with its 80,000 volts, and supply it by secondary 200-volt dynamos or 100-volt dynamos, through proper distributing wires, to the houses and factories and shops where it is to be used for electric lighting, and sewing machines, and lathes, and lifts, or whatever other mechanism wants driving power. Now the thing is to be done much more economically, I hope, and certainly with much greater simplicity and regularity, by keeping a Faure battery of 40,000 cells always being charged direct from the electric main, and applying a methodical system of removing sets of 50, and placing them on the town-supply circuits, while other sets of 50 are being regularly introduced into the great battery that is being charged, so as to keep its number always within 50 of the proper number, which would be about 40,000 if the potential at the emitting end of the main is 80,000 volts.

ON THE ARRESTATION OF INFUSORIAL LIFE.*

By Prof. Tyndall.

Three years ago I brought with me to the Alps a number of flasks charged with animal and vegetable infusions. The flasks had been boiled from three to five minutes in London, and hermetically sealed during ebullition. Two years ago I had sent to me to Switzerland a batch of similar flasks containing other infusions. On my arrival here this year 120 of these flasks lay upon the shelves in my little library. Though eminently putrescible, the animal and vegetable juices had remained as sweet and clear as when they were prepared in London. Still an expert taking up one of the flasks containing an infusion of beef or mutton would infallibly pronounce it to be charged with organisms. He would find it more or less turbid throughout, with massive flocculi moving heavily in the liquid. Exposure of the flask for a minute or two to lukewarm water would cause both turbitity and flocculi to disappear, and render the infusion as clear as the purest distilled water. The turbidity and flocculi are simply due to the coagulation of the liquid to a jelly. This fact is some guarantee for the strength of the infusions. I took advantage of the clear weather this year to investigate the action of solar light on the development of life in these infusions, being prompted thereto by the interesting observations brought before the Royal Society by Dr. Downs and Mr. Blunt, in 1877. The sealed ends of the flasks being broken off, they were infected in part by the water of an adjacent brook, and in part by an infusion well charged with organisms. Hung up in rows upon a board, half the flasks of each row were securely shaded from the sun, the other half being exposed to the light. In some cases, moreover, flasks were placed in a darkened room within the house, while their companions were exposed in the sunshine outside. The clear result of these experiments, of which a considerable number were made, is that by some constituent or constuents of the solar radiation an influence is exercised inimical to the development of the lowest infusoria. Twenty-four hours usually sufficed to cause the shaded flasks to pass from clearness to turbidity, while thrice this time left the exposed ones without sensible damage to their transparency. This result is not due to mere differences of temperature between the infusions. On many occasions the temperature of the exposed flasks was far more favorable to the development of life than that of the shaded ones. The energy which in the cases here referred to prevented putrefaction was energy in the radiant form. In no case have I found the flasks sterilized by insolation, for on removing the exposed ones from the open air to a warm kitchen they infallibly changed from cleaness to turbidity. Four and twenty hours were in most cases sufficient to produce this change. Life is, therefore, prevented from developing itself in the infusions as long as they are exposed to the solar light, and the paralysis thus produced enables them to pass through the night time without alteration. It is, however, a suspension, not a destruction, of the germinal power, for, as before stated, when placed in a warm room life was invariably developed. Had I had the requisite materials I should like to have determined by means of colored media, or otherwise, the particular constituents of the solar radiation which are concerned in this result. The rays, moreover, which thus interfere with life must be absorbed by the liquid or by its germinal matter. It would therefore be interesting to ascertain whether, after transmission through a layer of any infusion, the radiation still possessed the power of arresting the development of life in the same infusion. It would also be interesting to examine how far insolation may be employed in the preservation of meat from putrefaction. I would not be understood to say that it is impossible to sterilize an infusion by insolation, but merely to indicate that I have thus far noticed no case of the kind.

* British Association, 1881.

PLANTÉ'S RHEOSTATIC MACHINE.*

Translated from the French by the Marchioness Clara Lanza.

