ELECTRICAL NEWS.

Hertz's Researches on Electrical Oscillations.[1]

IN reading Faraday's "Experimental Researches on Electricity," one finds many experiments described in which that philosopher attempted to show that some relation must exist between natural phenomena which had been considered as having no connection with one another. He tried to prove that gravitation could produce magnetic or electrical effects; and although he failed, yet at the end of the research he expressed his belief that some connection existed, and would some day be discovered. But he did find that a magnetic field had an effect upon polarized light passing through it, and this discovery has been developed until Maxwell advanced the hypothesis that electrical vibrations may be propagated through space according to the same laws that govern the propagation of light, and with the same velocity; and now the theory of Maxwell has been experimentally verified by Hertz. The evidence in favor of Maxwell's theory, before Hertz published his work, lay principally in the facts that the equations of propagation of an electro-magnetic disturbance were practically those which have been deduced for light, and which have explained a number of the phenomena that take place. The velocity of such a disturbance is equal to a constant which can be determined electrically, and which agrees very well with the observed velocity of light; while a relation between the specific inductive capacity, determined electrically, and the index of refraction of a substance, agrees fairly well with that deduced from Maxwell's theory. Hertz has added to this evidence a proof — indirect, but fairly conclusive — that the "electrical displacements" in a dielectric, on which rests much of Maxwell's theory, really exist; that actual electro-magnetic waves are reflected and interfere with one another; and that the velocity of such waves is about what is calculated. We will describe Hertz's experiments as clearly and briefly as possible, referring those who desire a detailed description to Hertz's and De Funzelmann's papers.

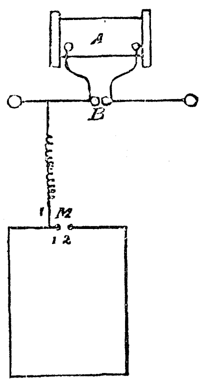


FIG. 1.

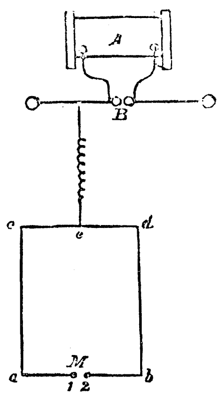


FIG. 2.

In the first place, it was necessary to produce electrical oscillations of a very small period. Roughly, the period of a light-wave is 10^{-15} of a second, and we know of no way of producing electrical oscillations, on a conductor of finite size, of any thing near so rapid a period. When Hertz took the matter up, the most rapid oscillations that had been experimented upon were those caused by the discharge of a Leyden jar through a resistance, the period being about 10^{-6} of a second. Theoretically a much shorter period would be obtained with conducting-wires forming an open circuit, the ends having small knobs on them; and this is the form Hertz first experimented on, his object being to discover whether measurable oscillations were really produced. The period in this case should be some hundred millionths of a second, — 10^{-8} as compared with 10^{-15} for light. The general arrangement of the apparatus is shown in Fig. 1. Here *A* is a large induction-coil, with the wires *B* fastened to the terminals of the secondary circuit. The coil Hertz used was a large one, 52 centimetres long by 20 centimetres in diameter, and it was run by six large Bunsen cells.

When the coil is working, there are sparks between the knobs *B;* and, when one of these sparks passes, we have the case of the discharge of conducting-wires forming an open circuit; and this will cause rapid oscillations along the wires, which will diminish in amplitude until they are re-enforced by another discharge. To observe these disturbances, Hertz arranged a circuit, shown in Fig. 1 at *M*. This was simply an open circuit of wire, with two adjustable knobs, 1 and 2. On connecting this "micrometer" circuit to one of the wires *B*, the connection being as shown in Fig. 1, sparks, sometimes several millimetres long, passed between 1 and 2.

The reason of this is, that the rapid and violent oscillations on *B* are transmitted to the knob 1, sometimes causing a high and sometimes a low potential at that point. Now, if it takes a finite time for this disturbance to travel around the circuit *M*, then there will be for a short time a considerable difference of potential between 1 and 2, and this causes the spark. With the connection to *M* made as in Fig. 2, the distances of *e* from 1 and 2 being equal, then the disturbance reaches these points at the same moment, and there is no difference of potential between them, and therefore no spark. This is what Hertz actually finds.

