boiling prolonged, the amount of fuel required to complete the digesting process shall be greater, and we admit this to be the case. But in well regulated mills the extra amount of fuel required to maintain the digesting operation for an additional two or three hours beyond the time ordinarily required is small compared with that required to commence the process, and continue it for the first hour or so. The extra quantity of coal will hardly be noticeable in actual fact, and in no instance, we venture to believe, will it seriously interfere with the consumption of the steam, or in the generation of the steam in the steam boilers. Of course, there are circumstances of which we can conceive under which a prolongation of time occupied for digesting would interfere with the ordinary routine work of any mill, but these are so extreme that it may be accepted that they seldom exist in general practice, and are absent in all well regulated factories.

Then, again, the necessity of requiring more plant or boiler space may be urged as another reason why this course should not be adopted, and it is quite true that the boiler capacity would require to be augmented should it only be sufficient for the requirements of the mills under any less economical system of working. The manufacturer himself is the only one to decide any such question where increasing the plant is concerned. The time of digesting might be kept the same as before, and the pressure raised, in which case the boiler capacity does not enter into the question, while the fuel is, of course, increased.

Most likely those practical paper makers who have followed us thus far have come to the conclusion that the question of percentage yield of fiber from esparto is to them a very important one, that, indeed, any increment in it favorably affects the cost of producing the pulp. They are, nevertheless, so bound to conform to certain matters relating to quality in the manufacture of their papers that it may seem to them very difficult to make alterations in their methods of working, and endeavor to realize any improvement in their particular case of manipulating esparto by acting upon the suggestions contained in this article. We do not anticipate from such any expectation that they will succeed in obtaining better results. But to those who know their methods to be somewhat crude, our aim has been served if we have made clear to them the principles which underlie the subject matter of this paper. We know well the advantage of possessing the power of chemical investigation and engineering practice in manipulating esparto, and probably there is no branch of manufacturing industry where greater skill and attention is required than in the boiling house of a paper mill when high-class results are wanted.—*Chemical Trade Journal.*

ON M. H. HERTZ'S EXPERIMENTS.*

By M. JOUBERT.

DR. HERTZ, professor at Carlsruhe, published in the course of the year 1888–89 some experiments of very great interest. I have repeated the greater number of them, with the assistance of M. De Nerville, at the Central Laboratory of Electricity in the Place Saint Charles. The large hall at the laboratory, which forms a rectangle of 15 meters by 14 meters, enabled me to reproduce them under very favorable conditions.†

The great interest of M. Hertz's experiments lies in the accurate information that we gain from them concerning the intervention of the external medium in electrical phenomena. The idea of this intervention is not new. After Faraday's experiments and Maxwell's theories, there remained no doubts upon this point in the minds of physicists; but the experimental proof was wanting, and this proof has now been given to us by M. Hertz's experiments. They show, in particular, that the medium which intervenes in electrical phenomena is the same ether that forms the seat of luminous phenomena; that the disturbances in both kinds are set up under the same conditions, and with the same rapidity; and lastly, that there is identity of nature between certain electrical phenomena and the luminous phenomena.

What is an electrical current? We do not know: but the following hypothesis gives us a very good idea of what occurs. Let us consider a conducting wire, in its natural condition, as connected to indefinite elastic cords, normal at its surface. To introduce a current into the wire is to displace the wire in a direction parallel to itself and with the nature of the current, so as to draw with it the points of attachment of all the cords. These latter become oblique and remain oblique while the current is passing, but return to their orignal position and resume their normal direction as soon as it ceases. These cords being indefinite, the effect of the current makes itself felt at any distance, but evidently less and less, in proportion as the distance is increased.

But it is also very evident that the effect is not felt everywhere at the same moment; it arrives progressively at the various points, and takes rather more than eight minutes to arrive at the sun. We may add that what is called the *coefficient of self-induction* is only the coefficient of the term that corresponds to this external work of the creation of the field.

It should be well understood that the phenomenon of which I have just spoken has not its analogy in luminous phenomena. In order to produce the resemblance, we must consider alternating currents. Let us introduce into our rectilineal conductor an alternating current of a sinusoidal form; the elastic cords will be drawn alternately into first one direction and then the other, and each one will be the seat of transverse vibrations propagated along its length. We will, according to custom, call length of undulation the path taken by the movement during a complete vibration backward and forward.

