in the number of species, of which there are several, which have come from Europe with comparatively clean passports to become aggressive and troublesome in America. This is the case with the Hawkweed (*Hieraceum aurantiacum*, Linn.), which is just coming into prominence in some parts of Canada and the Northeastern States.* There are two reasons for this: First, the comparatively very rapid changes, which practically all America has undergone, have largely destroyed the natural equilibrium of species, and this has made it easier for capable weeds to creep in. Second, the principle pointed out long ago by Darwin as 'the good derived from slight changes in the conditions of life,' applies to the case of plants imported from Europe. This 'good' accrues to the species through induced variability.

Even more interesting points of inquiry are revealed when we turn to study the migrations of weeds within the United States. Merely as a suggestion for further work, I have made a few comparisons between Eastern weed floras and that of Kansas. Professor A. S. Hitchcock † enumerates 209 species of Kansas weeds, of which only 51 are foreigners against 158 natives. Even then nearly all the foreign species are specifically stated to be rare in the State. In my own list of the 20 worst weeds of Kansas, instead of the remarkable proportion of foreign species noted in Vermont and New Jersey, there are 6 foreign and 14 native species. It is also interesting to note that exactly half this list is made up of native composites. Of course, we may expect that, as commerce goes on between Kansas and the Atlantic States, the proportion of foreign weeds westward will increase; but we may feel confident that the Daisy, the Hawkweed, and the Kales will find no such easy time making headway against the sunflowers and ragweeds of Kansas as they have had against the modest, shade-loving species of the Eastern States. The native species of Kansas have been used to live in the open country, exposed to fire and drought and browsing herds of buffalo. Now when they find a well plowed field, with perhaps a little irrigation, they are fully prepared to occupy the ground and hold their own against the world.

* See Vermont Exp. Sta. Bull. 56 (1897).

† Kansas Exp. Sta., Bull. 57 (1896).

Then there is the question of these Western species coming east. Sixty-five years ago *Rudbeckia hirta* was unknown east of the Alleghenies, yet now it is widely distributed in the Eastern States. *Coreopsis tinctoria*, Nutt., is a Western Composite and a bad weed, now much cultivated in gardens in America and Europe. From these it has already shown a tendency to escape, and may be counted as a coming weed. *Dysodia chrysanthemoides*, Lag., is said to be coming rapidly eastward. *Artemesia biennis*, Willd., also belongs to this list, and has recently been collected in the railroad and dock yards at Burlington, Vermont. This list might be greatly extended.

It seems probable that the great and variable and geologically modern family Compositæ is destined to play an increasingly important part in the future transformations of American weed floras, and that its representatives will be especially prominent among the successful native weed species, as, indeed, they already are in the weed floras of the Mississippi Valley States.

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THE EFFECT OF THE DENSITY OF THE SURROUNDING GAS ON THE DISCHARGE OF ELECTRIFIED METALS BY X-RAYS.

IT has been found that the rate of discharge which occurs when X-rays strike upon a charged body is affected by the pressure of the gas surrounding such a body. Certain contradictions concerning this variation which have been made by different experimenters indicated that it would be worth the trouble necessary to study this phenomenon with care. Perrin (C. R. 123, 351 and 878) states that the rate of discharge is proportional to the density, while Benoist and Hurmusezcu (C. R. 122, 926 and 123, 1265) state that the rate of discharge is proportional to the square root of the density. The only data given in any of these statements are those in one of the articles by Benoist and Hurmusezcu. They determined the rate of discharge by noting the time it took the leaves of an electroscope to fall from a given initial position to a given final position. The voltage to which the electroscope was charged is not given, but presumably it was large. The curve marked B. & H. in Fig. 1 gives the results of their experiments.

In experimenting along this line it was soon found that the curve given by plotting rates of discharge as ordinates and densities of air as abscissæ did not have the same form under all conditions, and while it may under certain conditions obey the law of Benoist and Hermusezcu, and may possibly under other conditions approximately obey that of Perrin, in general it does not obey either law.

The experimental work will be described more at length in the *Physical Review*, and only a brief account of the results are here indicated. My apparatus consisted primarily of a charged zinc plate and an electrometer. The plate was placed inside a box of the same metal from which it was insulated. The plate was connected to the electrometer and the box was ground, and both plate and box were placed in an air receiver which was connected to an air pump and a monometer. The rays struck the charged plate at nearly grazing incidence.

