ON THE NATURE OF THE IONS FROM HOT PLATINUM

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ABSTRACT

The mobilities of the ions produced by hot platinum were obtained by driving the ions across a stream of air by means of an electric field. The currents at a down stream point were obtained at different values of the field. The current voltage curves for the ions from platinum were compared with curves obtained in a similar manner using ions produced in air by alpha rays. An initial and a final positive ion and one negative ion were found, the same as in the case of the air ions. The mobility values obtained for these ions are also the same as for the air ions. A discussion of the results leads to the conclusion that the negative and final positive ions from platinum are air ions. The initial positive ion may also be an air ion, but this is less certain.

IN an earlier paper[1] results were reported showing that the positive ion from hot platinum has at first a mobility which is the same as the mobility of the negative air ion and the initial[2] positive air ion and that within an interval of the order of 0.3 sec. it changes into an ion which has the same mobility as the final positive air ion. It was also found that if the ions are allowed to remain for a time in the air which has passed the platinum, they load up and form a gradation of larger positive ions.

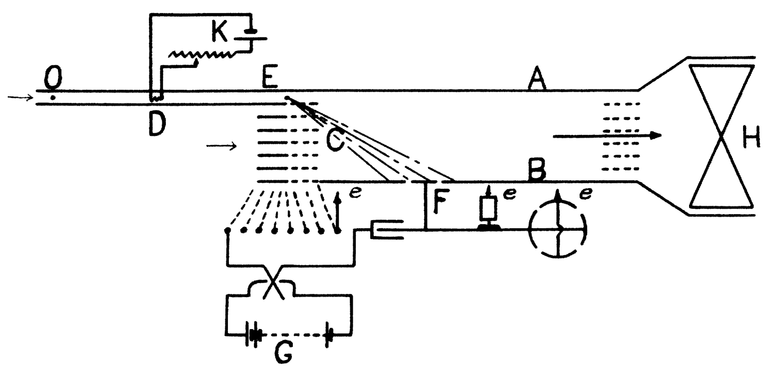

Fig. 1. Apparatus.

As these results were obtained by means of an apparatus which did not have a very high resolving power, it was thought desirable to repeat the work using an apparatus capable of more fully separating the two positive ions.

The method used may be briefly described as follows. By means of a fan H, air was drawn between the parallel plates A and B which were

[1] Erikson, Phys. Rev. **21**, p. 720 (1923).
[2] Erikson, Phys. Rev. **24**, p. 502 (1924).

3.5 cm apart and which were maintained at a difference of potential by means of the battery G. The platinum wire was placed at E, D, or O, and was heated by means of a current from the battery K. The ions formed at the platinum surface were carried with the air and when in the space between the plates A and B were drawn to A or B depending upon the sign of their charges. At plate B the current due to the ions coming to a narrow strip F was measured. These currents were obtained for different potentials between A and B. The currents are plotted as ordinates against the potentials as abscissas. By moving the platinum wire towards O, the age of the ions was increased. As the ion emission depends upon the length of time the wire has been heated, care was taken to keep the

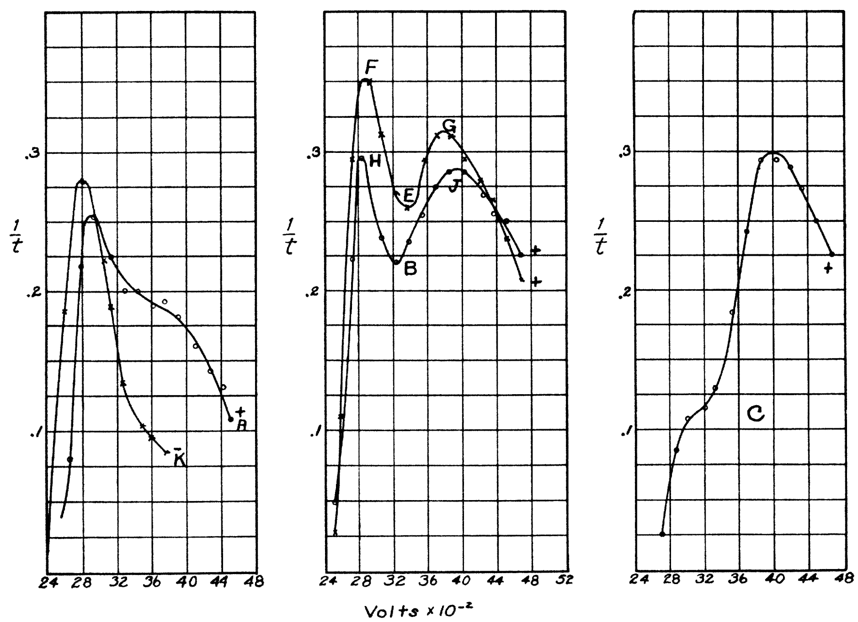

Fig. 2. Currents to strip F as a function of potential between A and B.

heating circuit open between readings. Continuous heating of the platinum during the hour or more required for a set of readings, causes a change in the ion emission which masks, in part, the effect sought for. In the case of the positive ion the platinum was kept at a deep red.

