

THE RECTIFYING EFFECT IN POINT AND PLANE DISCHARGE.

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IN this investigation the authors have sought to secure quantitative measurements on the rectifying effect between an electrified point and a plane.

It has been known for some time that when an electrified point is separated from a plane positively electrified a sufficient potential difference may be attained to produce a discharge, and if the point is positive the potential difference required for the discharge will be greater than if the point is negatively electrified.

In "Conduction of Electricity through Gases" J. J. Thomson quotes measurements from observations made by several experimenters, but as the minimum potential varies with the sharpness of the point used it is very hard to make comparisons except with different pressures and different distances of the electrodes when the same point is used. Tamm¹ found that the minimum potential required to cause a perceptible leak between a point and a plane several centimeters removed, at atmospheric pressure, was 2,140 volts when the point was electrified negatively and 3,760 volts when the point was positive.

Results of observations made by Röntgen,² Precht,³ Gorton and Warburg⁴ are also recorded. These observations were made at pressures ranging between atmospheric pressure and a pressure of 10 centimeters of mercury, for a number of gases including air. In air at atmospheric pressure Precht found the minimum potential necessary to produce a discharge for point positive to be 2,730 volts and for point negative 2,050 volts.

In a previous paper published in the *Philosophical Magazine*,

¹ Tamm, Ann. der Phys., VI., p. 259, 1901.

² Röntgen, Göttingen Nach., 1878, p. 390.

³ Precht, Wied. Ann., XLIX., p. 150, 1893.

⁴ Gorton and Warburg, Ann. der Phys., 1905.

July, 1908, the results were given for a series of observations on the "Discharge from an Electrified Point and the Nature of the Discharge occurring through very small Distances."¹ The distances ranged from one to one hundred wave-lengths of sodium light and the ionizing potential for a point and a plane was found to be about 338 volts in air. The critical distance was greater for a point and plane than for two plane electrodes. In view of these results it seemed advisable to extend the work, using the luminous discharge and a greater range of distances and pressures.

In Fig. 1 is shown a cross-section of the discharge chamber. The

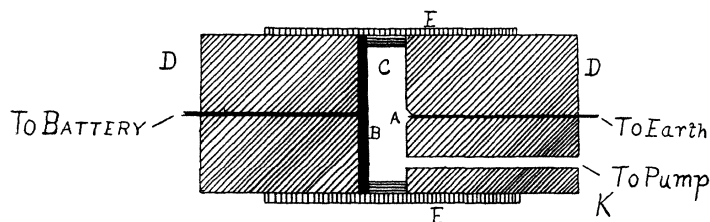


Fig. 1.

electrodes consisted of a plane brass plate *B* 3.5 cm. in diameter, which was fastened to a plug of red fiber *D*, and a small platinum wire slightly rounded at the point and firmly set in red fiber so that the end would be just even with the plane surface of the fiber. As shown in the figure the pieces of fiber were turned to fit the glass tube *EE* and further served to confine the gas in the chamber *C*. The piece of fiber in which the wire electrode was set was bored with a small hole *K* for the removal of the gas. For the purpose of making the joints air tight the Khotinski cement was used. The distances between the electrodes were determined by fiber rings carefully ground until they were accurate to one one-hundredth of a millimeter. The chamber was then connected in series with a drying chamber which had a capacity of about one and a half liters, a McLeod gauge and an air pump. A constant supply of phosphor pentoxide was kept in the drying chamber. A battery of 600 storage cells was used as a source to obtain the potential differences required in the work and a carefully calibrated Weston voltmeter with a suitable multiplier was used to measure them.

¹ Earhart, *Phil. Mag.*, July, 1908.

The diagram in Fig. 2 shows the arrangement of the apparatus.

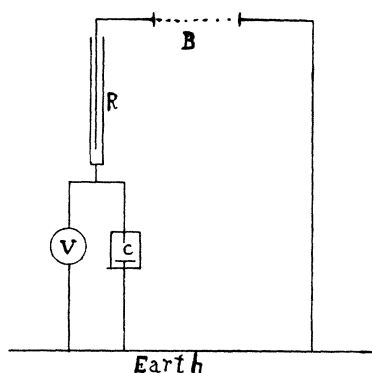


Fig. 2.

One terminal of the battery is earthed direct; the other is connected through a liquid resistance R to one electrode of the discharge chamber and the voltmeter which is in parallel with the discharge chamber. The other electrode of the discharge chamber and the other terminal of the voltmeter are connected to earth. With this arrangement it is quite easy to make the point or the plate electrode either positive or

negative by interchanging the earth and battery connections of the chamber.