It is under the action of these movements, transmitted through ether, that a conducting wire, stretched parallel to the first, becomes the seat of induction currents. We may remark that if this wire is stretched at a distance from the first equal to the length of undulation, it will give, at about the same intensity, the same phenomena of induction as if it were in contact; but that if it were placed at half this distance, *i. e.*, at a distance equal to a half length of undulation, the induced movements would be at each moment of a nature contrary to those produced in a wire adjoining the conducting wire, the only ones that we are accustomed to consider, and that the elementary laws of direct and inverse curcents would be reversed.

The experimental verification of this fact would be the most direct proof of the propagation of the electric action; but if the rate of propagation is the same as that of light, viz., 300,000 kilometers per second, and if the period of our alternating current be $\frac{1}{100}$ of a second, the wave length will be 3,000 kilometers, and the distance of the two wires would be 1,500 kilometers.

In order to get a wave length of 3 meters, the duration of the vibration must not exceed $\frac{1}{1000000000}$ of a second.

We cannot hope to produce directly alternating currents of such a short period; but we know that under certain conditions of resistance of the circuit the discharge of the Leyden jar is effected by isochronous vibrations of very short duration; but these oscillations have always been found to range from $\frac{1}{10000}$ to $\frac{1}{1000000}$ of a second. It is the same with the oscillation produced in the open circuit of the secondary wire of a Ruhmkorff coil at each interruption of the inducing current. This minimum duration of $\frac{1}{100000}$ of a second corresponds to a wave length of 3 kilometers.

One of M. Hertz's great achievements is to have found a method by which still more rapid oscillations can be given, the duration of which may be reckoned in billionths of a second. Theory points out that if two spheres (Fig. 1) charged with different potentials are put in communication by a conductor, equilibrium is established by a series of isochronous oscillations, rapidly checked, like those of a liquid contained in communicating tubes, the level of which has been disturbed. The duration of the oscillation depends on the capacity, C, and the coefficient of self-induction, L, of the system, and is given, when the resistance of the joining wire may be disregarded, by the formula

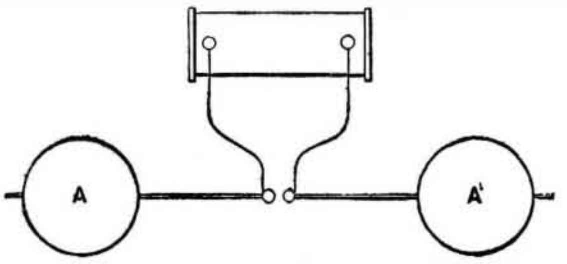

FIG. 1.

$$T = 2\pi\sqrt{LC}$$

Such is briefly M. Hertz's apparatus, which we will call the exciter; it consists essentially of a rectilineal conductor cut in the middle and terminated at its extremities by two capacities, two large spheres or two plates.

In the apparatus placed before the society the rectilineal conductor has a diameter of 0·5 centimeter and a length of 40 centimeters; the two spheres are 30 centimeters in diameter. Consequently we get

$$C = \frac{15}{9{\cdot}10^{20}}$$

$$L = 400$$

$$T = 16{\cdot}10^{-9}$$

From this we deduce for the length of undulation, the speed being supposed to be that of light,

$$\lambda = 4{\cdot}80 \text{ meters.}$$

In order to realize the instantaneous charging of the exciter we leave an interruption in the middle, terminating the two opposite extremities by little balls and putting each of these balls into permanent communication with the two poles of a Ruhmkorff coil. The bobbin employed with the exciter in question is a Carpentier bobbin (type 600 fr.) working with a Marcel-Deprez interrupter and a current which is 15 amperes when the interruption is suppressed.

This is the action of the apparatus. At the moment when induction is produced on the secondary wire of the coil, the two branches of the exciter which form the extremities are brought to different potentials, and at the same instant a bright spark flashes between the two balls, establishing during a very short period between these two balls a passage of low resistance, across which the rectilineal conductor discharges upon itself independently, almost as if it were separated from the bobbin. These oscillations are stopped before the following oscillation of the bobbin, which does not return until after $\frac{1}{10000}$ of a second has had time to take place, and they are renewed in the same manner at each oscillation of the bobbin. The condition of the exciter may be compared to that of a violin string, the vibrations of which are kept up by the sharp drawing of the bow.

