THE INFLUENCE OF HUMIDITY UPON THE ELECTRICAL DISCHARGE FROM POINTS IN AIR.

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THE electrical discharge from points in air is affected by the amount of water vapor present. It is of some importance to establish the magnitude of this effect so that the results of experiments performed on different days in the open air may be directly compared, and so that laboratory results for dry air may be applied to such cases, for example, as the discharge from the points of lightning conductors or the discharge from high potential wires.

Tamm¹ experimented on the current flowing from a point in air of various degrees of humidity, but unfortunately his values are given in arbitrary units and were obtained with a single potential of 6,000 volts throughout the series. The results are not suited for reducing observations from one humidity to another because the ratio of the currents for any two humidities may depend upon the magnitude of the currents in question, and upon how the humidity affects the potential required to start a discharge.

The experiments to be described in this paper had for their object the determination of the influence of humidity upon both the voltage required to start a discharge, and the magnitude of the potentials required to produce different currents.

The arrangement of the apparatus was essentially the same as that which was used in some previous experiments on point discharge, and is described on page 306 of Volume XXV. of the *PHYSICAL REVIEW*. A brass wire 0.26 mm. in diameter and 4 cm. long was used for the discharge point, and its rounded end was placed at a distance of 1.5 cm. from a brass disc 7.5 cm. in diameter. These were enclosed in a brass cylindrical vessel 15 cm. high and 13 cm. in diameter. The disc was connected to earth through a galva-

¹E. Tamm, *Ann. der Physik*, 6, p. 274, 1901.

nometer and a telephone, while the point could be maintained at any desired potential by means of a small Wimshurst machine.

Air was drawn at a uniform rate through the enclosing vessel during each experiment, while the starting potential and the currents for a series of voltages were observed. Fairly dry air was obtained by passing the air of the room through a large calcium chloride tower; moist air was obtained by bubbling air first through hot water and then through water at the room temperature; and air of intermediate degrees of humidity was obtained by using the air of the room directly or after it had passed within different distances from water contained in bottles.

After going through the vessel containing the point and plane, the air passed through two U-tubes containing fresh calcium chloride, and then through a calibrated gasmeter. The water contents of the volume of air measured by the gasmeter was thus obtained from the increased weights of the calcium chloride tubes.

Over twenty experiments were carried out for both the positive and the negative discharges in air of different humidities. The results were all reduced to a common pressure of 74 cm. and a common temperature of 22° C. by the method given in a previous paper,¹ and the currents corresponding to the different potentials were then plotted for each case. From these potential-current curves, the values of the potentials were then read which were required to produce certain fixed currents with the air at the different humidities which had been used. Finally, the values thus obtained were plotted to show graphically how the potential required to start a current and that required to produce the currents stated, varies with the humidity of the air.

Fig. 1 represents these curves for the positive discharge. The ordinates give the potentials required to produce the currents stated, while the abscissæ are expressed in terms of the number of grams of water contained in a cubic meter of air. The abscissæ are expressed in the units given because it has been found that the changes in the point discharge in air which are produced by the addition of water vapor are related to the absolute water content of the air, and not to its relative humidity.

¹ J. Zeleny, *PHYS. REV.*, XXV., pp. 326-331, 1907.

Evidence on this point was first obtained from the readings taken at the different temperatures on different days, but a more thorough test was made by reducing the temperature of the room to 3°C . and taking sets of readings for both discharges, first with the air dry

Fig. 1. The influence of humidity upon the positive discharge in air.

and then with the air saturated with water vapor. At this low temperature the saturated air contained only about one third as much water as was present in the saturated air used in the other experiments where the temperature averaged about 22°C .

The results showed that the ratio of the potential required to maintain a given current in saturated air to that required for dry air was much smaller when the air was at this low temperature than when it was at the ordinary room temperature. Moreover this ratio for the cold air corresponded in both discharges to that obtained for warm air of an equal water content, showing that the effect under consideration is dependent upon the absolute amount of water present in the air rather than upon its relative humidity.