Ruhmkorff's electric induction machine has proved in the most satisfactory manner that by the intermediary of inductive action, we can transform voltaic electricity into electricity of high tension. M. Bichat has likewise shown that by the same means, currents of high tension can be changed to currents of quantity, analogous to voltaic currents. M. Planté, with his secondary piles, has rendered this demonstration still more emphatic, and as his experiments demanded a greater tension than he was able to produce with his batteries, he undertook the manufacture of an apparatus by which he could obtain veritable discharges of static electricity, capable of forming at will, long thread-like sparks, or short, thick ones. In this way he was induced to make the battery of which we are about to speak, and which he calls the *rheostatic machine*.

Although this apparatus (fig. 1) was presented to the Academy of Sciences and exhibited to most of the physicians who witnessed M. Planté's fine experiments, it is as yet, but little known. Why this should be the case we are at a loss to understand, for it is one of the most perfect machines that can be employed in experiments of static electricity. Had the apparatus borne a foreign name, we are confident it would have attracted considerable attention long ago. It is much to be regretted that we are so constituted in France, that whatever is invented by an unknown man, a *savant* who does not rejoice in an established position or who is not a member of some scientific coterie originating from a celebrated school, is looked upon entirely as a matter of subordinate interest. "It is only an amateur's work," we hear on all sides for awhile and then the subject is dropped forever. In England it is quite different. Amateurs such as Grove, Gassiot, Warren, Delarue, Spottiswoode, Lords, Ross, Lindsay, Raleigh, Elphinstone and many others, find their efforts are appreciated as they deserve to be, and no one ever thinks of inquiring whether they are *savants* patented by the government or not.

M. Planté therefore, not being among the last-mentioned, was forced to meet with indifference which he forcibly overcame later by the fine work he performed with his accumulators. He was not so successful, unfortunately, with his rheostatic machine, and for this reason we shall dwell a little upon the important results it has afforded us.

M. Planté's machine consists of a series of condensers with mica plates, parallel one with the other and capable of being charged and discharged in a manner similar to his secondary batteries without any other alimentary electric source than these latter.

The various pieces composing the apparatus must be

* *La Lumière Electrique*, August 6th, 1881.

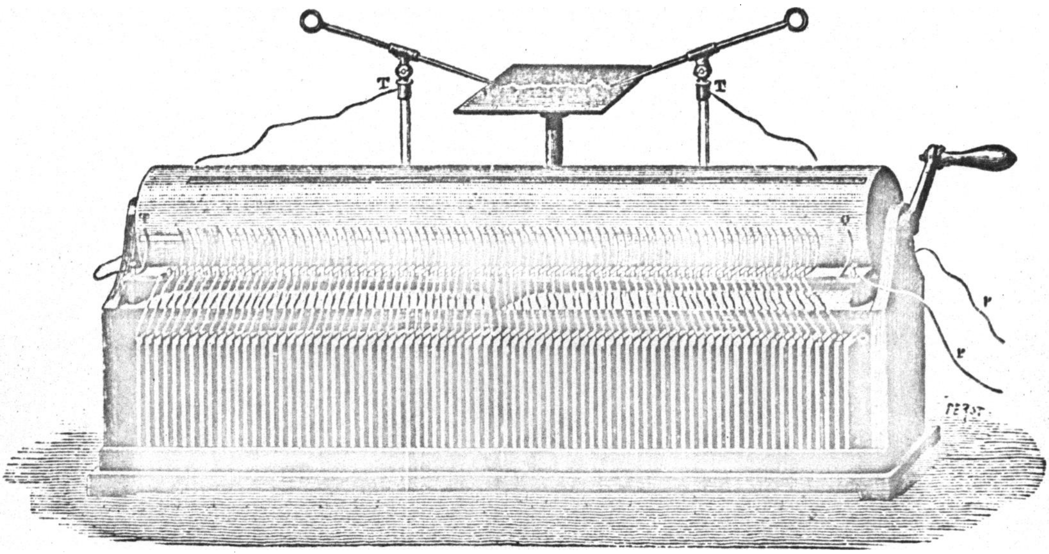

FIG. 1.