The essential condition of the phenomenon is, therefore, that the spark should pass and should be of the intensity required. If we separate the balls so as to suppress it and to leave open the secondary wire of the bobbin, we no longer get the proper oscillations of the bobbin, which are about 10,000 times slower than the proper oscillations of the exciter.

The production of rapid oscillations depends on complex and even somewhat mysterious conditions; they are influenced not only by the distance of the two balls, but also by the condition of the surface, the degree of polish of these balls, the dimensions of the bobbin, the intensity of the inducing current, etc.; a pretty strong violet light falling upon the balls completely puts a stop to the oscillations.

We know whether the apparatus is working well by the report and aspect of the spark; this spark is formed of very fine and very bright rectilinear strokes, giving rise to sharp crepitations.

The exciter naturally develops in the neighboring conductors alternating induced currents. I established experimentally, in 1880 (Comptes Rendus de l'Academie des Sciences, vol. xci., pp. 408 and 493, 1880), the laws of alternating currents. I showed, in particular, that the circuit seemed to have, instead of its resistance, R (the *true resistance*), an *apparent resistance* equal to

$$\sqrt{R^2 + \frac{4\pi^2 L^2}{T^2}}$$

In actual experiments, in consequence of the excessive smallness of T, the second term of the radical takes an enormous value, before which the proper resistance of the conductor may absolutely be disregarded. And thence arise several necessary consequences which impart to the phenomenon quite a special character.

In the first place, the resistance of the conductor is of no importance; all else being equal, the phenomena produced in a wire will be independent of the nature and thickness of the wire. In the second place, there will be established between two neighboring points of the same conductor, which are separated by an apparent resistance which may be enormous, differences of potential out of all proportion to those that we generally observe. Lastly, that property of variable currents of penetrating only progressively the thick layers of the conductor will be carried to its extreme, and the electrical movements will be solely superficial.

In fact, when the apparatus is working well, as at present, and the oscillations are produced, there is not in the room or in the adjoining apartments any piece of metal, large or small, insulated or in communication with the earth, from which we cannot draw sparks. We see them flash between the two extremities of a wire which we curve into a bow, between two pieces of money or two keys that we bring together; we obtain them, by presenting the point of a knife, from the gas pipes, water pipes, etc.

In order to analyze this phenomenon, M. Hertz uses a wire bent into a ring, the extremities of which can be brought together at will. We observe the sparks which pass between the extremities of the wire, and we judge of the intensity of the phenomenon by the explosive distance and by the brilliancy of the spark. On trying rings with different diameters, we find one with which the sparks take their maximum length; it is then that the period of the electrical movement excited in the wire which constitutes the ring is the same as that of the exciter; the ring acts as resonator. And, in fact, if we take a frame of the same diameter, but in which the wire makes several turns, we obtain much feebler sparks.

With a resonator well in accord, the sparks are from 8 to 10 millimeters in the neighborhood of the exciter; they decrease rapidly when the distance increases, but they are still visible at 15 or 20 meters from the apparatus.

I hoped to render these phenomena visible to an audience by employing a frog, but the frog gives absolutely nothing.

Instead of M. Hertz's ring, M. De Nerville and I have employed a rectilinear resonator composed of rods, formed of two copper wires, placed end to end, the extremities of which bear capacities consisting of sheets of tin (Fig. 2).

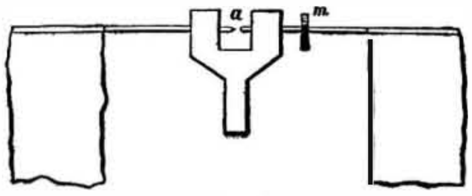

FIG. 2.

We determine by trial the length of the wires and size of the sheets of tin most suited to our purpose. At the interruption, *a*, one of the wires is rounded, and the other cut to a point. The system constitutes a species of micrometer; one of the wires bears a screw thread, and the explosive distance is made to vary by turning the milled head, *m*.

The spark flashes in the space between the two wires. When the exciter is working in the large hall of the laboratory, and the length of the wires and the size of the capacities are well regulated, we observe very brilliant sparks, which attain to 7 or 8 millimeters in the neighborhood of the exciter, and which are visible in all the other halls, in the yard, in the street, and even at a distance of more than 50 meters and through several walls.

