ON THE PRESENCE IN POINT DISCHARGE OF IONS OF OPPOSITE SIGN.

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SOME of C. T. R. Wilson's experiments[1] on the action of ions as condensation nuclei indicate that negative ions are present in the gas to which a point is discharging positive electricity; and similar results were obtained by Campbell.[2] Chattock and Tyndall[3] have considered a back discharge from the plane to be a possible explanation for the high values they obtained, from wind pressure, for the mobility of the negative ions in point discharge in pure hydrogen.

The following is an account of some experiments, in which dry air and hydrogen were used at different pressures, that were undertaken to find whether such ions of a sign opposite to that of the main discharge are present, at some distance from the point, in sufficient number to affect the electric field appreciably.

The method is based on the fact that when a wire probe, placed in a gas containing ions, is charged to a higher potential than that which it takes up of itself it cannot return to the latter potential if positive ions only are present, nor can it recover from an imposed lower potential if negative ions alone are present. Any leakage through the gas from a probe wire, placed near a discharging point and charged as stated, must be due to the presence of ions opposite in sign to that of the main discharge.

The accompanying figure shows the arrangement of the apparatus. The wire point B (diameter = .075 mm.) discharged to the plate D (distance = 14.8 mm.) above which the probe wire C (diameter = .26 mm.) was placed, usually at a distance of about 1.5 mm. but in some of the experiments at 6 mm., with like results. This probe wire was charged 200 volts or more above the equilibrium potential assumed by it when a given current was flowing between the point and plane, and its rate of leak noted on a voltmeter joined to it. The rate of leak for a like potential was then taken with no current flowing from the point to test the insulation of the supports.

[1] C. T. R. Wilson, Phil. Trans., 192, p. 403, 1899.
[2] N. R. Campbell, Phil. Mag. (6), 6, p. 626, 1903.
[3] A. P. Chattock and A. M. Tyndall, Phil. Mag. (6), 19, p. 449, 1910.

No appreciable leak of the probe, that could be ascribed to the ions in question, was observed in dry air at pressures between one atmosphere and half an atmosphere with steady discharge currents of either sign up to 7 microamperes in value, the largest that permitted the taking of observations at these pressures. By comparing the slowest leak detectable with

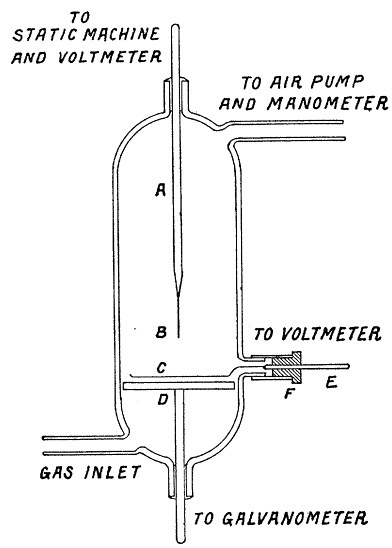

Fig. 1.

the rate at which the probe assumed the equilibrium potential after being earthed, an estimate was obtained for the upper limit of the number of these ions present and this shows that they must compose less than one fiftieth per cent. of all the ions.

Discharge Current in 10^{-6} Amperes.	Rate of Leak from Probe.		
	Negative Discharge.	Positive Discharge.	
0	.08 volts per sec.	.08 volts per sec.	Support insulation leakage.
.4	.25 volts per sec.	.40 volts per sec.	
7.	1.0 volts per sec.	1.6 volts per sec.	
15.	7. volts per sec.	12. volts per sec.	
29.	100±. volts per sec.	very fast.	Glow on plate with negative discharge.

With pressures less than half an atmosphere a leak from the probe was observed; at the higher of these pressures, with large discharge currents only, but with all currents at the lower pressures, of which the lowest used was 3 cm. of mercury.

The preceding set of readings with the air pressure at 17.6 cm. will illustrate the nature of the results. Some idea of the numbers obtained at other pressures may be formed from those given by taking the leakages very roughly inversely proportional to the pressures.

The potential of the probe was in each case over 1,000 volts, and the capacity of the probe and electrometer was about 50 cm. To get an estimate of the relative number of the two kinds of ions present in this case, a capacity was added to the probe system and the rates at which the potential changed were measured when the probe was on the average 250 volts above and below its equilibrium potential. With a positive discharge current of 7 microamperes, for which the potential of the point was 3,600 volts and that of the probe 900 volts, the rate of charging was over 250 times as fast as that of discharging, showing that the ions of opposite sign to the discharge current were less than half a per cent. of the total number present. For the larger currents, however, they were relatively more numerous, as the leakages increase more rapidly than the discharge currents.

It will be noticed that the number of negative ions in the positive discharge is greater than the number of positive in the negative discharge. This is somewhat remarkable since with the largest current used above there was a visible glow on the surface of the plate with the negative discharge and none with the positive. It would seem that this luminosity is not an accompaniment of an ionizing process but may be caused by the impacts of negative ions against the molecules of the gas wherever the ionic velocity is sufficiently great, a potential drop at the surface of the plate being supposed in this case. Such a view would help account for the fact that the light at the surface of a point discharging negative electricity extends some distance into the gas while in positive discharge the light is much more confined to the metal surface.

Observations made at night failed to detect any glow on the surface of the plate when a non-intermittent positive discharge was passing with the gas at any of the pressures used, although with the negative discharge a faint glow was noticed for the largest currents used even when the pressure was as high as half an atmosphere.

In some experiments which were made to see if luminosity may attend recombination, the ions from two points, one discharging positive and the other negative electricity were sent from opposite sides into the space between two earthed gauzes or metal rings but no light effects were seen even with the gas under a greatly reduced pressure.

The results on probe leakage in electrolytic hydrogen were similar to those for air except that the leakages observed were somewhat larger and no glow was observed on the plate for either discharge.

In general then, the experiments show that while at lower pressures and especially in the larger currents there is a considerable number of ions in the gas, of opposite sign to that of the discharge, nevertheless, for pressures down to as low as 15 cm. and with currents up to 7 micro-amperes at least, these ions are not sufficiently numerous to affect the electric field appreciably.

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