taken apart with great care. The commutator is formed of a long cylinder made of hard rubber. It is furnished with longitudinal metallic bands destined to connect the surface condensers, and crossed by pieces of copper wire bent at the ends, the object of the latter being to unite the condensers of tension. To this end, metallic wires, fashioned like springs, rest upon the cylinder and are associated with the two armatures of each condenser by very fine copper wires covered with gutta-percha. They are attached to an ebonite plaque on each side of the cylinder, and the latter can be made to rotate rapidly and continuously by means of a set of wheels. The final springs are separated considerably from those preceding them, in order to prevent the electric sparks from dis-

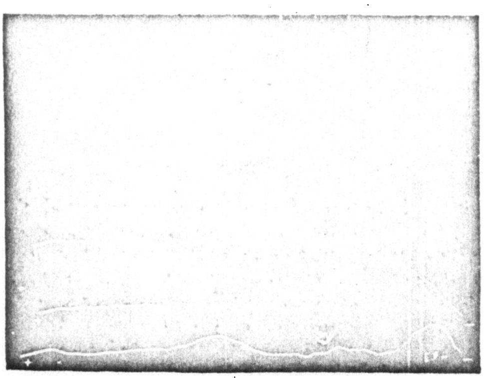

FIG. 2.

charging between the tension poles of the rheostatic machine and those of the secondary battery.

The mica plates in the condensers are 0^{m} 18 in length and 0^{m} 14 in breadth. The armatures are made of tin-foil. The edges of the condensers are rendered adherent by frames or simple ebonite plaques. These give them more rigidity and cause them more readily to maintain a vertical position, one beside the other, without coming in contact.

When the cylinder is so turned that the longitudinal metallic bands come in juxtaposition with the springs, the armatures in an even range with all the condensers unite on one side, while those in an uneven range are joined on the other, forming a single condenser of large surface. The armatures discharge by causing the right hand boundaries, which can be easily distinguished in the figure, to communicate with the poles of the battery.

When, on the contrary, the cylinder is so turned that its transversal pins are presented to the springs, all the charged condensers are connected in a series or in tension. The armature of the furthest condenser on the left, communicates with the last spring on the other side of the cylinder and ends at branch T of the excitant. The armature of the final condenser on the right communicates with the spring next to the last, and this spring unites with the last metallic pin traversing the cylinder. The last spring placed in the opposite side of the cylinder communicates with the other branch T′ of

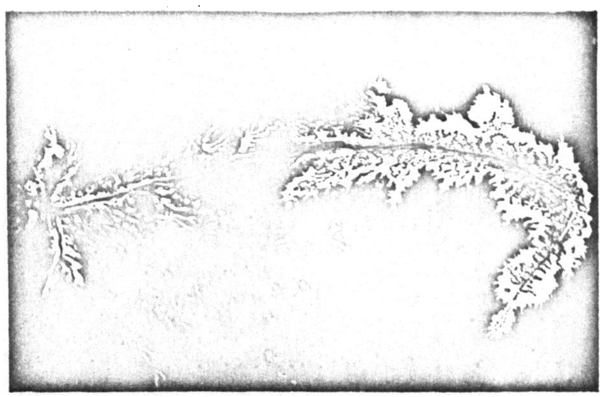

FIG. 3.

the excitant. While the condensers are thus connected, the pole, or battery, which charges the apparatus, is entirely beyond the circuit.

M. Planté has constructed rheostatic machines of different sizes. The one here represented is supplied with eighty condensers. The commutative cylinder is is one meter long and 0^{m}.15 in diameter.

When this cylinder is put in motion and the machine connected with the battery of 800 secondary couples, we perceive, as the charge begins to act upon the commutator, long lines of sparks at those points where the metallic contact is effected. It becomes a tube of sparkling light and the effect is equally apparent when the discharge in tension occurs. At the same time we obtain a long spark at the excitant T T′.