This apparatus leads us to a very curious experiment, showing plainly the influence of light on the production of the oscillations. On bringing the resonator near to the exciter, we see that the character of the spark of the exciter changes, and at the same time the spark of the resonator disappears. On interposing any screen whatever, the phenomenon reappears in all its brilliancy. A sheet of glass has the same effect as an opaque screen; but, on the contrary, the interposition of a thin sheet of quartz, which allows a violet light to pass through, does not re-establish the phenomenon. The spark of the rectilinear resonator is at its maximum when the resonator is parallel to the exciter. The spark is ***nil*** when the resonator is in the symmetrical plane of the exciter, but when turned a few degrees, we see the spark reappear.

A stone wall acts in the same way as a transparent plate as regards the undulations, and we can hardly note any difference between the sparks obtained on the different sides of the wall. A metallic plate acts like a glass very slightly silvered; it reflects part of the wave, but lets a very considerable part pass through; thus the sparks are still very appreciable behind a metallic surface formed of a sheet of tin or a plate of zinc of 0·5 millimeter, or even of a plate of iron of 3 millimeters. These figures are simply the thicknesses of the plates tried, and they have no other meaning. It is probable that we should obtain a more complete reflection with plates of greater thickness or greater conductivity.

I come now to one of M. Hertz's fundamental experiments, that which demonstrates in an undeniable manner the existence of the waves in question. It is an experiment exactly analogous to that by which Savart showed the interference of direct sound waves with waves reflected by a wall. The bottom of the hall was covered with plates of zinc, forming a metallic

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* Bulletin de la Societe Internationale des Electriciens, July, 1889.—*Electrical Review.*

† The materials necessary for these experiments were very kindly supplied to us by Messrs. Carpentier and Lemonnier, and by the company for working metals by electricity. I take this opportunity of thanking them for their generous assistance. I must also express my sincere thanks to the young engineers at the laboratory, Messrs. Marganie, Dierman, and Bary, for the help they rendered us throughout.

surface of 4 meters by 6 meters, and the exciter was placed opposite to it at the other extremity.

The vibratory movements provoked by the exciter are reflected upon the metallic surface. By well known mechanism, the reflected waves, interfering with the direct ones, give rise to stationary waves separated by fixed nodes. And, in fact, if we place the resonator very near the wall, we only see faint sparks; they increase when it is drawn away, attain a maximum, then go on decreasing, and finally disappear at a distance of about 2·4 meters, to reappear again. Thus, there is a first node in contact with the wall, as is the case with sound waves when the reflection takes place with change of sign, and a second at a distance of 2·4 meters. The distance corresponds to half a wave length. If we take in the duration of the vibration as calculated above, *i. e.*, 16 billionths of a second, we deduce from it that the rate of propagation is 300,000 kilometers, *i. e.*, that of light.

Thus the vibratory electrical movements, and the vibratory luminous movements, are propagated with the same rapidity. They answer, then, to a modification of the same nature of the same medium. The only difference is in the duration of the period. We can easily obtain electrical vibrations of a billionth of a second, and consequently wave lengths of 30 centimeters. The length of undulation of the visible rays is on an average 0·00005 centimeter; that is, 600,000 times shorter. M. Hertz carried still further the analogy between the two phenomena, and we have repeated the greater number of his experiments. Unfortunately, they are too delicate to be shown in public, and I can only invite the members of the society to come and see them at the laboratory in the Place Saint Charles.* I will now merely indicate the principle of them. An exciter with a very short period is placed according to the focal line of a parabolic cylinder, having a height of 2 meters, with an opening of 1·20 meters.†

The area in which the phenomenon is appreciable, and in which sparks can be obtained with the resonator, is limited by two vertical planes passing through the edges of the mirrors and parallel to the axis of the parabola of the base. We get thus a true parallel electric ray, similar to the luminous ray that would be given by a source of light placed in the position of the exciter. By receiving this ray upon a second mirror, similar to the first, we may repeat the well-known experiment of the two conjugate mirrors, and show that the vibratory movement is concentrated upon the focal line of the second mirror. We may also reflect this ray upon a plane, and show that the angle of incidence is equal to the angle of reflection. We may also make it pass through a prism, show that it deviates toward the base of the prism, and from the deviation deduce the index of refraction of the substance for the electric ray. M. Hertz made this last experiment with a prism of asphalt. This is the only one that we have not been able to repeat, for want of a prism of sufficient dimensions.