As far as any influence of water vapor upon the ions of the air is concerned here, the result might have been expected, for although it has been shown¹ that the presence of water vapor does change

¹J. Zeleny, Lond. Phil. Trans., 195, p. 231, 1900.

ionic velocities, still this action cannot be related to ordinary condensation at the dew point for C. T. R. Wilson¹ found that drops do not form upon the ions until the air is supersaturated over four-fold.

The points in Fig. 1 which are marked by circles are those where a faint sound was heard in the telephone indicating that the current was intermittent, at least in part. The readings were discontinued when the sound in the telephone became loud, as it usually did for high values of the current.

The curve for current = 0 in Fig. 1 represents the potentials required to start the current in the different cases. It is seen that the amount of water vapor present has but little effect upon this quantity, although the potential appears to diminish slightly as the amount of water vapor increases, the total change being about one and one half per cent. for the whole range.

The potential required to maintain a given current (between 10^{-6} and 15×10^{-6} amperes) increases with the humidity of the air, as is indicated by the upper curves of the figure. The increase is somewhat more rapid for the drier air, it is relatively not much different for the currents given, and the total change in potential for the whole range from dry to moist air is about seven per cent. in each case.

The ratio of the potentials required to produce a given current in air containing two different amounts of water vapor may be obtained readily from the curves in the figure, and used to reduce other results from the one humidity to the other.

It is desirable for some purposes to know how much the current obtained with some given potential changes with a change in the amount of water vapor in the air. This relation may be obtained by plotting the potential current curves for any two humidities in question, with values taken from the curves in Fig. 1. From these new curves the ratio of the currents for any potential is readily obtained. This ratio varies considerably from one potential to another, and for a given change of humidity is larger than the corresponding ratio of the potentials required to maintain a given current.

¹ C. T. R. Wilson, Lond. Phil. Trans., 189, p. 301, 1897.

The results of the experiments on the negative discharge are shown in Fig. 2.

As is usual, the results for the negative discharge are less regular than those for the positive discharge. It was found, however, that this irregularity diminished as the humidity of the air increased,

Fig. 2. The influence of humidity upon the negative discharge in air.

which indicates that moist air is to be preferred for experiments on the negative discharge.

The irregularity showed itself markedly in the retardation of the starting potential. As the potential was gradually increased when the air contained but little water vapor, the current would not increase gradually from zero value, but would start suddenly with a considerable magnitude, and it would do this in spite of the presence outside of the vessel of a tube of radium bromide which usually tends to diminish this retardation of the starting potential. It must be said that the surface of the point became coated with a rather heavy layer of oxide by its use in moist air, and it may be that this oxide in a dry state caused the large retardation of the starting potential as well as the greater irregularity of the results generally.

The curve for the starting potential, marked current = 0, is drawn in two branches for the more dry air. The upper branch represents

the average observed values, all of which are not marked. The lower branch represents values of the potentials which were obtained by extending the potential-current curves for these cases downward until they reached the axis for current = 0. Presumably these are the values of the potentials at which the current would have begun to flow had it started to flow gradually. The points on these two branches are not as concordant as would appear from the figure since some of those diverging most from the average have been omitted to avoid confusion.

As seen from the curves in Fig. 2, the potential required to produce a given current increases here also as the amount of water vapor in the air increases, the change being again more rapid when the amount of water present is small. The total increase from dry air to saturated air averages about sixteen per cent. This number does not differ greatly for the different currents used, and is much larger here than it was for the positive discharge.

The curves given may be used for reducing results on point discharge from one humidity to another in the same way as was indicated for the positive discharge.

Some experiments were carried out with alterations in what appear to be the essential experimental conditions, to determine how extended the application of the results here obtained may be. In the first of these, the distance between the point and the plate was changed from 1.5 to 3 cm., and readings were taken for both the positive and the negative discharges in air containing two widely different amounts of water vapor. In the second, similar sets of readings were taken when the point previously used (0.26 mm. in diameter) was replaced by a new one consisting of a brass wire having a diameter of 0.084 mm.

In both cases, the results for both of the discharges agreed well with those here recorded, the widest difference of about one per cent. being well within the experimental errors.

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