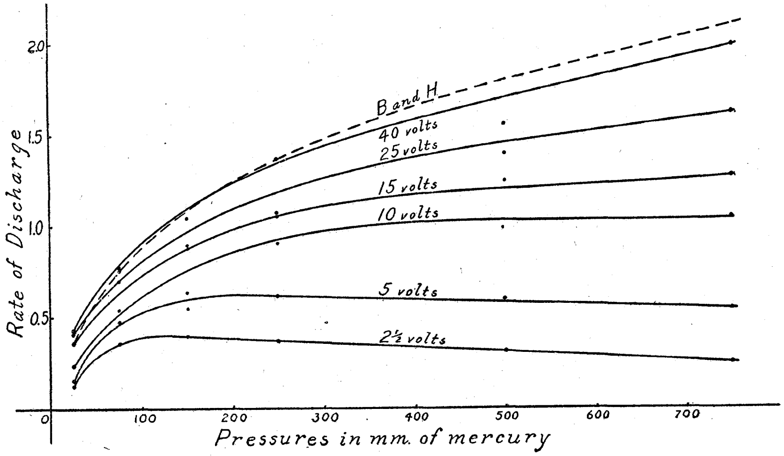

FIG. 1.

Care was taken to avoid ordinary electrical leakage and electro-static induction due to the action of the induction coil, also to protect the electrometer and its connections from the action of the X-rays, and from the action of the air through which the X-rays had passed.

The zinc plate had an area of about 50 qc.; the sides of the box were 2 cm. from the plate. The capacity of the plate, the connections and a small condenser placed in multiple with the plate was about 400 electrostatic units.

The rate of discharge was found by noting the fall in potential when the rays were allowed to strike the charged body for a few seconds, usually four, and also by noting the fall in potential when the zinc plate was connected through a very high resistance to a constant source of potential and the rays were allowed to strike the plate continuously. The high resistance was secured by winding two wires about each other which were covered with cotton insulation. The resistance through the insulation was about 5,000 megohms. The results from these two methods were in as fully complete concordance as could be expected from the nature of the work.

That which had the most effect upon the relation between the rate of discharge and the density of the surrounding gas was the potential at which the discharge took place. Curves are given in Fig. 1 for the rates of discharge when the initial potentials were $2\frac{1}{2}$, 5, 10, etc., up to 40 volts. The ordinates indicate the number of volts that the charged plate fell per sec., and the abscissas indicate pressure in mm. of mercury. The difference in the essential character of these curves can be seen by comparing that for 40 volts with that for $2\frac{1}{2}$. The former obeys fairly well the law of Benoist and Hurmusezcu, that the rate of discharge is proportional to the square root of the density. This agreement is shown by plotting the rates of discharge as given by them. The curve thus found is practically the same as that for 40 volts. The curve for $2\frac{1}{2}$ volts obeys an entirely different law, having, in fact, a maximum for about 200 mm. pressure. This effect seems less improbable when we remember that the discharging effect for the ultra-violet reaches a maximum at about 200 mm.

It is known that a metal tends to assume a final potential different from zero when X-rays strike upon it. It was thought at first that this effect might be complicating the phenomena that were being studied, but care was taken that the plate from which the discharge took place was surrounded by a grounded plate of the same metal, and the final potential when the plate was disconnected from the source of the E. M. F. and the X-rays were allowed to strike upon it continuously varied so little from zero as to be entirely negligible.

It is evident that another set of curves could be plotted showing the relation between the rate of discharge and the E. M. F.

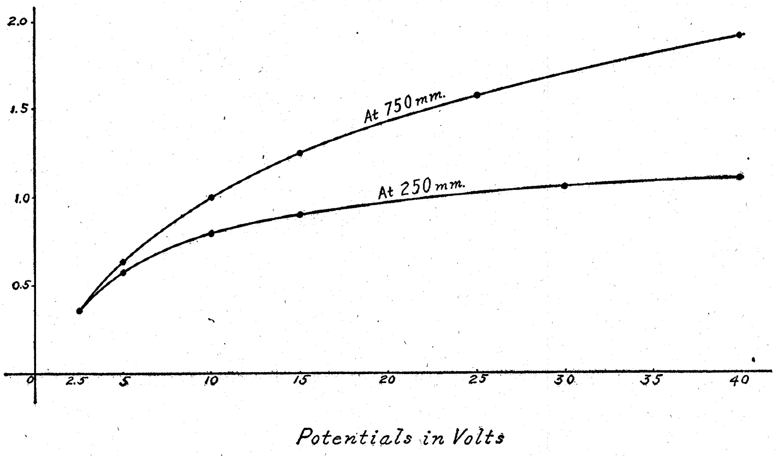

FIG. 2.