The president warmly thanked M. Joubert, and congratulated him upon the charm which he had imparted to his communication upon a subject of the highest scientific interest. He adds that the members of the society ought to congratulate themselves on the fact that their laboratory has enabled these remarkable experiments to be realized.

PUBLIC EXPERIMENTS IN ELECTRICITY.

THE first scientist who drew electricity from the narrow domain of the laboratory and of learned societies was Lemonnier, son of a physicist of influence in the city as well as at the court. His father was one of the principal members of the Academy of Sciences at the time of the discovery of the Leyden jar. Young Lemonnier, who was scarcely thirty years of age, became deeply interested in the Dutch scientist's discovery. In order to ascertain whether the shock of the Leyden jar was communicated to great distances, he conceived a project that does him the greatest honor.

In the middle of the 13th century, Saint Louis had called the Chartreux to Paris and installed them in the Hotel Vaurant, which popular superstition claimed to be haunted by demons, and which was located at the beginning of Rue d'Enfer. The cloister was surrounded by an immense close, which the prior put at the young experimenter's disposal.

Lemonnier began by placing around the cloister two parallel wires six feet apart, and the total length of which was two and a half miles. The close embraced the Bullier gardens, the School of Mines, the School of Pharmacy, etc. Directing an operator to hold one end of each wire in his hand, and taking himself one of the ends in one hand, he with the other hand touched the other wire with the ball of a Leyden jar that had been charged in advance. At the moment the contact occurred, Lemonnier felt a smart shock, which also struck the man who was interposed in the circuit.

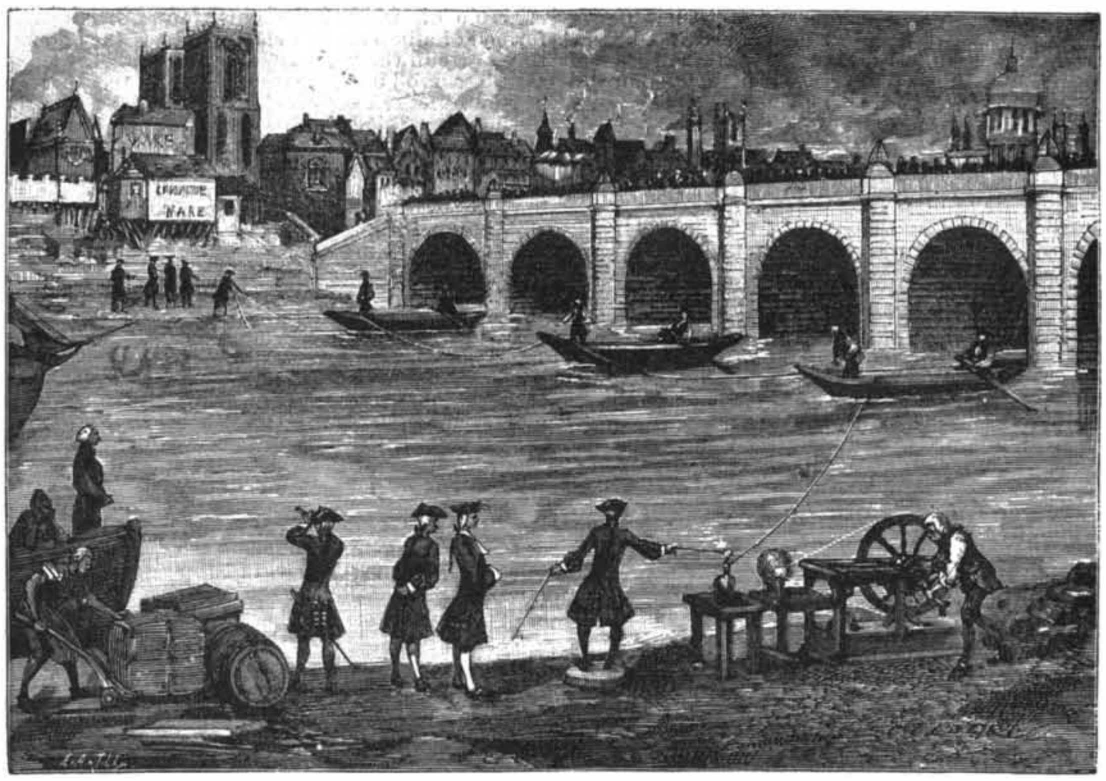
The astonishment which we were witness of at the time of the discovery of the electric telegraph was but a repetition of the wonder of our ancestors. But Lemonnier did not continue in so good a path. He conceived the idea of making the electric fire cross a certain quantity of water. This second operation took place in the great basin of the Tuileries, which Louis XIV. had established in organizing the garden. The arrangement was the same, a wire being carried around a half circumference. Near one of the extremities Lemonnier placed a cork float traversed by an iron pin, which consequently entered the water. Things being thus arranged, he took the extremity of the chain in his left hand, and in his right held a Leyden jar. At the other side of the basin his assistant grasped the chain with his right hand and plunged his left hand in the water. Seeing that his man was at his post, Lemonnier touched the upper extremity of the pin with the jar, and as soon as the contact occurred, both operators received a shock at the same instant. The electric fire had, therefore, traversed a body of water as long as the towers of Notre Dame are high without being extinguished. It is unnecessary to describe here the exclamations that accompanied this experiment.