In making the measurements the potential was increased by small steps and sufficient time allowed to ascertain whether or not a dis-

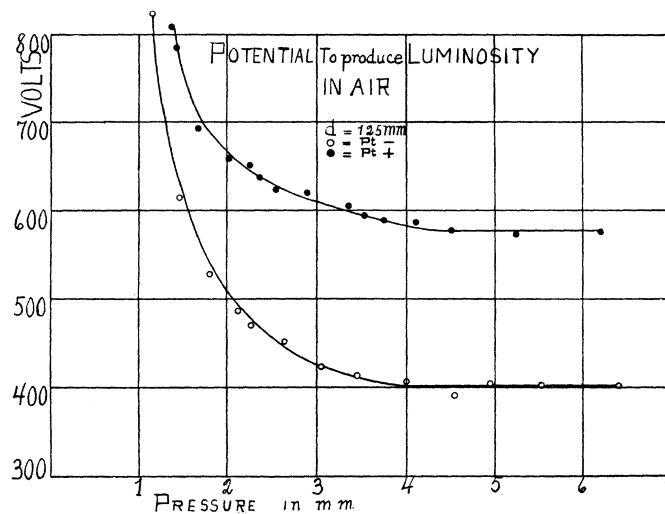


Fig. 3.

charge would occur before it was increased. The passage of the discharge could be readily detected by a sudden dropping off in the

voltmeter reading and the cessation of the discharge could likewise be noted by a sudden increase in the voltmeter reading. In order to insure a greater degree of certainty as to the beginning of the

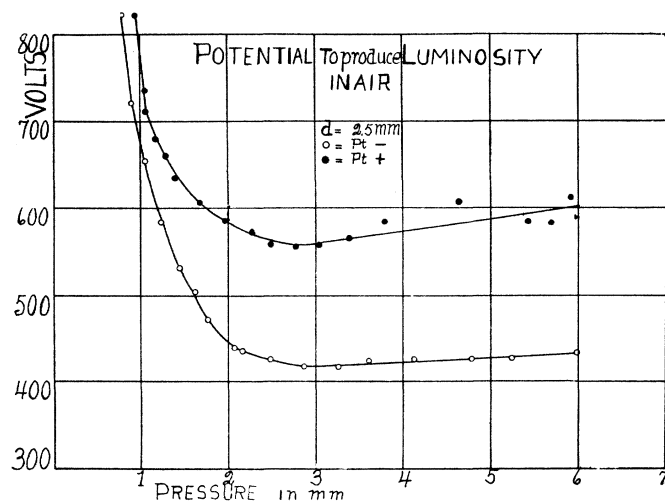


Fig. 4.

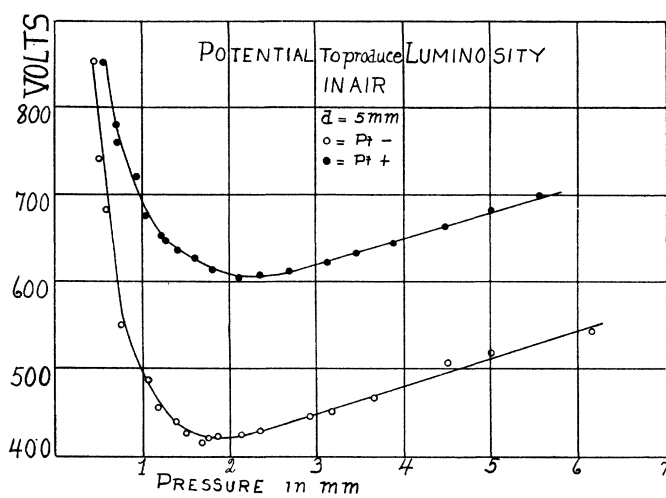


Fig. 5.

luminous discharge a small hole was bored in each of the washers employed to separate the electrodes so that the discharge could be

seen. However this precaution was not necessary, the kick of the voltmeter being sufficiently reliable.

Since the luminous discharge presupposes a supply of ions a dis-

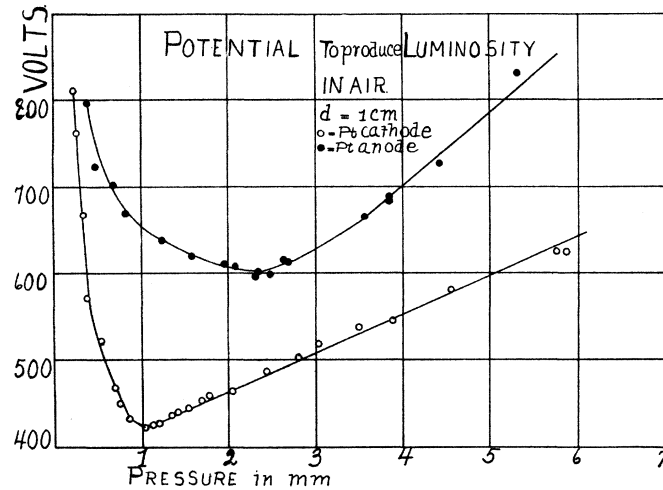


Fig. 6.