at different densities of the gas. Thomson and Rutherford (*Phil. Mag.*, 42, 392) and others have already studied this subject and shown that the current does not obey Ohm's law. As high E. M. F.'s are reached the current does not increase in a manner proportional to the increase in E. M. F. In Fig. 2 I have plotted such a set of curves, and it will be noticed that the form of the curve is not the same for different densities of the gas. Thomson and Rutherford have shown that the form of curve is not the same in the cases of air and hydrogen. The curve for air as given by them (Ibid, p. 404) is similar to the curve given in Fig. 2 for normal density of the air. That for hydrogen is similar to that given in Fig. 2 for pressure of 250 mm. However, it can scarcely be said that the form of the curve depends upon the density of the gas. The curve for mercury vapor as given by Thomson and Rutherford does, indeed, differ from that given for air in the opposite manner from that for hydrogen, but their curves for chlorine, sulphuretted hydrogen and air coincide in form, and the densities of these gases differ widely. They infer from their theory of this action "that more conducting particles are produced by the rays in air than in hydrogen, but that the product of U, the velocity of these particles, and T, a time which is proportional to the time these particles linger after the rays are cut off, is greater for hydrogen than it is for air." It is altogether possible that the same explanation may apply to the case where the same gas is used at different pressures. However, experiments to prove this would certainly be desirable. They also state that "the gases which have large saturation curves are those which contain the elements which have abnormally large specific inductive capacities in comparison with their valency." This remark does not seem to apply to the case where the same gas is used at different pressures. The saturation currents here do differ, and it is hard to see how either the specific inductive capacities or the valencies can differ for air at different densities.

It has also been found that the form of the curve between rates of discharge and density of air is different for different intensities of the rays. The curves which have already been plotted were taken with the tube near to the plate to be discharged. A series of curves were also taken with the tube at some distance from the plate and several inches of board placed between the two. These curves were somewhat similar to those shown in Fig. 1, but there was not as marked a difference between the curves for different potentials. In fact there was no curve which showed a maximum for pressures less than atmospheric pressure. It, therefore, seems scarcely advisable to try to get the form of the curves with any great degree of accuracy at present, for the form depends upon the intensity of the rays and there is no way of determining this intensity in any standard unit. I can define the intensity no better than I have already defined it in stating the rate of discharge which it produces from a zinc plate of given area with an approximate guess at the number of units of capacity in the system of plate, condenser and connections.

It has been stated by Perrin (C. R. 124, 454) that the discharge effect can be separated into a surface effect between the gas and the charged metal, and a volume effect throughout the gas. It was, therefore, thought that covering the zinc plate with a thin film of paraffin might change the form of the curve when the density of the air is changed. This was tried and no such change was noticed. It has not been possible to keep the action of the tube exactly constant, and so one cannot be entirely sure of the correctness of the results, but if coating the zinc plate with paraffin causes any change in the form of the curve it is at least small.

The plate to be discharged was then placed in the shadow of an opaque obstacle, and rays allowed to strike only the air near the plate. The form of the curve was not different from that obtained when the rays were partially screened off from both the plate and the surrounding air. These two experiments do not corroborate the theory of Perrin as given above.

It is also to be noted that the conditions in this last experiment were similar to those under which Perrin worked when he found the relations between the rate of discharge and the density of the gas, but the results which I found did not agree with the law as given by him.

There is also a fact in connection with this work which is worthy of note, although it does not directly bear upon the experiments here described. After the discharge had taken place the plate would often appear to recharge to a very noticeable degree. The electrometer used was a 'dead beat' electrometer. The recharging seemed to be more noticeable when the original potential was small, and the intensity of the rays great. My apparatus is not well adapted to study this phenomenon, nor have I had the time to do so. I hope hereafter to give a better proof of the existence of this phenomenon than I can at present offer, and to study the conditions under which it occurs more fully.

The experiments which I have described indicate a conduction effect through the gas rather than a convection effect due to particles thrown off from the discharging plate, but it would seem scarcely advisable to attempt to form a theory to explain these phenomena until they have been studied more completely.

Since writing the preceding I have investigated more completely the dependence of the rate of discharge caused by X-rays upon the potential used at different pressures of the surrounding gas. I find that the limiting value of the current is sooner reached when the experiment is carried on at low pressures than it is at higher ones, and that the limiting values, called by Thomson and Rutherford saturation points, are roughly proportional to the square roots of the density of the gas.

Stoletow (*Journ. de Phys.* 9, 471) found that in the case of discharge caused by ultra-violet light the pressure of the gas at which a maximum effect occurred was proportional to the potential with which he was working. I have tested the discharge caused by the X-rays in this respect, and for this purpose I used much greater intensity of radiation than I had previously used. I found the pressure for maximum effect to be roughly proportional to potential of the charged plate. Also the intensity of the rays has a very great effect on the point of maximum effect. The greater the intensity the lower was this point.

I have also tried allowing the rays to strike the charged body at normal incidence, and the results were the same which I had previously found when the incidence was grazing.

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CURRENT NOTES ON PHYSIOGRAPHY.

CORNISH ON SAND DUNES.

MR. VAUGHAN CORNISH discusses the formation of sand-dunes (*London Geogr. Journ.*, IX., 1897, 278–309), and throws much light on their growth and movements. Basing his work on observation and experiment he discusses the effects of supply and texture of sand and of direction and strength of wind, and reaches satisfactory explanations of transverse, longitudinal and crescentic dunes (*barchanes* of Arabia, *medanos* of Peru), adding a suggestive hypothesis for the origin by wind-excava-