ART. XII. — *Radium and the Electron Theory*; by JOHN TROWBRIDGE and WILLIAM ROLLINS.

THE mechanism of electric conduction through metals continues to be one of the greatest mysteries of electricity; and there is no plausible explanation of it unless we accept the theory of electrons. This theory, as is well known, supposes the existence of small bodies called electrons, which move between the molecules of the metals during the passage of an electric current. It has been much developed by Drude.*

The theory seems to bring the electrical conduction in metals into close touch with conduction in gases; for in both cases we suppose a movement of small particles. These particles have a greater free-path in rarified gases than they have between the molecules of a metal, and their action is much modified by the X-rays. This modification is usually attributed to a species of ionization due to a physical connection between the energy emitted by the X-rays and the transformation of energy witnessed in the rarified gas. A Geissler tube, for instance, which will not permit the passage of an electric current, when the degree of exhaustion is beyond the point of breaking down with the electromotive force employed, is made conducting when the X-rays fall upon it.

We mention this fact in order to give a significance to our experiments with radium. This remarkable substance, also, in common with the X-rays can affect by what we call ionization, the conduction of electricity through gases. The X-rays and certain emanations of radium can also pass through thin sheets of metal, especially sheets of aluminium. We are, therefore, for the first time in the history of electricity, in a condition to test the question, whether radiant energy exhibiting light and passing through a metal can affect the passage of a current of electricity.

In this connection one is immediately reminded of Faraday's attempt to discover whether ordinary light is modified in passing through an electrolyte which is submitted to the action of a current of electricity. He thought that there might be a state of tension which could be detected by polarized light; and he therefore passed a beam of polarized light in the direction of the current and also at right angles to this direction. The result of the experiment was negative; absolutely no effect was observed. Faraday's custom of publishing both positive and negative results has its advantages, especially in the early days of a science; and particularly when it shows us

* Ann. der Physik., No. 1, 1900.

the working of a great mind groping in a region not yet submitted to calculation. Lesser minds must, however, use caution in publishing negative results; for due regard must be had for brevity of publication and the limits of experimentation.

Can we not, however, imagine Faraday continuing his efforts to discover some connection between the passage of light through an electrolyte or a conductor and the passage of a current of electricity, if he could penetrate such a conductor by light. In other words, might he not have been tempted, if he had had command of the X-rays or radium, to discover some action of the energy emitted by the new and wonderful manifestations on a current? Apart, however, from such a view of the working of the great physicist's mind, can we not get a foothold in mounting to the heights of the electron theory by endeavoring to show that the X-rays or the emanations from radium do or do not have a discoverable action upon the passage of an electric current, through aluminium for instance?

It must be premised that no mass is ascribed to the electron. Its supposable inertia is due to self-induction, and perhaps it should not be called a body. On this conception it does not seem probable that particles shot off from radium, or ions resulting from the radiation of X-rays, could influence such immaterial bodies. Nevertheless our view of the electron theory might be influenced by proceeding to an actual test, and by looking at the results and limitations of possible experiments. We therefore experimented as follows:

A meter of aluminium wire No. 24 was wound in five turns around a thick sheet of lead which was eight centimeters in length and one centimeter in width. The wire was wound around the longest dimension of this shuttle-like piece of metal, and was insulated from it by thin sheets of vulcanite. The electric current, therefore, passed in one direction along the upper layer of the wire, and in the opposite direction along the lower layer. The lead, intervening between the upper and lower layer, could serve to confine the radiations from suitably placed radium either to the upper or the lower layer of wire. The lead shuttle with its layer of wire was enclosed in a lead cylinder and a specimen of pure radium bromide was enclosed at one end of the layers of wire so that its emanations could sweep along the upper or the lower layer of this wire. A lead diaphragm could be used to shut off the entire effects of the radium from the wires.

The wire was made one branch of a Carey-Foster bridge; a suitable key made it possible to reverse the current through the aluminium wire, and after adjustment the wire was exposed to the radiations from the aluminium under the varying conditions of reversals of current; radiations confined to the lower layer

and afterwards to the upper layer. The bridge was competent to detect a change in resistance of one hundredth-thousandth of an ohm. On account of the difficulty of distinguishing between a heating effect and what may be called an electrodynamic effect, the observations occupied a comparatively short interval of time. No instantaneous effect was observed: a very slight creeping deviation of the galvanometer mirror came after a considerable interval of time, which might have been due to change of temperature. It could not be ascribed with reason to the presence of the radium.

The light from the radium could be seen through a slab of iron an inch thick; yet this manifestation of energy passed through the aluminium without any apparent effect upon the mechanism of the electric current. Should we reason, therefore, from this negative experiment that the theory of the immaterial electron is supported, or that a theory of dissociative effect on gases between each molecule of the metallic conductor under the effect of a current is also negatived: for the radium emanations, like the X-rays, can produce this dissociative effect in the passage of electricity through gases?

Mr. McKay, graduate student working in this laboratory, has endeavored to detect the effect of the X-rays in changing the apparent resistance of thin films of metals. The effect, if it exists, is extremely small. He, however, is still continuing his work upon this subject.

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