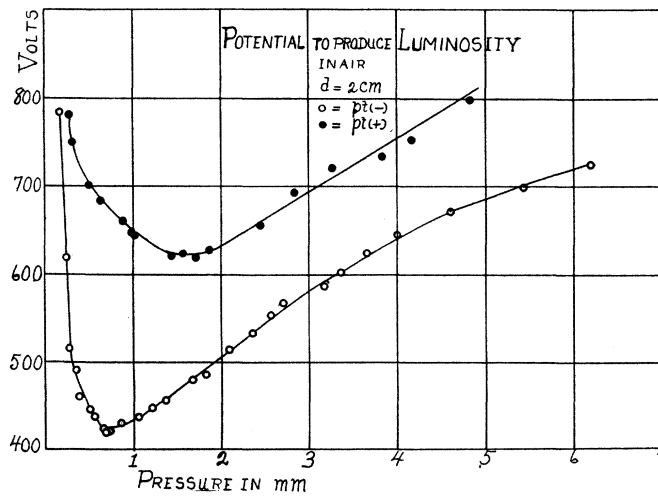


Fig. 7.

charge was produced to create them and then after several minutes the voltage was increased by small steps in the manner previously described until the discharge again passed. After each observa-

tion sufficient time was allowed to elapse for the gas to reach its normal condition before another reading was taken.

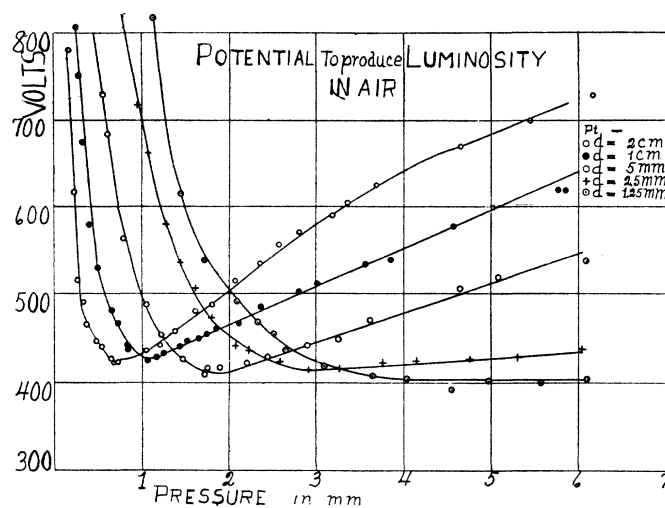


Fig. 8.

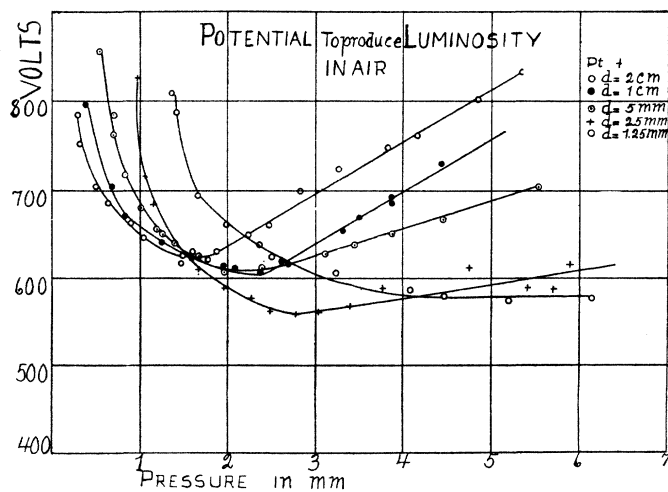


Fig. 9.

The delay in the passage of the discharge which has been noted by a number of investigators and carefully studied by Warburg¹

¹ Warburg, Ann. der Phys., 62, p. 385.

was observed. As Carr¹ has noted, the lag was greater near the critical pressure. It was also greater below the critical pressure than above it.