Sparks produced by this machine attain, when fully exposed to the air, a length of 12 centimetres when influenced by the secondary battery of 800 couples. With less powerful machines, however, the length is reduced, and, according to M. Planté, it will be *in proportion to the number of condensers.* When a spark discharges across metallic filings it sometimes reaches the length of 70 centimetres.

We must remark here that discharges produced in this way have no alternate positive and negative sense, but are always the same. The loss of force resulting from the transformation should, therefore, be less than in induction machines; for as the Voltaic circuit is never closed upon itself for a single instant, no portion of the current is converted into a calorific effect. The machine, moreover, can be kept rotating for a long time and it produces a considerable number of discharges without any apparent weakness being visible on the part of the secondary battery.

The most interesting effects studied by M. Planté, by means of the sparks of this machine, were obtained by causing them to pass over pulverized sulphur in a compound of sulphur and minium. If these powders are spread upon a surface composed of resin and paraffine (1/10) the sparks, while passing over the sulphur, leave a bluish line distinctly visible, as though traced in black lead. This gives us an exact autograph, we may say, of the spark's course. It is easily effaced, however, by being rubbed. But if carefully followed and indented with some sharp pointed instrument it can be rendered intact. Afterwards we can study it thoroughly by tracing a drawing of it. The sparks represented by Fig. 2 were produced as above described.

When we come to investigate these sparks, we find, according to M. Planté, that when they have not the maximum of length which they are capable of attaining, they often display enclosed branches resembling *anastomoses*, and which are likely to escape while our attention is fixed upon the luminous track. Their sinuosities are always rounded, and that angular zig-zag, which is apparent in most electric sparks, is never seen. It is true that this form is sometimes indicated by effects of perspective when the flash is at the horizon. The sinuous shape, however, predominates, and frequently the spark resolves itself into two demi-undulations, forming a sort of S, which is also often seen in flashes of lightning that strike the ground. We find there particularly a very characteristic hook-shaped form, upon which M. Planté has long endeavored to attract attention, and which is produced at the negative pole in a constantly varying manner. M. Planté thinks the formation of this hook arises from the collision of two motions opposed to the ponderable matter drawn from the points of the excitant, an effect which always happens under an angle more or less pronounced, and with a more rapid movement on the side of the positive pole than the negative, doubtless because there is greater electric tension at the former. Our readers will probably recollect that I demonstrated this tension in several ways with the induced currents of Ruhmkorff's bobbin.[1]

If a portion of the sulphur spread upon the plate of the excitant is removed by giving the latter a few slight taps, the sparks change to luminous branch-like aigrettes which are truly magnificent. Fig. 3 represents one of these at its natural size, having a luminous track 15 centimetres in length. M. Planté calls these *arborescent sparks*, and he thinks they serve to explain those impressions of a vegetable appearance sometimes observed upon the bodies of persons struck by lightning, and which merely result from the ramifications of the fiery track made by the flash itself. He attributes these impressions to certain pulverulent particles which are in the course of the discharge, and which, after being projected into the air, heated or blazing, in various directions, fall upon the body that has been struck and produce a kind of cauterization if the particles are merely heated, and luminous impressions if they are blazing.

These experiments are extremely interesting, for they clearly show that the pretended reproduction of neighboring objects upon persons struck by lightning is purely imaginary.

If we neglect to give the taps, before mentioned, to the sulphur-powdered plate, the spark is displayed as represented by Fig. 4. We observe, in this case, that the size

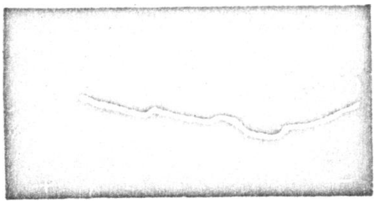

FIG. 4.

of the track is increased on the side of the positive pole, and grows contracted as it advances towards the negative pole. Around the positive pole we see traces corresponding to branches or rays in proportion to the quantity of sulphur removed. On the side of the negative pole we find circular tracks of an entirely different kind, representing, probably, the luminous spots, generally blue, which appear at the negative pole simultaneously with the spark of Ruhmkorff's bobbin.

