ELECTRODELESS RING DISCHARGE—MAGNETIC, INDUCTIVE, AND CENTRIFUGAL ACTION

BY

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The electrodeless discharge was first studied and exhibited in England some forty years ago. Since then many contributions have been made by physicists and physical chemists throughout the scientific world.

MAGNETIC STUDY

Considerable attention is again being directed to the rôle of the two fields—electrostatic and magnetic—in the production of the discharge within the tube. In March[1] of this year the writer published a number of photographs showing the relative intensities of the magnetic and electrostatic illumination components in the electrodeless discharge produced in a specially designed tube. The method used was to place obstructions in the path of the discharge and from the shadows cast, inferences could be drawn as to which field was responsible for the most intense illumination and, hence, for the discharge. Figures 1 and 2 are photographs showing the two types of discharge. When the time of exposure is taken into account the photographs obtained (only two are here reproduced) show in every instance that the discharge (at any rate that responsible for the most intense illumination) was due to the magnetic field. This experimental result seems to support the view set forth by Sir. J. J. Thomson.

INDUCTIVE STUDY

Another phase of the experimental study of the electrodeless discharge was undertaken by J. K. Knipp and the writer. The measurements contemplated were not, at this writing, completed, although the investigation had been carried far enough to warrant inclusion in this summary. It has long been a question as to what magnitude the current might rise in the electrodeless discharge. Theoretical calculations of this current have been attempted by several investigators, but

[1] Knipp, C. T., Phys. Rev., vol. 37, No. 6, Mar. 15, 1931.

...nental method seems to have been devised. The ... ...ein described is simple and direct.

It is clear that an inductive method in which the gaseous cur... would serve as the primary could not be used, since its effect on the secondary would be completely masked by the inductive effect of the energizing coil. This difficulty has been overcome by piping, so to speak, the gaseous current aside through a tube where it is bent into a coil of two turns and then returned to the initial coil which consists of three turns. The circuitous path formed by the re-entrant tube was thus continuous. Figure 3, which is a photograph taken while the dis-

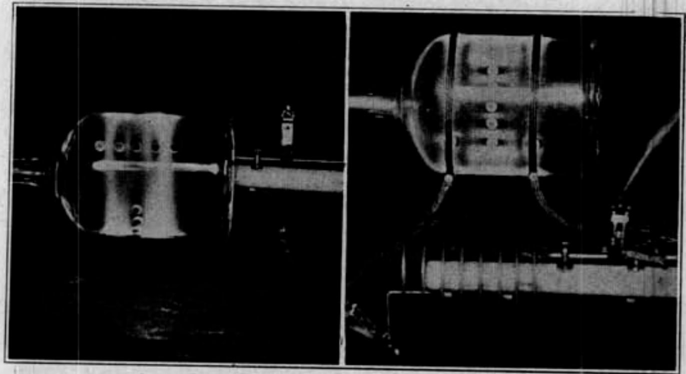
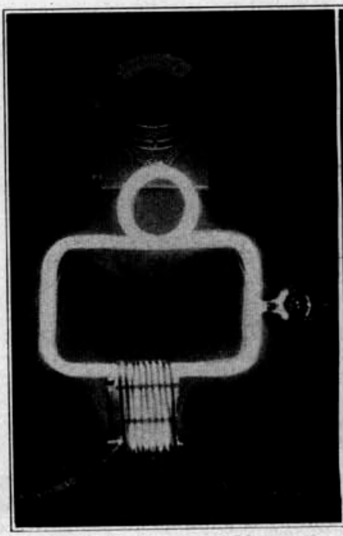


FIG. 1. *(Left)* Electrodeless ring discharge completely formed when an energizing coil of 8 turns was placed inside the vessel. Illumination intense white; time of exposure 6 seconds followed by a photoflash. Shadows due to obstructions plainly show the path of carriers. No electrostatic effect visible.

FIG. 2. *(Right)* Electrostatic discharge only. The band electrodes were placed on outside of vessel as shown and looped across a coil of 8 turns. (This coil was placed on the inside of vessel in Fig. 1.) Illumination a faint purplish-red glow; time of exposure 130 seconds. The direction of the electrostatic field is clearly shown by the shadows cast. The dark region parallel to each electrode is Crookes dark space. Overhead lights to finish exposure.

charge was passing, shows the relative positions of the two glass coils of the discharge tube. The figure also shows the energizing coil (the primary) carrying the high-frequency current surrounding the electrodeless discharge tube (the secondary) with their planes parallel and at right angles to the plane of the paper. This secondary is not reentrant within the exciting coil, but as stated above, is piped aside and the loop into which it is shaped is given a turn of ninety degrees, as shown, placing its plane in the plane of the paper. This glass coil carrying the gaseous current becomes the *primary* of a low-resistance secondary of one turn of a copper braid conductor placed around it, the terminals of which, in turn, were connected to a radio ammeter as shown in figure 3.