The Positive Ions

The results obtained, in the case of the positive ion, are shown in Fig. 2, where the ordinates represent the currents to the strip F in arbitrary units.

Curve HBJ was obtained with the platinum at D, Fig. 1, the median position. Curve FEG is for the positive ions produced in air by the alpha rays from polonium placed at D, the conditions otherwise being identical, and is inserted for comparison. The maximum F of the air curve FEG is due to the initial positive air ion[2] and the maximum G is for the final positive air ion. These correspond respectively to mobilities of 1.87 and 1.36 cm/sec/volt/cm. It is thus seen that hot platinum gives rise to two positive ions which have the same mobilities as the initial and final positive air ions.

That the positive ion from hot platinum which gives rise to the maximum H in curve HBJ is an initial ion is shown by the series of curves A, B and C, Fig. 2. The three curves were obtained with the platinum at E, D, and O, Fig. 1, respectively. Comparison of these shows that this ion changes into the slower ion as it becomes older.

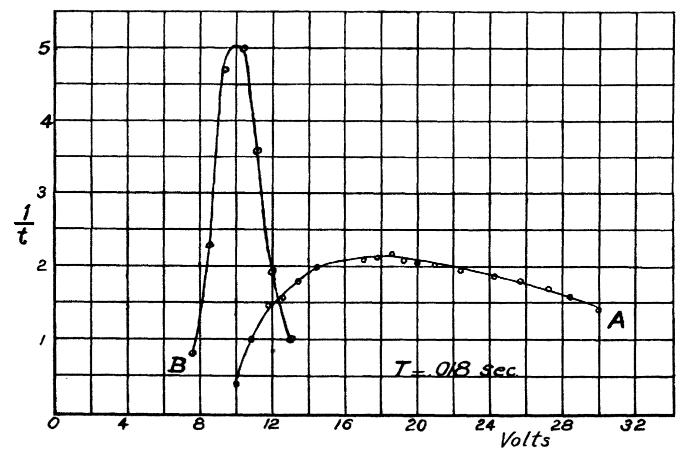

Fig. 3.

In Fig. 3, curve A shows the result when the platinum is placed at O, Fig. 1, the velocity of the air reduced, and the platinum raised to white incandescence. It is seen that a gradation of positive ions are obtained. In this case the ions are in an atmosphere of platinum dust for a considerable time and attach themselves to platinum particles of various sizes. Curve B, Fig. 3, is for the negative air ion and shows the position the initial positive ion from platinum would have if present. On account of this loading it is necessary if the pure initial effect is desired, to have the platinum at the lowest temperature which will give sufficient ions for measurement.

The Negative Ion

In Fig. 2, curve K is for the negative ion and was obtained by placing the platinum at E, Fig. 1, and heating it to incandescence. Indication of only one ion was obtained. This ion, it is seen, has the same mobility as the initial positive ion from platinum and hence the same mobility as the negative air ion also.

Discussion as to the Nature of the Above Ions

The question as to the nature of the ions from hot platinum can not be completely answered from the standpoint of present experimental evidence. The writer believes, however, that the final of the two positive ions is formed when the initial positive ion attaches itself to a neutral air molecule. That this transition is possible is shown by satisfactory experimental evidence, not only in this but in earlier work on gas ions. It can with fair certainty be said also that the negative ion is an air molecule which has attached an electron since electrons are emitted from hot platinum and such attachments are known to be possible. That the initial positive ion is also an air ion can not be stated with equal certainty, although it is very probable that such is the case, as this ion is not formed continuously in a vacuum. It is difficult to make even a hypothetical statement as to the mechanism of its formation because the electron must pass from an air atom of higher electron affinity to one of lower. Langmuir and Kingdon[3] have shown that caesium atoms upon striking a clean tungsten surface lose valence electrons and leave the surface positively charged. The reason they give for this is that the electron affinity of tungsten is 4.53 volts whereas the electron affinity of caesium is only 3.88 volts and this reason seems entirely valid. In the case in question it is necessary for the electron to pass in the opposite direction. There may, however, be other determining factors. In the case of platinum in air at normal pressure it is one collision in about 10^{14} per sq. cm per sec. with which we are concerned. If metallic conduction is due to free electrons or electron interchange between the atoms of the metal, then some of the platinum atoms it would seem, in view of the thermal agitation, must exist for a time minus an electron. It may be that when a neutral gas molecule collides with one of these positive platinum or metal atoms, it gives up an electron even though its ionizing potential is higher than that of the metal atom.

Financial aid toward this research was given by the Executive Committee of the Graduate School of the University of Minnesota, and the author wishes to express his appreciation of this help.

Physical Laboratory,
University of Minnesota,
February 1, 1925.

[3] Langmuir and Kingdon, Proc. Royal Society **A107**, p. 61 (1925).