If the plaque of the excitant belonging to M. Planté's apparatus is arranged so as to produce Lichtenberg figures—that is to say, covered with a compound of pure powdered resin, pulverized sulphur and minium—magnificent arborescent sparks of yet another kind can be obtained, the most curious examples of which are shown by Figs. 5 and 6. Tracings of these sparks are made by placing a sheet of varnished black paper upon the plate.

The different effects produced by the aigrettes and the sparks are particularly marked. When the distance between the points of the excitant is too great to admit of the spark discharging, and merely an aigrette appears, the electric movement of ponderable matter which leaves the negative pole and is manifested by the powdered minium adhering to the resin, does not extend to the positive pole. The latter presents no traces of red powder in the sulphur wreath and divergent rays surrounding it, as may be seen in Fig. 5. If the spark has

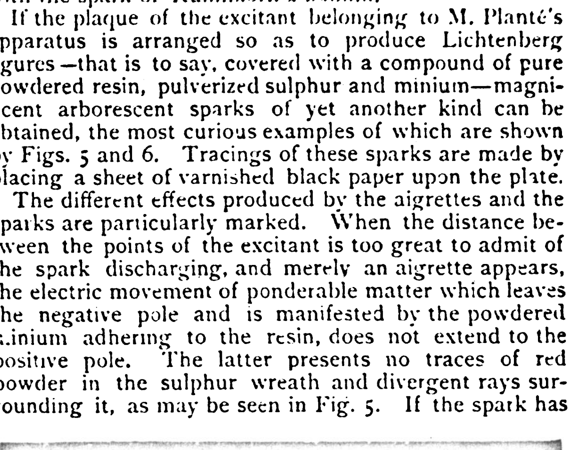

FIG. 5.

discharged, however, the wreath is open and the interior filled with red dust, showing that the electric movement proceeding from the negative pole, extends to the departing point of the positive electricity, as represented by Fig. 6.

[1] See Vol. II. of La Lumière Électrique p. 439, and also a paper on *La non homogénéité de l'étincelle d'induction*, p. 89.

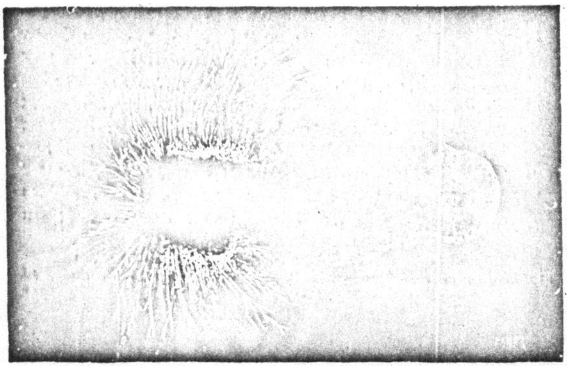

FIG. 6.

"With the spark," says M. Planté, "the distribution of negative electricity presents a curious crab-shaped appearance (Fig. 6.) With the aigrette, the electric movement around this same negative pole gives us the no less bizarre form of a polypus whose tentacles extend towards the positive pole, but do not reach it." (Fig. 5.)

From these results and other experiments quoted by M. Planté, he concludes that a blending of the two electricities may exist at each pole. This would infer that with electric currents of sufficient tension to obtain a continued series of discharges of static electricity, we could have a complete decomposition of the water at each pole and consequently a mixture of hydrogen and oxygen.

Pushing the study of these sparks still further, we find that the movement proceeding from the positive pole, externally, envelopes the negative electric movement like a bundle of curved sky-rockets. However, we often see at the same time an inward flux of positive electricity around the line of the spark between the positive current enveloping the exterior, and between both, the negative electric current which appears as though inhaled by the positive pole. This led M. Planté to suppose that the negative electricity, or else the ponderable matter which it carries with it, moves in an annular space furnished by the electrified matter proceeding from the positive pole. According to him, it would follow that the aspiratory or ascendant effects of the water obtained by electric currents of high tension might explain the ascension of water in a cloudy form as seen in water-spouts.

