THE EFFECT OF A LONGITUDINAL MAGNETIC FIELD ON SPARK POTENTIALS.

By Robert F. Earhart.

THE present paper may be regarded as a continuation of an article published in the February number of this journal on the "Discharge in a Magnetic Field."[1] The former paper sought to extend the work of Paalzow and Neison[2] by studying the variation in the magnitude of a discharge current between parallel plate electrodes. The electric force and magnetic force were parallel. The quantitative measurements showed that for gas pressures exceeding the critical pressure, the effect of a magnetic field was to diminish the current. As the pressure was reduced the effect of the field diminished and as the critical value was approached the effect vanished. For pressures less than the critical pressure small fields increased the current strength but strong fields were not so effective as the lesser ones in some cases.

The effect of the weaker fields in increasing the current was explained by Townsend[3] in commenting on some experiments of Strutt.[4] He suggests that the helical motion imparted to an electron by the longitudinal field will so increase its path that ionization by collision will take place with a smaller potential gradient between the electrodes.

For higher pressures it would seem that this would be offset by another effect. In a luminous discharge at the higher pressures the motion of an ion or electron will probably be complex because collision is frequent and the forces on any electrified unit will vary continually in magnitude and direction. If this be true the motion of an ion will at times have a component velocity normal to the lines of force and thus be subject to a force tending to divert it to the walls of the tube. If a longer tube of the same section should be substituted the opportunity for the charged body to be diverted would be increased. Again if the tube should be maintained of constant length but its section increased together with the area of the electrodes the probability of the ion reaching the electrodes would be increased.

[1] Phys. Rev., N. S., Vol. III., p. 103, 1914.
[2] Wied. Ann., I.–XIII., p. 207, 1897.
[3] Phil. Mag., VI., 26, p. 730, Oct., 1913.
[4] Proc. Roy. Soc., *A*, 89, p. 68, 1913.

Having this in mind it seemed possible to attempt a test of the hypothesis. A discharge chamber D in Fig. 1 was placed between two brass electrodes A and B. These were mounted on the poles of a large electromagnet by means of fiber collars. The pole pieces M, M in the figure were 5.08 cm. across the face so that the midportion of the field was quite uniform. This was tested and with satisfactory results. Fields of 10,000 C.G.S. could be obtained with the gap made necessary by the insertion of the discharge chamber. The spark chamber was made from a disk of hard rubber sealed to the electrodes. The disk itself served to measure the distance between the electrodes and at the same time confine the discharge to the uniform portion of the electric and magnetic fields.

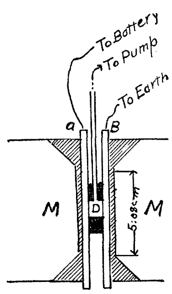

Fig. 1.

The length of the discharge path was made 2.5 mm., 5.0 mm. and 10.0 mm. and in each case apertures of three sizes were used. The apertures were 3, 6 and 9 mm. approximate radius. They were bored out with a $\frac{1}{4}$, $\frac{1}{2}$ and $\frac{3}{4}$ inch drill. The ratio of their areas is therefore 1, 4, 9. The electrical arrangement was similar to the one described in the previous paper and is not reproduced. In each of

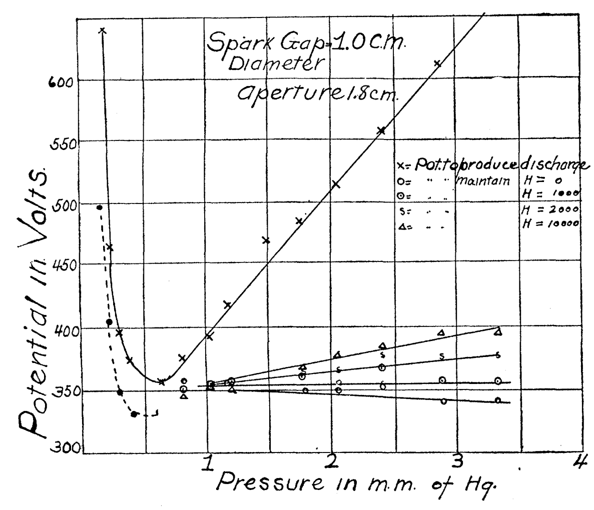

Fig. 2.

the nine cases the gas pressure was varied between .2 mm. and 5 to 6 mm. The fields were of strength 0, 500, 1,000, 2,000, 5,000, 10,000 C.G.S. units. Air was the only gas used.

It is well known that for a particular pressure a definite potential is required to start a discharge but that once started a lower potential will maintain it.

All these experiments show that for pressures above the critical value the potential required to start the discharge is unaffected by the magnetic field but that the potential required to maintain the current flow must have a higher value when a field is on than for a zero field. This is shown in figure 2, where the distance separating the electrodes is 1 cm. and the aperture is 18 mm. in diameter. The variations in the potential required to maintain the discharge are quite appreciable. This is in