Some of the facts that Hertz obtained were these: In the first place, the effect in the micrometer circuit depends on the shape of the terminals *B* and on the nature of the spark: the material and size of the wire of the micrometer circuit has very little influence on the spark. If, when the contact is at *e* (Fig. 2), a conductor be joined to one of the knobs 1 or 2, then the spark re-appears.

This last, Hertz thinks, shows that the phenomenon cannot be due to single waves in the directions *ca* and *db* respectively, but must be due to a series of oscillations set up in the micrometer circuit; and the addition of a conductor to one of the knobs changes the period of vibration of that branch, the periods being determined by the product of the coefficients of self-induction into the capacities of the branches. The fact that the material of which the circuit is made has no effect on the spark, tends to show the same thing; namely, that the phenomena in the micrometer circuit are dependent upon self-inductions and capacities, that is, upon time-constants.

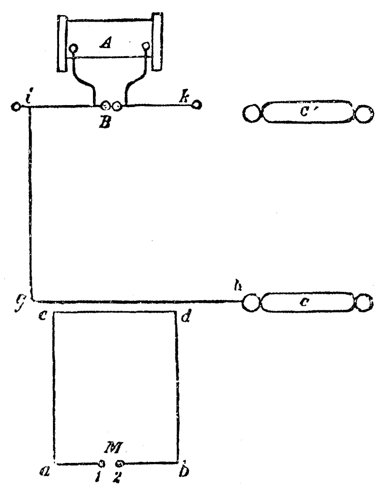


FIG. 3.

To further prove the oscillatory character of the discharge, Hertz used the arrangement of Fig. 3. Here the micrometer circuit was placed with one of its sides parallel to the wire *igh*, which was connected to one of the discharge wires *B*. The sparks at *M* were very feeble until a conductor, *C*, was attached to the free end, *h*, of the wire, when they increased to two millimetres. No effect was produced when *C* was attached at *g*. When the knobs at *B* were so far apart that no sparking took place, the sparks at *M* also disappeared, which showed that they were due to the sudden discharges, not to the charging current. While *C* was attached to *h*,

[1] Hertz's original papers are in Wiedemann's Annalen, 1888. Mr. G. W. de Funzelmann has given an excellent *résumé* of Hertz's work in the London Electrician, Nos. 539 545, 547, 548.

and the knobs at M drawn so far apart that the sparks only passed singly, then if a similar conductor, C', be brought up to k, a stream of sparks was immediately observed. This action of C' could only be explained by supposing the current in gh was oscillatory.

The reason that a powerful induction-coil gives rise to oscillatory motion is, that, first, it charges the terminals C and C' to a high potential; second, it produces a spark in the intervening circuit; and, third, as soon as the discharge begins, the resistance of the air-space is so much reduced as to allow of oscillatory motion being set up. If the terminal conductors are of very large capacity (for example, if the terminals are in connection with a battery), the current of discharge may indefinitely reduce the resistance of the air-space; but, when the terminal conductors are of small capacity, this must be done by a separate discharge, and therefore, under the conditions of Hertz's experiments, an induction-coil was absolutely essential for the production of oscillations.

Hertz slightly modified the form of apparatus used to that shown in Fig. 4, where the conductors C and C' were in the same straight line, three metres apart, with the discharger B at the centre. With this arrangement, sparks were obtained in the micrometer circuit when its distance from CBC' was one and a half metres. Hertz replaced the micrometer circuit shown in Fig. 4 by another, which