The history of the progress of electricity is somewhat that of the rivalry of France and England. The Royal Society of London would have thought itself dishonored had it lain still under the blow of this brilliant demonstration. It was necessary to do better. After mature reflection, Watson, who had just obtained the Copley medal, announced that he would pass electricity through the waters of the Thames. The experiment, which is shown in the engraving, and which needs no description, was repeated several times. It was but a repetition of that of our compatriot.

Watson, who was born in London in 1715, where he died in 1787, was one of the physicists who most contributed to the establishment of Franklin's theory and to the victory of Jenner's doctrine. He died after being created a baronet and loaded with honors. His rival was not so fortunate. Louis XV., and afterward Louis XVI., took him for an out-and-out physician, and he was named member of the Academy of Sciences; but, when the revolution came, he escaped by a miracle on the 10th of August. He was completely ruined and was obliged to open a small herbalist's shop at Montreuil, near Versailles. It was by carrying on this little trade that he escaped death by hunger—a kind of punishment still worse than that received by Lavoisier—the scaffold. Vicissitude did not disturb his good humor, and, up to 1799, the epoch at which he rendered the last sigh, he preserved the philosophy of a sage.

One cannot imagine how popular the Leyden jar became in consequence of the experiments just described. Young and old, beautiful and homely, nobles and peasants, everybody wished to take a shock. Then one began to see operators in full blast, and the owners of booths at the St. Laurent fair were seen selling electrization for a few sous. The same was the case at the permanent fair which was called the Boulevard du Temple.

Thus was soon to spring up the cabinet of Abbot Nollet, who was a member of the Academy of Sciences, and a very popular man among philosophers, as may be seen from the following incident: Voltaire, who liked neither electricity nor electricians, twice allowed him an annuity, one of £1,200 and the other of £2,000, as a mark of his esteem. This cabinet was replaced by that of Charles, who is equally well known. To these great scientific establishments must be added that of the aeronant Robertson, which is posterior to them, and which connects them with that of Comte, Robert Houdin, Robins, Cleverman, Dickson, etc.



EXPERIMENT IN ELECTRICITY PERFORMED BY WATSON IN THE EIGHTEENTH CENTURY.

Of all those that are well enough known, we shall say nothing except that electricity played a large part in them; but special mention must be made of the French Museum, which was established at Marais. It is here that Pilatre de Rosier made his debut when he arrived at Paris.

Hydrogen having just been discovered, the bold Messin conceived the idea of filling his lungs with it and setting fire to it, and thus to cause a flame to issue from his breast. It is a trick that fakirs sometimes perform, but is not unattended with danger. In one of these performances Pilatre allowed the flame to reenter, and there resulted an explosion which broke two of his teeth.—*La Nature.*

A SUMMARY OF THE DIFFERENCE BETWEEN POSITIVE AND NEGATIVE ELECTRICITY.

