RELATIVE INTENSITIES OF THE MAGNETIC AND ELECTROSTATIC ILLUMINATION COMPONENTS IN THE ELECTRODELESS DISCHARGE

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Abstract

Recent theory indicates that a considerable portion of the illumination in the electrodeless discharge is due to the electrostatic field. A discharge vessel was constructed to test this point experimentally. Obstructions were set in it with the idea that each type of discharge would cast its own shadow. Distinct shadows were obtained for both discharges when acting separately. When the magnetic field predominated and the ring discharge was fully formed no evidence was obtained of shadows due to electrostatic discharges, and conversely, as is shown by the photographs that accompany the article. The intensities of the two illuminations, as judged by the times of exposure, varied about as 1 to 50. The photographs seem to support the calculations of Sir J. J. Thomson.

Recent theory indicates that a considerable portion of the illumination in the electrodeless discharge is due to the electrostatic field; that under favorable conditions of gas pressure and position of the energizing coil and electrodes this illumination may amount to a considerable part of the total. This result is in addition to the calculations made a few years back by Sir J. J. Thomson.[1]

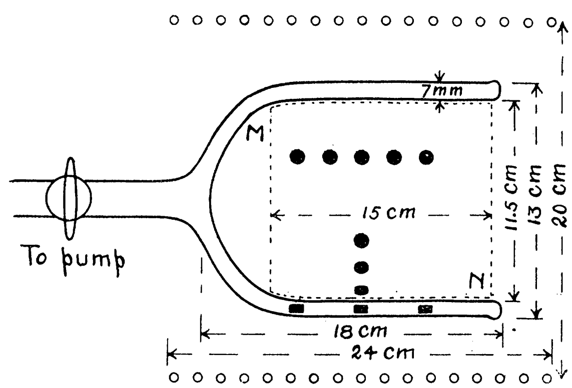


Fig. 1. Sketch of discharge vessel. Similar to a large Dewar vacuum test tube. Asbestos obstructions are shown. These appear in the four photographs that follow. A cylinder, MN, of black paper screened off high lights on opposite side. The position of energizing coil is shown.

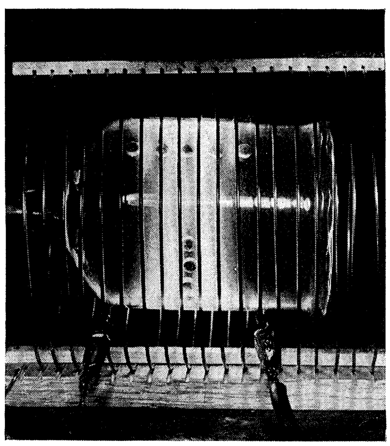
A tube was designed by the writer with which it was hoped to test this point experimentally, at least qualitatively. In appearance the discharge ves-

[1] J. J. Thomson, Phil. Mag. 4, 1128 (1927).

sel was not unlike a wide-mouthed Dewar vacuum flask. Two Pyrex beakers of 1.5 and 2 liters capacity, respectively, were used in its construction. Its length when completed was 18 cm, its diameter 13 cm, and the interspace about 7 mm. Asbestos disks about 8 mm in diameter were placed at regular intervals throughout the interspace similarly to the spacing disks in a vacuum bottle. Fig. 1 shows a section through the vessel and coil.

The idea in mind was that these obstructions should cast shadows, similar to the Malteze cross experiment in a Crookes tube, and thus under proper conditions it was hoped that the direction of the discharge due to either field would be made visible.

The study was made with residual air at pressures of about 0.2 mm of mercury. The discharge vessel was energized by damped oscillations from a motor-generator high-voltage high-frequency set. The maximum voltage was about 25 kv operating on a frequency of about 800 kc.



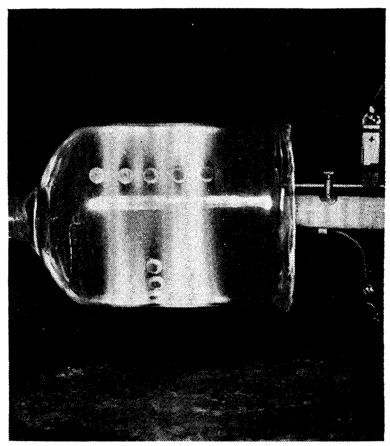


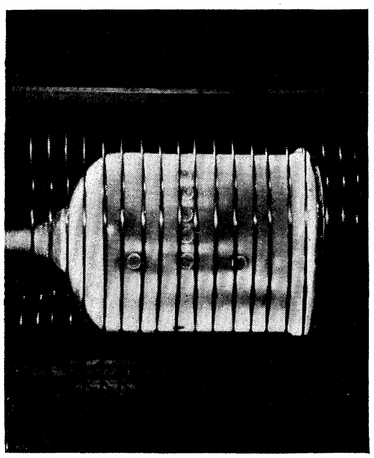
Fig. 2. Electrodeless discharge completely formed by using 8 turns of energizing coil. Residual air, pressure about 0.2 mm Hg. Illumination intense white. Time of exposure 6 seconds, followed by a photoflash to get apparatus. Shadows are in plane of coil. No shadows due to electrostatic field are discernable.

Fig. 3. Electrodeless ring discharge completely formed when an energizing coil of 8 turns was placed inside of vessel. Illumination intense white. Time of exposure 6 seconds followed by a photoflash. Again shadows due to the asbestos obstructions plainly show the paths of the carriers. No electrostatic effects are visible.

To give prominence to the magnetic field the energizing coil should be compact and of comparatively few turns—6 or 8 in this instance. This may be placed either round the vessel as indicated in Fig. 2, or the coil may be replaced by one of smaller diameter and placed within the discharge vessel as shown in Fig. 3. If an outside coil of too large a diameter, or of too many turns, is employed the ring discharge will not form.