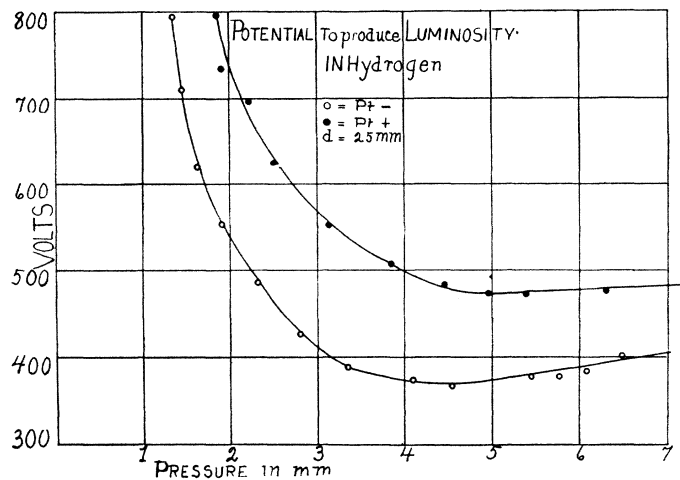


Fig. 10.

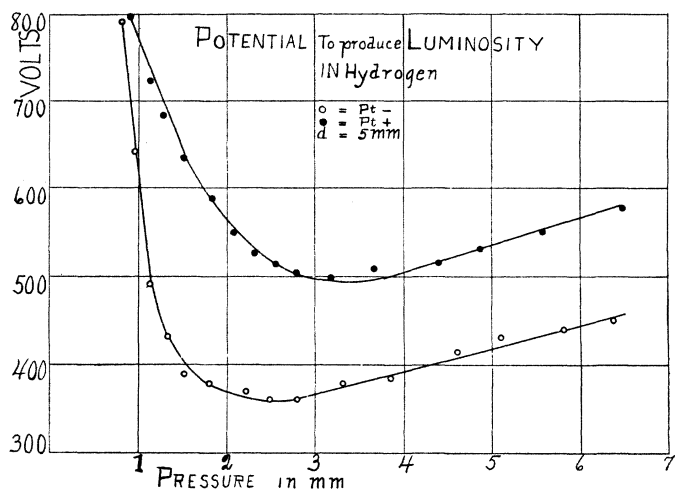


Fig. 11.

In beginning a series of readings in air the whole apparatus was exhausted to a pressure of about one millimeter of mercury and

¹ Carr, Phil. Trans. Roy. Soc., CCI., p. 403.

then refilled by allowing the air to pass in slowly through a tube packed with phosphoric pentoxide. The apparatus was then exhausted to a pressure of 10 mm. of mercury and allowed to stand over night, the air in the chamber being in constant contact with the phosphoric pentoxide in the drying chamber.

The measurements in the air were made at five different distances of the electrodes, 1.25, 2.5, 5, 10 and 20 mm., and extending over a range of pressure from 8 mm. to 0.27 mm. of mercury. The

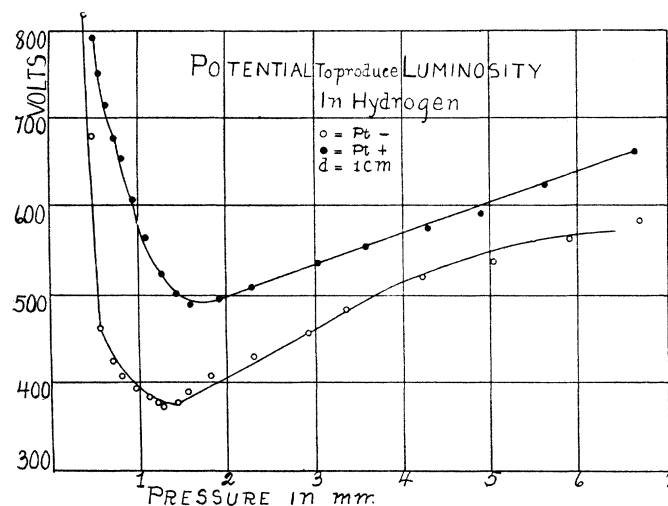


Fig. 12.

results of these measurements are shown graphically in Figs. 3, 4, 5, 6 and 7. Each curve shown is made from one continuous set of readings and is not a selection from several sets, although three series of readings were made for each distance and the average one was selected.

