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XX. *On the Point-Discharge in Mixtures of Gases.*By KARL PRZIBRAM, *Ph.D. (Graz)* *.

THE observations which led to the following investigation were made whilst experimenting on the point-discharge in different gases. The apparatus used in these experiments consisted of a thin platinum wire whose distance from a fixed circular metal plate could be altered at will, the whole being inclosed in a glass vessel, which could be filled with the gas to be investigated. A Wimshurst machine was used and the potential-difference measured with a Braun's electrometer. It was found, in accordance with the results of Warburg†, Precht‡, and others, that the potential-difference of the point-discharge was greater when the point was positive than when it was negative. This holds for air, CO_2 and H_2 . In CO_2 the potential-difference when the point is positive is considerably greater than in the same case for air, being for instance 4400 volts for air, 5200 for CO_2 , the distance between the electrodes being in both cases 5 mm. If the point is negative, the potential-difference in CO_2 was found to be slightly less § than in air, 3700 volts for air, 3500 for CO_2 .

When the apparatus had been filled with CO_2 , and the gas afterwards replaced by air, then, the point being positive, the electrometer gave readings quite different to those previously obtained in air; the values for the potential-difference were in these cases always too small. This was found to be due to traces of CO_2 that had not been removed. As one would expect an admixture of CO_2 rather to increase the potential-difference, the potential-difference in pure CO_2 being higher than that in pure air, the point-discharge in a mixture of air and CO_2 in varying proportions was investigated. The vessel used contained a platinum wire of 0.09 mm. diameter fused into a glass tube, so that only a few mm. were left free, inside a platinum cylinder of 54 mm. height and 15 mm. diameter, with a rectangular opening to allow the luminosity at the point to be observed. When the vessel contained air (dried over CaCl_2 and freed from dust by a plug of cotton-wool) and the point was positive, the luminosity was restricted to a small star just at the point. But if one now introduced a

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† *Ann. der Phys.* Neue Folge, vol. ii. p. 295 (1900).‡ *Ann. der Phys.* vol. xlix. p. 150 (1893).§ Precht (*loc. cit.*) found the potential-difference for the negative point-discharge in CO_2 slightly greater than in air.

small amount of CO_2 into the vessel, the star immediately stretched out into a thin, steady brush without ramifications, which reached in a continuous curve to the wall of the surrounding cylinder. At the same time the electrometer showed an appreciable fall in the potential-difference.

The relation of the effect to the amount of CO_2 introduced was next investigated. A measured quantity of air was pumped out of the vessel and CO_2 let in until the original pressure was re-established. Thus a series of observations reaching from pure air to pure CO_2 was obtained, and also one in the reversed order, starting from CO_2 and introducing always more and more air. The approximate equality of the potential-differences in mixtures of equal composition obtained in these two ways showed that the gases had really mixed homogeneously; to effect this one had to wait some time. Removing the CO_2 contained in atmospheric air by passing it through caustic potash had no appreciable effect on the discharge, this quantity being too small. But a quantity of CO_2 corresponding to something like 1 mm. of pressure produces the long brush and a decided fall in the potential-difference from 4500 to 4200 volt. If more CO_2 is introduced the brush contracts until, in pure CO_2 , there is again only a star visible at the point; the potential-difference rises rapidly until for about 20 mm. of CO_2 it reaches the same value as in pure air; then it increases, if one allows for the experimental errors, nearly proportional to the amount of CO_2 present until it reaches the value of 5500 volts for pure CO_2 .

Thus it seems that a gas in which the point-discharge requires a higher potential-difference than in air, lowers the potential-difference in air if introduced in small quantities, the electric strength—if this term may be applied to the point—as well as to the spark-discharge—being smaller in the mixture than in either of the constituents.

Lowering the pressure lessens the effect; the long brush disappears, and the curve giving the connexion between the potential-difference and the quantity of CO_2 gets more smooth, until the minimum can no longer be observed.

Also when the point is negative the mixture of air and CO_2 shows a remarkable behaviour. In this case the introduction of a small amount of CO_2 causes the potential-difference to rise* from 3700 to 4400 volts. For the interval

* Warburg (*loc. cit.*) found a very large increase in the potential-difference of the negative point-discharge in nitrogen by the presence of very small traces of oxygen, but then the potential-difference for pure oxygen is higher than that for pure nitrogen, whilst in the case of CO_2 it is lower than for air, and yet addition of a little CO_2 increases the potential-difference in air for the negative point-discharge.

between 100 and 600 mm. of CO_2 the potential-difference seems nearly independent of the composition of the mixture and then drops down to 3600 volt in pure CO_2 . There is no alteration in the luminosity, which, in this case, remains a mere star at the point, somewhat brighter than when the point is positive.

These facts having been established for CO_2 , a number of other gases were tested and in most cases the same results were obtained. The lowering of the potential-difference for the positive point-discharge and the appearance of a long brush was observed in mixtures of

CO_2 , Cl_2 , CO , NH_3 , H_2S with air, and of CO_2 with H_2 .