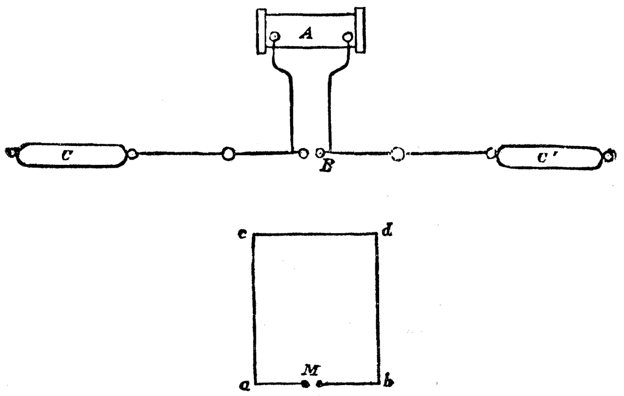


Fig. 4.

consisted of two wires parallel with CBC', with knobs at their ends, there being a micrometer, M, at the middle. Sparks were obtained at the micrometer, as with the other form of circuit. When the knobs at B were drawn so far apart that there was no spark between them, there was still a spark at M due to the electrostatic effect of charging C and C'. By bridging across M with a damp thread, this effect was got rid of; but, when there were sparks at B, there were sparks at M, even with the thread. So the thread was sufficient to afford a passage to the comparatively slow alternations of the coil-discharge, but was not sufficient to provide a passage for the immeasurably more rapid alternations of the oscillatory current.

If there really are oscillations of the nature of a regular vibration, then an oscillatory current of a definite period would exert a much greater inductive effect upon one of equal period than upon one differing from it; that is, we ought to get resonance phenomena from currents, as from sound-vibrations. If two circuits are taken having as nearly as possible equal periods of vibration, the effect of one on the other will be diminished by altering either the capacity or coefficient of self-induction of one of them, as a change in either of these would alter the period of vibration of the circuit.

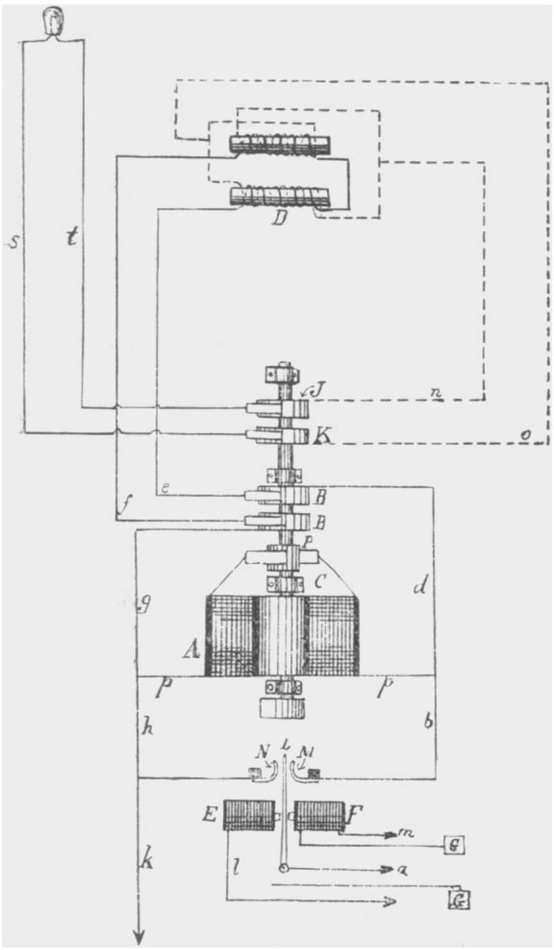
(To be continued.)

Another Electric Road at Atlantic City, N.J. — We take great pleasure in announcing in this issue of our paper a most important indorsement of the electric system of street-railway propulsion. This indorsement comes from the Pennsylvania Railway Company, who have during this last week, through the general managers of that company, closed a most important contract with the Sprague Electric Railway and Motor Company for the complete equipment of their system of electric street-railways at Atlantic City, N.J. Before awarding this contract for the equipment of this road, the Pennsylvania Railroad appointed a committee who should have charge of making a most minute and careful investigation of the merits of all the different systems of street-railway propulsion, both electric and cable, now in use. The committee in charge of the investigation were composed of mechanical and electrical experts of the highest class, and of wide reputation. The period of investigation extended over five months, and during this time the committee visited all the principal electric railways and cable roads which are in operation in this country, and carefully examined the operation of each. The Sprague Company are certainly to be congratulated upon securing this contract.