It will be seen that the curves for point negative are similar to those obtained by Carr and other experimenters for parallel plates, but with point positive the voltage required for a discharge at any certain pressure is higher than the voltage required at the corresponding pressure for point negative and the critical pressure for point positive is higher than for point negative. The potentials where rectification is possible obviously lie between the lines representing

the discharge for point positive and for point negative. Theoretically for an alternating potential within this region discharge would proceed only in one direction. It should be noted that within the limits of the experiment the most favorable region for this effect lies near the critical pressure and for the longer spark gap. For the purpose of comparison all the curves made with point negative

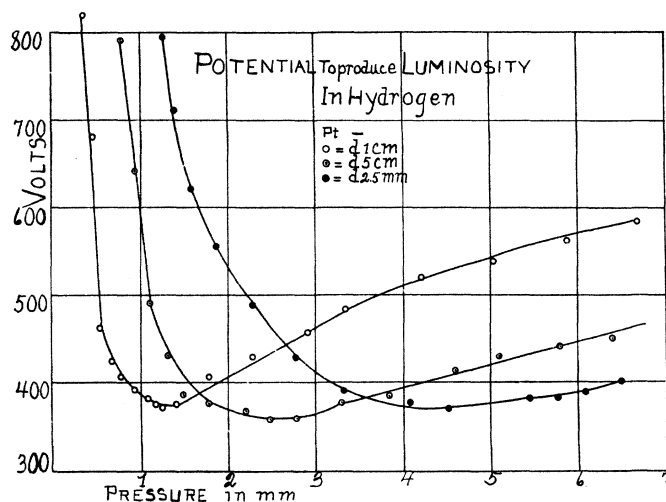


Fig. 13.

in air are shown in Fig. 8, while Fig. 9 shows a similar set of curves for point positive. Carr found the minimum potential required for a discharge between two parallel plates to be independent of the distance which separated them. In general the potential required for discharge depended only on the mass of gas between the electrodes, that is, Paschen's Law. In the case of discharge between parallel plates the entire mass of gas without doubt is affected. In the case of a point and a plane it is quite improbable that the entire quantity of gas within the chamber functions when the discharge takes place. Our lack of knowledge on the distribution of the discharge from a pointed conductor renders it impossible to say just what portion of the gas within the chamber functions; however it is not improbable that Paschen's Law holds in this case also. The minimum potentials as shown on the different curves are somewhat more consistent for point negative than for point positive. The

critical pressure varies with the distance of the electrodes in every case, but for any certain separation of the electrodes the critical pressure for the negatively electrified point is less than when the point is electrified positively.

In order to further test the laws governing such discharges it seemed advisable to carry out the experiment using another gas. Figs. 10, 11, 12, 13 and 14 show graphically the results obtained with hydrogen. The apparatus used was the same as in the experiments with air. The hydrogen was prepared in a Kipp apparatus by the action of sulphuric acid on chemically pure zinc and after passing through solutions of potassium permanganate and pyrogalllic acid was dried by being passed through tubes packed with phosphoric pentoxide. While in this way absolutely pure hydrogen

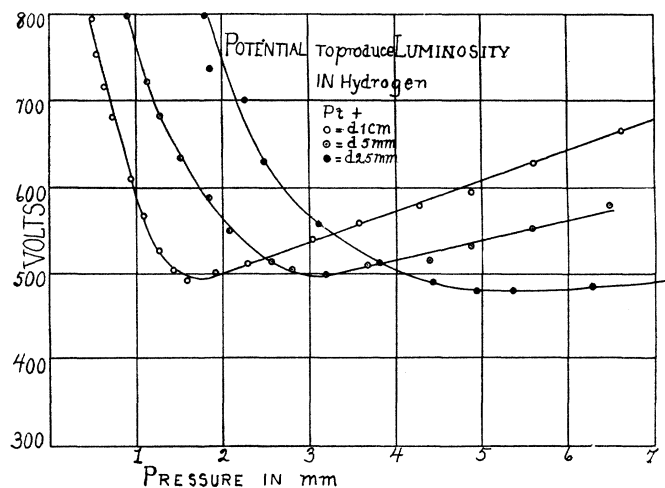


Fig. 14.

cannot be procured it is thought that the small amount of impurity did not seriously affect the results.

Before making the measurements with hydrogen the apparatus was exhausted of air to a pressure of about .5 mm. of mercury and then filled with hydrogen to atmospheric pressure. It was then exhausted and refilled four times to make certain that all air was removed after which the gas was allowed to stand for several hours in contact with phosphor pentoxide at a pressure of about 10 mm. of mercury before any readings were attempted.

The results obtained for hydrogen are quite similar to those obtained in air. The differences being just such differences as would be expected; the minimum potential required for the discharge being considerably less than for air and occurring at higher pressures.

These experiments have suggested several phases of this problem and it is hoped to make some considerable extension of it in the near future.

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