All these gases gave about the same drop of potential of 200 to 300 volts. The effect could not be observed in mixtures of N_2 with H_2 , and of Cl_2 with CO_2 .

The figures show the curves giving the connexion between the potential-difference, in units of 100 volts, and the partial pressure of the mixture, in cms. of mercury. Fig. 1 is for a

Fig. 2.

Fig. 1.

mixture of air and CO_2 . Fig. 2 for hydrogen and nitrogen and CO_2 respectively.

In all cases the light from the brush was too weak to allow spectroscopical analysis. But if the gas admitted was CO , the colour appeared decidedly different to the naked eye, the brush having a greenish tint, whilst it was more violet in all other cases.

A number of organic vapours were tried next. Air which had been standing over the liquid concerned, so as to get saturated, was blown in varying quantities into the vessel.

The formation of a positive brush was observed on introducing vapours of CS_2 , ether, ethyl alcohol, benzole; acetone, no effect, or only a very slight one, was produced by chloroform and methyl iodide. Taking into account the vapour-pressure of the liquids, alcohol, benzole, and acetone are most effective, CS_2 and ether must be added in greater quantity.

The actions of two different admixtures to a third gas are not independent of one another. Thus, if a brush is produced in air by adding a little CO_2 , this brush will disappear again if so much Cl_2 is added as would form the brush in absence of CO_2 , so that the addition of Cl_2 has the same effect as adding more CO_2 . So it is not possible to lower the potential-difference still more by adding a third gas.

If a small platinum disk as cathode was placed opposite to the point, which was made movable by passing the glass tube carrying it through a bit of rubber tubing drawn over the narrow end of the vessel, a well-developed brush could be obtained by just once quickly turning round the stopcock separating the vessel from the Kipp's apparatus in which the CO_2 was generated. The electrodes could be separated as much as 20 mm. without the brush ceasing to appear, whilst in pure air the electrodes had to be brought to a distance of 2 mm. from one another before a brush-discharge occurred, and then sometimes sparking would set in. Thus this small amount of CO_2 gives a brush about ten times as long as that in air. If air is drawn through the vessel, the long brush disappears immediately. When the brush is well-developed, one sees that it starts from a bright point and, widening a little and losing in intensity, goes straight across to the cathode, where there is an increase in luminosity. In the way the brush goes straight to the part of the cathode just opposite it differs from the brush in pure air, which can be produced to considerable length by slightly lowering the pressure and introducing a small spark-gap into the circuit. In this case the brush, which is very unsteady, forms a curve having its end on a prominent point on the sharp edge of the cathode. Adding a little CO_2 will immediately make the brush go straight to the middle of the cathode.

It would be rash at present to venture an explanation of the behaviour of the mixtures. I would only like to point out that the potential-difference of the discharge depending upon the amount of ionization and the mean free path in the gas, an easily ionized gas, which requires a higher potential-difference because of its smaller mean free path, might be expected to lower the potential-difference in another gas of longer mean free path by furnishing more ions, if it is only

added in such small quantities as not to alter the mean free path. This may possibly account for the effect produced on the positive point-discharge in air by a small admixture of CO_2 and other gases; but it does not explain the different effect obtained when the point is negative.

It may also be noted that under the influence of the not uniform field a gas of higher specific inductive capacity, as for instance CO_2 , will tend to concentrate round the point and to displace the air, so that the discharge may really pass through a mixture containing a larger proportion of CO_2 than observed in the experiments.

I am at present investigating the oscillatory discharge from a point, as observed by Himstedt, in gaseous mixtures, which may throw some more light on the subject.

Through the kindness of Professor J. J. Thomson I was enabled to carry on these experiments in the Cavendish Laboratory, Cambridge, and I take this opportunity of expressing my sincerest gratitude for the kind interest he has shown in my work.

XXI. *The Electric Intensity in the Uniform Positive Column in Air.* By HAROLD A. WILSON, B.A., D.Sc., Fellow of Trinity College, Cambridge*.

IN the following paper some measurements of the electric intensity in uniform positive columns in air at low pressures are described, the object of which was to determine the variation of the electric intensity with the current density when the latter is very small.

In a previous paper † by the writer it was shown that the electric intensity in a uniform positive column in air falls off slowly with increasing current. When the current was less than 10^{-4} ampere, however, the intensity appeared to be nearly independent of the current. The value of this maximum intensity was found to be given by the equation $X = 35\sqrt{p}$ where X is the electric intensity in volts per cm. and p the pressure in millimetres of mercury.

When the current through an ordinary vacuum-tube containing air at about one mm. pressure is diminished much below 10^{-4} ampere, the discharge becomes intermittent, and on further diminishing the current goes out altogether.

In order to make measurements with very small currents it was therefore necessary to use a special device to prevent the discharge going out.

* Communicated by the Author.

† "On the Hall Effect in Gases at Low Pressures," Proc. Camb. Phil. Soc. vol. xi. pt. iv.