West End Electric Road at Boston. — The West End Electric Railway at Boston is running very successfully, and carrying a large number of passengers each day between Park Square (one terminus of the road) and Brighton (the other terminus of the road). The cars run fast, and are under quick and perfect control. The residents in Brookline who use the cars regularly in coming into Boston and returning are enthusiastic over the time saved over the ordinary horse-car. The change of the overhead to the underground system is made very quickly, and without stop, so that no delay is experienced at this point. The car-drivers, or "motorneers," as some Bostonians persist in calling them, are not expert electricians, but simply street-car drivers, who have been detailed to operate the electric cars, and who have learned their necessary duties very quickly. All of these old drivers are enthusiastic over the ease with which an electric car can be driven, and are well pleased with their new position. On the 20th of January a very heavy snowstorm reached the city, and covered the tracks of the railway to the depth of from two inches to a foot. The electric snow-ploughs, which are being equipped by the Sprague Company for use by the West End Road, had not been finished, and the cars were obliged to run without this aid for clearing the tracks. In spite of this, the cars ran very successfully over the entire distance of the roads, clearing their own way, and carrying large numbers of passengers. The president of the road and the directors expressed themselves as well pleased with the demonstrated efficiency and strength of the electric road, as exhibited during the snow-storm, even without the aid of the regular Sprague electric snow-ploughs. The *Boston Herald*, in an editorial of Jan. 17, in commenting on the road, said, "Those who have made the experiment of taking a ride on the new electric railway on Beacon Street must have come to the conclusion that this method of securing rapid transit in the suburban wards is one of the most promising that has yet been brought forward in this city. The speed attained, where the conditions are favorable, is quite equal to that of the elevated railroads in New York City, while the structures supporting the electric wires are by no means as much of a disfigurement as it was at one time supposed that they might be." So long as a mixed service is maintained, — that is, so long as some of the cars are drawn by horses, — the full advantage of the electric system cannot be realized. The speed of the electric car has to conform to the speed of the horse-car which may be in front of it; but, if the experiment proves as successful as there is now every reason to think that it may, the West End Company will before long feel compelled to substitute electric for animal power in the service of all of its lines. When that change is brought about, the speed that can be made, even in the centre of the city, will be very much accelerated over the average speed of to-day.

A Southern Electric Railway started. — During the past week the Asheville Electric Street Railway, which has been in course of construction for the last month under the Sprague Electric Railway and Motor Company of New York, was successfully put in operation. The first trial trip of the motor-cars was made on Jan. 21, in presence of the president, Mr. W. P. Penniman, jun.; superintendent, Mr. J. H. Barnard; and a number of prominent citizens, — Capt. T. W. Patton, Gen. Jonstone Jones, Dr. S. D. Pelham, and about sixty others; some being stockholders in the road, and others interested, directly or indirectly, in the success of the enterprise. The test proved a great success. The run was made over the entire distance of the line, about two miles, in less than eight minutes, carrying a large number of passengers. The citizens of Asheville are enthusiastic over the new electric line, and the directors of the road express themselves as very well pleased with the successful performance of the motor-cars.

A NEW SYSTEM OF ELECTRICAL DISTRIBUTION. — One of the problems which has claimed the attention of inventors in the past few years has been the conversion of high-tension to low-tension electric currents. The object is to distribute electric energy at a high potential, using comparatively small wires, and at the points of consumption to reduce the potential to that demanded by safety and the requirements of incandescent lighting. A large part of the cost of an incandescent electric plant is in the wires used for distribution; and the size of the wire required to distribute a given amount of energy varies inversely as the potential used. One of the most successful converter systems is that



THE DICKERSON SYSTEM OF ELECTRICAL DISTRIBUTION.