In a forthcoming article we will study other phenomena no less remarkable, which have been revealed by M. Planté's rheostatic machine. Among these are colored sparks and vibrations determined in a platinum wire traversed by a current of interrupted quantity, a phenomenon which can account for the effects produced in telephones by a simple wire crossed by a current.

TH. DU MARCEL.

To be continued.

ON A PROCESS FOR UTILIZING WASTE PRODUCTS AND ECONOMIZING FUEL IN THE EXTRACTION OF COPPER.*

BY J. DIXON (ADELAIDE, SOUTH AUSTRALIA.)

This paper contains an account of a process for extracting copper from sulphurous ores, in which the heat generated by the combination of the oxygen of the air with the sulphur of the ore is utilized for the smelting of the ore. This process is based upon experiments, which, although the author regards as incomplete, show (1) that the charge grows visibly hotter by simply blowing air through it; (2) that the melting of the raw ore or regulus and its reduction can be carried on in the same furnace; (3) that if the ore is in lumps, and fed at the top whilst the air is admitted by the side, a practically clean slagg can be obtained; but if added in a coarse powder, as it is generally found in the market, it either blows out again or chokes the furnace; (4) that a rough copper of about 96 per cent pure metal can be obtained by the successful working of this process.

*British Association, 1881.

ON THE CHEMICAL ACTION BETWEEN SOLIDS.*

BY PROF. THORPE, PH. D., F.R.S.

The author drew attention to the extremely rare instances of such action hitherto observed, showing how many of these might be explained on the supposition that combination actually occurred between the bodies either in solution or in a state of gas. For example, the formation of cement steel, by the combination of carbon with iron, which had long been adduced as an example of such combination between solids, was now explained by the fact that iron at a high temperature was permeable to gases, and that in the actual process of cementation oxides of carbon were formed, which were in reality conveyors of carbon to the metal. He then illustrated by experiments the formation of several compounds by bringing together the components in solid form, choosing as examples such as would manifest their formation by characteristic coloring. Thus, as instances, potassium iodide and mercuric chloride, potassium iodide and lead nitrate, and silver nitrate and potassium chromate, were powdered together in a mortar, and in each case evidence of an action was exhibited by the production of characteristic colors of the product of the reaction of these compounds. The author referred to the memoir of the Belgian phycisist, Prof. Spring, on the same subject, some of whose experiments he had repeated and in the main confirmed. One of the most remarkable results obtained by the Belgian professor was the formation of coal from peat by subjecting the latter material to a high pressure. Peat from Holland and Belgium, when exposed to a pressure of about 6,000 atmospheres, was, according to Spring, changed into a mass which in all physical characters resembled ordinary coal. Experiments of the same nature made by Dr. Thorpe with various samples of British peat yielded, however, a very dissimilar result. These experiments were made with pressures which were considerably less and more than those employed by Spring. Although solid, compact masses, hard and very much changed in structure, were attained, in no case was any product obtained which could be confounded with bituminous coal. He said it was highly improbable, on purely chemical grounds, that mere pressure had been little more than an important factor in the transformation of woody matter into coal.

A NEW DEMONSTRATION OF THE CARBONIC ACID OF THE BREATH.

BY C. F. CROSS.

Some time since I made the observation that the carbonic acid of the breath determines the liberation of iodine from a mixture of potassium iodide and iodate, and that the presence of starch renders the decomposition a very effective lecture-experiment, in demonstration of the presence of an active acid body in respired air. A friend to whom I lately communicated this result, threw doubt upon my interpretation, and while admitting the occurrence of the decomposition under the condition of respiring vigorously into the solution, preferred to attribute it to the action of the air or of acid vapors accidentally present. I therefore repeated the experiments

*British Association, 1881.