IN a recent number of *La Lumiere Electrique*, M. Decharme sums up in the short article following the principal differences which have been shown to exist in the behavior of positive and negative electricity:

It has been shown by Wachter, in the *Journal de Physique*, that "in a conductor of high resistance the section which is at a mean potential is not symmetrical with respect to its two terminals, and that the higher the resistance of the conductor, the nearer to the negative terminal is this point of mean potential." With regard to mechanical effects, it is evident by Lichtemberg's figures, pierced cards, etc., that in discharges of static electricity solid or liquid substances are generally carried toward the — pole and away from the + pole, or, at any rate, more abundantly in this direction than in the other. The action of electrified points on flames may be summed up by saying that negative electricity attracts and positive electricity repels them. An electrified flame is also more powerfully attracted than a flame upon which it induces electricity. It is also well known that there is a decided difference of temperature in the poles of the voltaic arc. In air the + electrode is heated to incandescence, while the — electrode is at a lower temperature.

On the other hand, if the arc is struck in highly rarefied air, the — electrode attains the temperature of melting platinum, while the + electrode is relatively cool. If one of the electrodes is pointed and the other flat, the point becomes entirely incandescent if it is positive, but it only becomes hot at its extreme tip if it is negative. M. Semmola has devised a very striking experiment to show this phenomenon in an indirect way. He uses a fine point, made of bismuth and antimony, and thus forms a thermo-electric couple. If this point is connected to the conductor of an electric machine, a galvanometer placed in the circuit immediately shows the rise in temperature of the point, and especially so when the point is negative.

When a rather long electric spark takes place across an air gap, it sometimes spreads out near the middle, always, however, closer to the — pole than to the + pole. When the gap is lengthened, the spark frequently assumes an arborescent character, and it is observed that the lateral branches are all directed toward the — pole, showing clearly that there exists an electric tension in the body of the spark itself. Moreover, when wires are fused by an electric discharge, the fused metal is projected laterally. The hook-like shape of the electric spark obtained from the rheostatic machine of M. Gaston Plante shows that the electricity coming from the + pole meets the electricity coming from the — pole at a point close to the latter. Photographs of sparks exhibit curious differences, characteristic of the two electricities. In 1877, M. A. Righi published a lengthy memoir, entitled, "Ricerche Sperimentali sulla Scariche Electriche," in which are given numerous illustrations of the electric spark, copied from photographs taken under different conditions by the author. The characteristics of the two discharges are here clearly delineated; the positive discharges being spread out, the negative being more concentrated. The same memoir also contains an illustrated description of the various forms taken by the electric spark in air and liquids, showing most perfectly the difference in shape and color presented by the two electricities.

As to the induction spark, it consists of two streams and an aureola. In air, at ordinary pressure, the positive and negative brushes display differences arising from the inequality of potential at the moment of discharge. These differences become less accentuated as the air becomes more rarefied. The hook-like brush shows the same peculiarities as the spark. In a partial vacuum the difference between positive and negative electricity is very marked by the color of the glow around the two poles, by the shape of this glow, and above all—and this more especially when an induction coil is used—by the presence of striæ. These phenomena are much affected by the medium. In a complete vacuum the purple glow seems to move in the same direction as the positive discharge.

Another fact not less important, which ought to be kept in mind, is that in vaccuum tubes and with sufficiently powerful E.M.F.'s, the striæ are always turned in the same direction with the convex side toward the — pole. This phenomenon is analogous to that which is presented where a gas makes its way through a liquid, which it never does in a continuous stream, but always in bubbles more or less large according to the pressure. In the same way electricity, when it penetrates a gaseous medium more or less rarefied, does not pass through it in an unbroken stream, but in a vibratory manner. In this way perhaps the phenomenon of striæ can be explained mechanically, for it is produced with continuous currents as well as with intermittent or alternating currents.

In air at ordinary pressure we can say, so far as regards potential, loss of charge, and propagation, that negative electricity is always at a lower potential than positive electricity, that a negative charge is more rapidly dissipated than a positive, that negative electricity is more easily propagated than positive. The contrary holds good in a disruptive discharge, when positive electricity has the greater tendency to discharge through the air. In rarefied air these differences disappear, whether high potentials or large currents are employed. There is, therefore, nothing ab-

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* An extra *seance* took place at the Place Saint Charles on Friday, July 12th, for the repetition of these experiments.

† We are indebted for these mirrors to the kindness of M. Lemonnier.