used by the Westinghouse Company, where alternating currents are employed, and the reduction is effected by transformers, — induction-coils working backward. But there are some disadvantages in the use of alternating currents, and many attempts have been made to invent a continuous-current converter, that will do for continuous what the transformer does for alternating currents. Storage-batteries would offer an ideal method of effecting this, but for their cost and depreciation. Several mechanical methods have been tried, among others a motor-generator arrangement, — a combined motor and dynamo, the former supplied from the high-potential circuit, the latter supplying current at a low potential to the local circuit. Other plans have been proposed in which the main circuit is interrupted and advantage is taken of its inductive effect on the secondary circuit. None of these systems, however, are in successful operation on a large scale. Mr. Edward N. Dickerson, jun., of this city, received last week (Jan. 22) a patent on an improvement in his method of converting high-tension into low-tension currents. Feb. 14, 1888, a patent was granted Mr. Dickerson for a method of converting a direct high-tension current into an alternating low-tension current; and by his recent improvement he is able to obtain a continuous low-tension current, which is a considerable advantage if the resulting current is to be used for a motor or for electric plating. The accompanying figures will make it clear how this result is obtained. A high-tension current flows out upon the circuit a, and returns to the generator by the circuit k. By the switch L it passes through the motor C. On the shaft of this motor is arranged the double reversing-commutator BB, the sections of which are alternately connected with the circuit d and with the circuit g. The current upon the circuits ef is a high-tension reversing current, and operates the converter D, which converts the reversing high-tension current into a reversing low-tension current. This induced alternating current passes to the reversing-commutator JK, by which the reversing currents are rectified. It is of course essential that the two commutators shall move synchronously, and the commutator JK should be so adjusted on the shaft as to allow for the time required by the converter. The switch EF may be omitted; but by it it is possible to throw any house into circuit from the central office.

THE WESTINGHOUSE AND UNITED STATES COMPANIES.— An agreement is reported between these companies whereby their interests are united. The United States Company is one of the oldest electrical manufacturing companies, and has a large factory in Newark, N.J. The Westinghouse Company was already the lessee of the Consolidated and Sawyer-Man Electric Companies of New York, and the owner of the Waterhouse Electric Company of Hartford, Conn., and the Tesla Electric Light and Manufacturing Company of Rahway, N.J. The new combination has a manufacturing capacity of over 15,000 lamps a day, and the two companies own and control about 700 patents in every branch of electrical invention.

NOTES AND NEWS.

IT is announced that a post-graduate department in electrical engineering will soon be established by the trustees of Columbia College, this city. A beginning will be made upon an economical scale, and the facilities will be increased in proportion to the patronage, which it is believed will increase rapidly, as New York is a city in or near which all or nearly all of the many applications of electrical science may be studied in practical operation. The course will be open to graduates of all scientific schools.

— An electrical exhibition will be held in the Chicago Exposition Building, in connection with the National Electric Light Association Convention on Feb. 19, 20, and 21. Many exhibiters have already secured space, the electric railway companies being especially forehanded in that respect. The exhibition, though not intended to be of long duration, promises to be interesting and important.

— The *Journal of the Society of Arts* reports the discovery of a new textile on the shores of the Caspian. This plant, called "kanaff" by the natives, grows in the summer, and attains a height of ten feet, with a diameter varying from two to three centimetres. By careful cultivation and technical manipulation, M. O. Blakenbourg, a chemist and engineer, who has made a special study of kanaff, has obtained an admirable textile matter. It is soft, elastic, and silky, gives a thread which is very tough, and can be chemically bleached without losing its value. The stuffs manufactured out of kanaff, and then bleached, can be successfully dyed in every shade of color, and would compete with any of the ordinary furnishing materials now in use. But it is particularly for making sacks, tarpaulin, ropes, etc., that this new textile, from its cheapness and its extraordinary resisting power, might defy all competition. Its specific weight is much less, but its resistance much greater, than those of hemp. Thus, a cord of 8.25 millimetres diameter, woven with the hand out of three threads of kanaff, requires a weight of 180 kilograms to break it. A cord half an inch thick, manufactured at Moscow, did not break till the weight of 625 kilograms was reached. When it is considered that Russia annually consumes more than one hundred and fifty millions of sacks, a third of which are imported, it may be easily seen that the appearance of this new textile on the Russian market is an event of no slight importance.