XLI. *Experiments on the Electromagnetic Action of Dielectric Polarization.* *By* Prof. W. C. RÖNTGEN*.

THE theory of electrical and magnetic phenomena proposed by Faraday and elaborated by Clerk-Maxwell, is based upon the assumption that in insulators bounded by electrified conductors there exists a dielectric polarization or displacement—a change which, in whatever way produced, exerts electrodynamic effects exactly like an electric current flowing in a conductor.

* Translated from the *Sitzungsberichte der Berliner Akad. der Wissenschaften* for February 26, 1885.

Helmholtz has shown that none of the consequences of this assumption are opposed to the fundamental laws of mechanics, and that this assumption, together with the extended law of potential, affords a complete explanation of the phenomena presented by closed and by so-called open conductors.

So far as I know, however, no direct experimental proof has been given of the correctness of the assumption of Faraday and Maxwell; and I have for several years had the intention to fill this gap when the opportunity presented itself. After many fruitless attempts I have at last been successful in finding a method which yields practical and decisive results, of which I venture here to give an account. A good insulating disk of ebonite, 0·5 centim. thick and 16 centim. diameter, was mounted upon a vertical axis, which by means of a string could be put into rapid rotation (120 to 150 revolutions per second) in a horizontal plane. Beneath the disk and parallel with it was placed a perforated glass plate of 17·5 centim. diameter, provided with two half-ring coatings of tinfoil: the inner radius of the rings was 2·25 centim. and the outer radius 7 centim.; the portion cut out between the two half-rings was 1·4 centim. wide. Above the ebonite disk also was fixed a second horizontal glass plate of 21·5 centim. diameter, which was completely coated with tinfoil. The tinfoil coatings of the two glass plates faced the ebonite disk, and were at a distance from it of about 0·1 centim.; the coating of the upper plate was permanently connected to earth. Either of the half-rings could be placed in connection with the inner coating of a large Leyden jar, so that the one became positively electrified, and the other at the same time negatively. A commutator permitted the electrification to be changed.

It will now be understood that the dielectric polarization produced in the rotating ebonite disk by the electrification of the tinfoil coatings changes its sign at the point where the interval between the coatings occurred. Upon the one half of the disk (say the front half) the particles moved from the positive towards the negative half-ring, and a displacement of positive electricity took place while they passed from the one half-ring to the other, which would have a vertical component tending downwards. At the same time on the other (hinder) half of the disk, there would be a vertical component tending upwards. These displacements lasted as long as the disk rotated with unaltered electrification; and they must therefore, according to the theory of Faraday and Maxwell, produce the same electromagnetic effect as continuous currents, which, for the direction of rotation assumed, would circulate downwards in the front half of the disk, and upwards in the back half. The question is, then, whether these vertical components do actually exert such an effect.

In order to determine this, the upper glass plate was surmounted by a metallic case, connected to earth, which contained an extremely sensitive astatic pair of needles; the lower needle was about 0·6 centim. distant from the ebonite plate, its centre being in the prolongation of the axis of rotation of the disk, and its direction parallel to the dividing-line of the two half-rings; the length of the needle was about 4·8 centim., a little more than the inner diameter of the half-rings. The second needle was situated 21·5 centim. above the lower one. The deviations were read by means of a telescope and scale at a distance of 3 metres. All the necessary precautions were taken that the needle should not be affected by external statical electricity; and a special construction of the axis was adopted so that the deviations produced by rotational magnetism should be as small as possible (2 to 3 divisions of the scale). Notwithstanding, upon rapid rotation of the disk the needle changed its position of rest continually, which made the observations much more difficult. The reason of these motions lay, as I satisfied myself, in currents of air, and more particularly in small vibrations to which the apparatus was exposed, in consequence of the defective arrangements of the Institute here.

The experiments were arranged so that one observer sat at the telescope whilst an assistant revolved the disk, and another changed the commutator upon a signal from the observer.

The observer intentionally remained ignorant of the direction in which the commutator was moved until the end of the series of experiments; generally the commutator was changed eight times during each series of experiments. There was no possibility of accurately determining the magnitude of the deflection produced by reversal of the commutator, since in all cases it was very small and under the best conditions only amounted to 1·5 division of the scale, generally amounting only to a fraction of a division. The observer therefore confined his attention to determining the direction of the deflection each time, and for this a certain amount of practice was necessary in consequence of the continual small motions of the needle. As the result of more than 1000 observations I have obtained so much practice that in the later experiments I have been able almost without mistake to determine every time the direction of deflection.

From these experiments, which were varied in many ways, the result was obtained that the deflection always agreed with that given by Faraday's theory. The change in the dielectric polarization consequently exerts an electromagnetic force, exactly like an electric current flowing through a conductor in the same direction in which the displacement of positive electricity in an insulator takes place.

The complete description of the experiments here briefly described, as well as of the numerous experiments made for the purpose of excluding all possible deception, will be given elsewhere.

I am now occupied with the construction of a piece of apparatus upon the same principle, which I hope will possess fewer defects and will be capable of producing greater deflections than those described. Also I intend to put to experimental proof some other of the consequences of Faraday's theory.

In conclusion, it should be mentioned that with the suitably arranged apparatus I have repeated Rowland's experiment described by Prof. Helmholtz as a test of its sensitiveness. The ebonite disk without coatings was charged by means of points. Upon reversal of the electrifications a deflection of 8 to 10 scale-divisions took place each time.