The diamond, too, discloses a certain amount of permanent polarization and electric hysteresis. Besides, it is very weakly para-magnetic and pyro-electric.—Journal der Goldschmiede-Kunst.

AN UNUSUAL FORM OF CAPILLARY ELECTROMETER.*

By EMILE GUARINI.

MR. S. W. T. SMITH, Demonstrator in Physics at the Royal College of Science, London, has devised and had constructed an unusual form of the electrometer, the principle of which was applied for the first time in the Lippman electrometer, in which the superficial tension at the surface of contact of the mercury and diluted acid is modified when an electric current is passed through the surface that separates the two liquids.

In the construction of his apparatus the inventor

FIG. 1.—DIAGRAM OF THE CAPILLARY ELECTROMETER.

has endeavored so to arrange it as to obtain great sensitiveness in the measurement of the difference of potential, and to avoid such inconveniences as imperfect contacts, thermo-electric effects, vibrations of the meniscus due to the spring key, difficulties in using, etc., inherent to the old form of the capillary electrometer. In order to prevent the evaporation of the solution of sulphuric acid without interfering with the free motion of the liquids inside of the apparatus, the large tubes are closed at the top (Fig. 1) and connected by a transverse tube. The apparatus may be easily exhausted of air. The capillary tube extends from the center of one of the large tubes to the center of the other. The quantity of mercury is nearly sufficient to fill one of the tubes, and that of the solution, to fill half of it. The distribution of the mercury may be varied by means of a transverse tube provided with a cock and placed at the bottom of the apparatus; but this is not indispensable. The electrodes, P , P' , consist of small plates of platinum, and may, without inconvenience, be moistened by the acid solution.

The usual spring key is replaced by a U-shaped tube closed at one extremity and communicating through the other with a rubber bulb. In the curve of the U-shaped tube there is some mercury. Three platinum wires are inserted in the tube, as may be seen in the figure. Upon pressing the bulb, B , the same change of contact is produced as in employing a spring key.

Fig. 2 gives a view of the apparatus reproduced from a photograph. The extremity of the thread of mer-

FIG. 2.—THE SMITH CAPILLARY ELECTROMETER.

cury is illuminated by means of a concave mirror fastened to the base of the apparatus.

In order to ascertain the differences of potential between two points, a circuit is established by means of the rubber bulb and the meniscus is examined by means of the microscope fixed to the apparatus.

The sensitiveness of the electrometer, on employing the mercury key, is such that when the diameter of the large tube is 1 centimeter and that of the capillary one about 1 millimeter, a difference of potential of

0.0001 volt suffices to produce a perceptible displacement in the meniscus, which can be noted with certainty with a microscopic enlargement of 100 diameters. The real extent of the motion is sometimes variable and amounts to about 0.01 millimeter. The sensitiveness of 0.0001 volt is sufficient for many measurements. The electrometer is for this purpose more practical than a galvanometer with a suspended magnetic system. It is more easily mounted than the galvanometer, and there are no lamp suspensions, no spark, and, so to speak, no leveling. The apparatus can, without inconvenience, be placed in various positions for transporting. Besides, the contacts of the key are not directly exposed to the atmosphere of the laboratory, and the thermo-electric effects are minimum, since the changes of contact take place between the mercury and the platinum, which are almost identically thermo-electrical. The heat imparted to the key by the hand of the operator is negligible, and that produced by the compression of the air in the key can be but minimum. The key may be fixed upon the rest of the apparatus, because the pressure is never but a few grammes, while with the spring key it is 500 and over. The microscopic examination likewise can be more attentively done. The potential at E must never be less than a few tenths of a volt, or more than 1 volt at E^2 .

A CONTRIBUTION TO THE THEORY OF LIGHTNING RODS.

In most lightning rods, round copper wires are used. Flat iron is also employed occasionally. In a paper recently published in the *Elektrotechnischer Anzeiger*, A. Schortau suggests the substitution of flat iron for copper wires, experiments made in the laboratory of the author having proven that lightning-rod circuits of flat iron insure greater safety than those of round copper. This may be demonstrated in a theoretical way as follows:

According to Faraday, electrified bodies are wholly analogous in their behavior to condensers and Leyden jars. Federsen has shown by photographic means that disruptive discharges are of an oscillatory nature. The photographs taken by him give evidence of the regular variations in the luminous intensity, resulting in a reciprocating movement of electricity and a gradual vanishing of the intensity of the single sparks, whereas these phenomena as an entirety are presented to our eyes in the form of a single spark vanishing rapidly. Lightning, accordingly, may be considered as the oscillatory discharge of a condenser, the dielectric of which is the atmospheric air, whereas the clouds and earth will act as armature. These oscillatory discharges hence constitute alternating currents of infinitely small periods and infinitely high frequencies, these frequencies being designated in the following by the letter n .

According to Poynting's theory, high-frequency alternating currents are propagated only at the surface of a conductor, the current diminishing from the surface toward the interior of the conductor, resulting in an apparent augmentation of the resistance of the latter. This apparent resistance, termed *skin effect*, is calculated by means of the formula

$$R = W \sqrt{\pi n l \mu q}$$

where W is the ohmic resistance, n the frequency, l the length, μ the permeability, and q the cross section of the conductor. Hence it is inferred that the apparent resistance will increase as the square root of the frequency. The condensation of high-frequency currents on the external portions of a conductor is observed with a particularly high intensity in the case of magnetical metals and especially for very low frequencies. This condensation, as determined by J. J. Tomsen, decreases from the surface toward the central part inversely as the square roots of the surface. This diminution for any point distant from the surface, in the interior of the conductor, is

$$F = 2 \pi \sqrt{\frac{\mu n}{c}}$$

where μ is the permeability, n the frequency, and c the specific resistance. This shows that alternating currents of an infinitely high frequency are capable of penetrating into the conductor only for a small fraction of a millimeter. The specific resistance therefore plays a rather unimportant part, c being small as compared with n . In order to diminish the condensation of high-frequency alternating currents on the surface of the conductor, the latter should have the form of broad metallic ribbons, possessing the advantage of a greater surface. An additional advantage results from the inductance being diminished in the case of similar metallic strips. M. Wien showed as far back as 1894 that a strip of sheet metal offers a much lower inductance than a round wire of equal length and cross-section. The following table gives some of his results:

Breadth of strip.	Inductance of zinc strip. Measured.	Calculated.	Inductance of wire.
11.5 mm.	483.8 cm.	488.9 cm.	568.9 cm.
21.5 mm.	428.5 cm.	430.2 cm.	535.5 cm.

From the above evidence it is shown that the substance lightning rod circuits are made of, is of no material importance, the geometrical form of the conductor determining the qualities of the circuit, and the most practical form being constituted by thin flat iron bars such as found in trade in the form of pieces 50 inches in length. The *skin effect* is thus best utilized, and the inductance lowered to a noticeable degree.

As both the inductance and ohmic resistance should be a minimum and the surface a maximum, and as, on the other hand, the ohmic resistance is always much smaller than both the apparent resistance and the inductance, the author suggests testing lightning rods by making determinations of the inductance in addition to readings of the resistance as now exclusively made. In order to insure a contact as perfect as possible, strong tinfoil should be interposed between any two contact surfaces. The use of flat iron rods offers the additional advantage of being more economical than copper wire, and of being more easily and more rapidly fixed and mounted.—A. G.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.