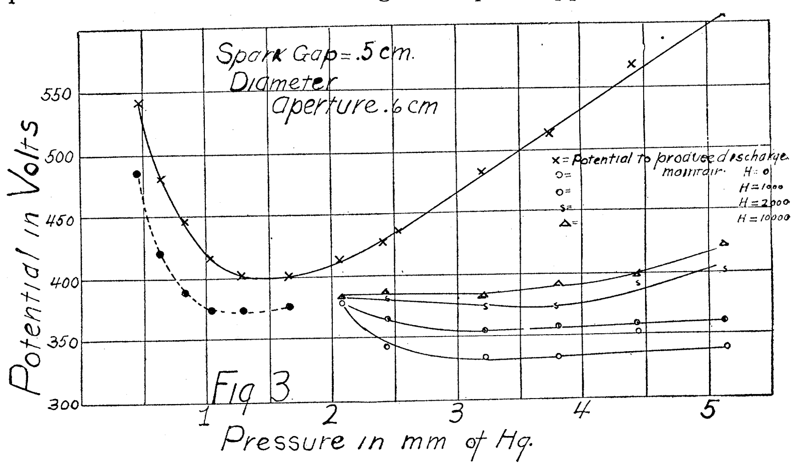

Fig. 3.

agreement with the current-potential curves obtained in the previous experiment because the current value depends on the excess of potential over the value required to maintain the current rather than its relation to the potential required to start the discharge. The graphs show only the results for fields of strength 0, 1,000, 2,000, and 10,000 units. It will be noted that these curves converge near the critical pressure. For pressures below the critical value the discharge potential is reduced by the magnetic field. These are shown by full black circles. Here the variations due to different fields are small. The ones represented are for a field of 10,000 units. The values for the fields from 1,000 to 10,000 differ very slightly from the ones shown. Figs. 3, 4 and 5 exhibit the variation due to size of aperture. It will be noted that a higher potential is required to maintain the discharge for the smaller aperture. Fig. 5 should be compared with Fig. 2 to show the effect of length of path. All of the nine families of curves (four only are reproduced) are consistent with one another save a vagary exhibited by the tube 1 cm. long having the smallest aperture. In that case all the effects due to variations of the field were duplicated but the entire family of curves was displaced upward along the *Y*-axis, meaning that higher potentials were required.

In my judgment this is due to another effect superposed on the one sought. In a paper entitled "Some Characteristic Curves for Gases at Low Pressures"[1] the author reported on some experiments made when

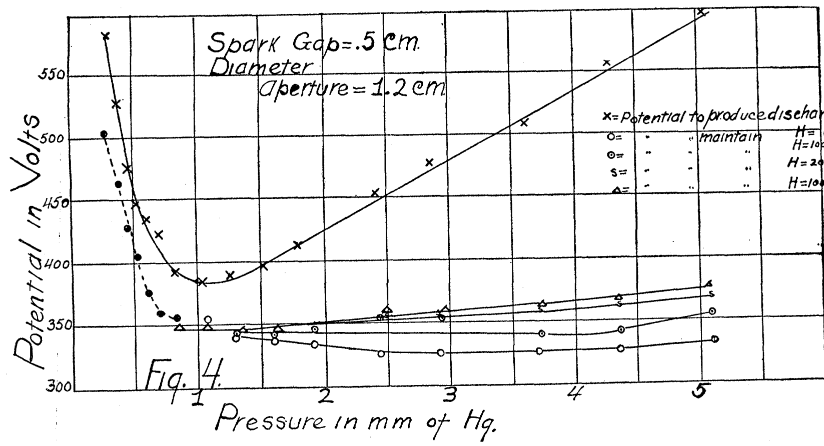

Fig. 4.

thin diaphragms having small apertures were interposed between the electrodes, also when the discharge was made to pass through a tube serving as a constriction in the path. It was found that the effect of

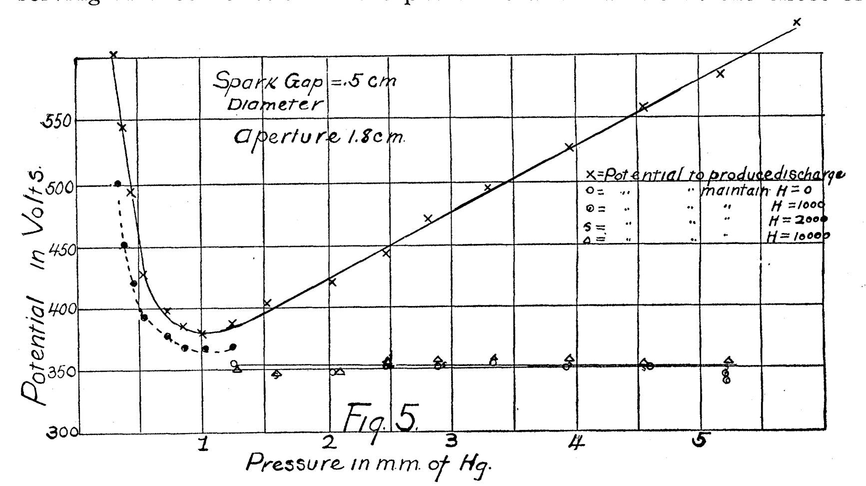

Fig. 5.

introducing such a constriction was determined by the length of the constricted portion and that the potential required to maintain a discharge of given strength had to be raised. The only effect on the characteristic

[1] PHYS. REV., N. S., Vol. I., p. 85, February, 1913.

curve thus obtained was to displace it upward along the potential axis. It seems that in the case of the long tube with the smaller aperture that the superposition of constrictive effect on the other is to require a higher potential to produce the same variations of change due to the magnetic field.

The conclusions are:

1. Spark potentials for pressures above the critical pressure are unaffected by a longitudinal field.

2. Spark potentials below the critical pressure are decreased by a longitudinal field.

3. When the pressure exceeds the critical one, the existence of a longitudinal field requires a higher potential to maintain the discharges than if no field existed.

4. The variations noted in (3) are increased with increasing fields and become larger as the gas pressure is increased.

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