…n this arrangement the ammeter, on excitation of the …discharge, read 4.8 amperes. This magnitude came as a surp… As the resistance of the secondary (the ammeter circuit) was exceedingly low it is safe to assume that its readings represented quite accurately the gaseous current flowing through the reentrant discharge system. This, as the gaseous current made two turns and the copper secondary but one, would be approximately 2.4 amperes.



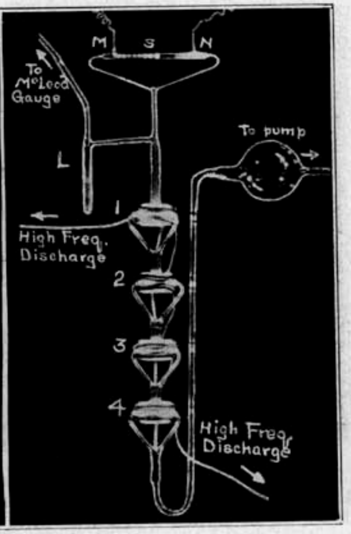


FIG. 3. *(Left)* Electrodeless discharge in a reëntrant discharge-tube formed by an energizing coil of 9 turns. Secondary within energizing coil consisted of 3 turns of glass tubing which led out through the rectangular shaped circuit to a glass coil of 2 turns. This coil carrying the gaseous current formed the primary, the secondary of which consisted of one turn of heavy copper braid conductor connected to the radio ammeter as shown. The ammeter shows 4.8 amperes. Time of exposure 6 seconds, followed by a photoflash. The pump connection is shown at right.

FIG. 4. *(Right)* Special tube to show centrifugal action in the electrodeless ring discharge. Four units are connected in series. The magnification factor is thus four times the effect produced by one unit. The discharge tube MN shows the striae. When the high frequency discharge was turned on the striae at MN moved apart and receded toward M, indicating a reduction in pressure in MN as was expected. Exposure 6 seconds, followed by a photoflash. To get the striae S an additional long exposure was required.

The generating current flowing in the exciting coil was measured by a shunted radio ammeter, so connected as to correct for inductive effects, and found to be 56 amperes. Thus the gaseous current was about one twenty-third that of the exciting current, an interesting result which it is hoped will be found to agree with theory.

Centrifugal Study

It occurred to the writer recently while working with the electrodeless ring discharge where the discharge tube was blown in the form of a toroid (reentrant) that possibly there might be a centrifugal action of the electrons, in their excursions to and fro, of sufficient magnitude to be observable if proper conditions of experimentation were selected. This was suggested by Professor Nipher's experiments[2] of many years ago, and also by the shadows cast in the magnetic study described above.

On second thought it is evident that the carriers in this case would be confined wholly to electrons, as the heavy ions could not possibly respond to the frequency of 800 k. c. per second that was impressed on the circuit in these experiments. Also it is doubtful, even at the high velocities employed, whether the electrons, although they do travel over a considerable distance (as shown by their shadows) would by reason of their small mass be driven towards the periphery of the toroid. To test this point experimentally a special centrifuging tube was designed, and, to magnify any possible effect, four such tubes were connected up in series.

The complete set-up is shown in figure 4, which is a photograph of the tube while the electrodeless discharge was circulating through it. The four units are shown with an exciting coil of four turns surrounding each. A discharge tube actuated by 1500 volts, small storage cells, was fused to the top to detect a possible change in pressure. A McLeod gauge was also attached. Each unit has three ports leading from the periphery to the center of the unit below. The centrifuged electrons, when the discharge is passing, find their way through these ports and on down to the center of the next unit where the action is repeated. The lower end of the series is connected to the exhaust pump. The optimum pressure for the electrodeless discharge to form is about .2 mm. of mercury. The action, thus, is as follows: with the pressure in the system, as measured by a McLeod gauge, at .2 mm., and the exciting coil *not* in action, the discharge tube at the top showed, on closing the 1500 volt circuit, a definite spacing of the striae. If now the exciting coil is energized the striae should move apart and also shift toward the anode, indicating a reduction in pressure in that portion of the system. This was exactly what took place, showing that the horizontal discharge tube experienced a reduction in pressure. This is an interesting result and is the subject of further investigation.

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[2] Nipher, F. E., Science, vol. 28, pp. 93 and 807, 1908; vol. 29, p. 237, 1909.