On the other hand to give prominence to the electrostatic field a long solenoid, as shown by the extended coil turns in Fig. 1, should be used. Better still is to place external electrodes consisting of a band conductor to the right and to the left of the medial line as shown in Fig. 4. To prevent heavy sparking with the attending danger of disrupting the vessel a parallel coil of about 10 turns should be inserted. By adjusting the number of turns included in this parallel circuit a wide range of electric field intensities may be obtained.

The two fields may indeed be obtained simultaneously by simply using a long energizing coil of from 20 to 30 turns and of about 1 cm pitch. For the electrostatic field to predominate it is only necessary to make connections at the ends of this solenoid, Fig. 4. To localize the magnetic field (as is necessary in order to have the ring discharge form) the connecting leads should now be transferred to include 4 to 6 turns at the center of the solenoid, Fig. 2. Moving the leads from the ends to the center does not seem to reduce the resultant electrostatic field very greatly, but it does serve to localize the ring discharge due to the magnetic field. It should be added that at no time, even with the electrodes most favorably placed, was it possible to get the characteristic ring discharge by means of the electrostatic field alone.



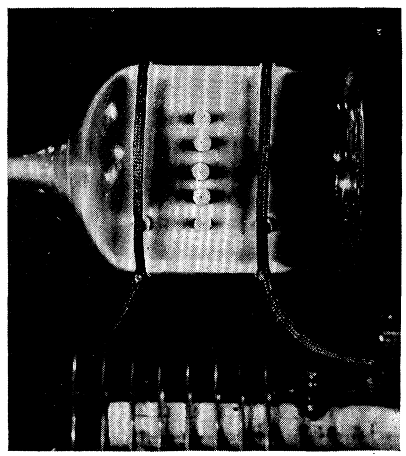


Fig. 4. Electrostatic discharge only. Electrostatic field obtained by using full length of energizing solenoid. Illumination faint (compared with that in the ring discharge). Time of exposure about 2 minutes. Overhead lights to get outline of apparatus. The direction of field is clearly shown by the streamers. Magnetic field not intense enough to form the ring discharge.

Fig. 5. Electrodeless discharge only. The band electrodes are looped across a coil of 8 turns (this coil was placed on the inside of vessel in Fig. 3). Illumination a faint purplish red glow. Time of exposure 130 seconds. The direction of field is clearly shown by the shadows cast. Overhead lights to finish exposure.

Summary

1. To form an intense ring discharge required but a comparatively few turns of the energizing coil. Figs. 2, 3.

2. The paths of the carriers in the ring discharge were in the *plane* of the coil as is distinctly shown by the *shadows cast.* Figs. 2, 3.

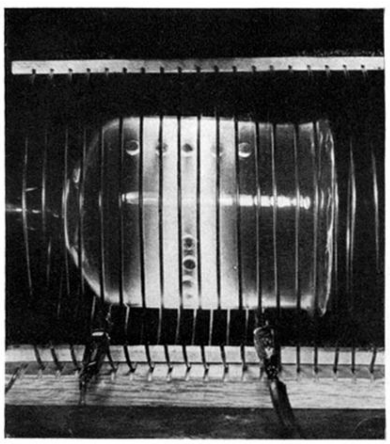
3. The illumination was very intense. It required but 6 to 8 seconds to make an exposure.

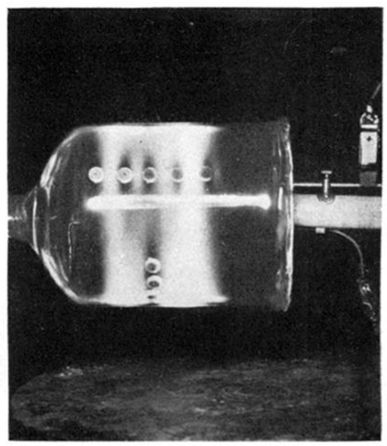
4. The electrostatic discharge may be produced by either external electrodes, or by a long solenoid. Figs. 4, 5.

5. The paths of the carriers in this case, as one should expect, were parallel to the axis of figure as is distinctly shown by the *shadows cast*. Figs. 4, 5.

6. The illumination was very weak, a purplish red, as compared with the intense white of the ring discharge. It required 2 to 3 minutes to make an exposure of the density shown in Figs. 4 and 5.

7. At no time while the ring discharge was formed were the electrostatic effects visible. These, however, may have been masked by the greater intensity of the former.





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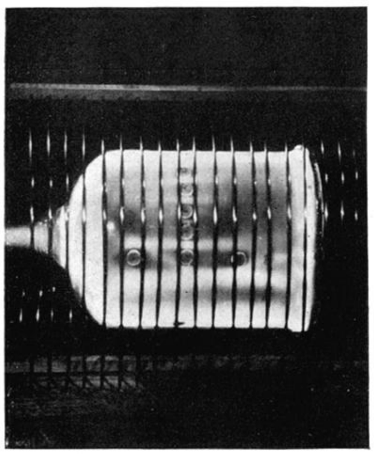 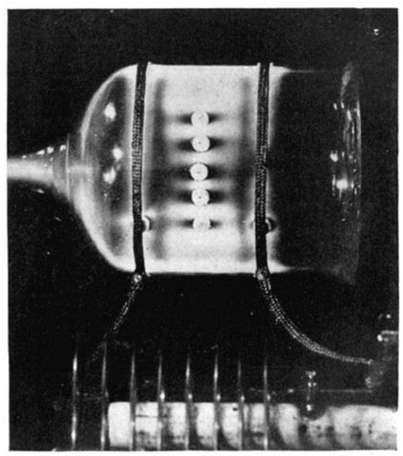

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