On the negatively charged Particles in the Positive Ray Tube.

By

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The negatively charged particles in the positive ray tube has been investigated by J. J. Thomson. The results he obtained may be summarized as follows:

(i). The atoms of hydrogen, carbon, chlorine, and sulphur occur with a negative charge, but those of helium, nitrogen, neon, krypton, xenon, and vapour of mercury do never so appear.

(ii). The molecule of a compound with a negative charge does not occur at all; but a few kinds of molecules of certain elements, namely, O_2, C_2, O_3, H_3, with a negative charge are fonnd in some exceptional cases.

(iii). The radicles of OH and CN with a negative charge are observed.

The aim of the present paper is to furnish some further knowledge on the negatively charged particles observed in the positive ray analysis.

The method of photographing the positive rays is quite the same as that described in a former paper[1] by one of the present authors. The experiments were carried out with the gases of chlorine, hydrogen sulphide, sulphur dioxide, and the vapours of carbon bisulphide and nitric acid, introduced into the discharge bulb. The results of the examination of the lines on the photographic plates are given below.

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1 M. Ishino, "On the Evidence of the Existence of Isotopes of Chlorine," in this number of the Memoir.

(1). Negatively charged atoms.

In agreement with J. J. Thomson's results, the carriers of the negative charge were commonly found in the atomic type. The atoms of hydrogen, carbon, and oxygen were found in almost every case. The intensity of the parabola due to O^- was sometimes stronger than that due to O^+. When chlorine was present in the discharge bulb, the two isotopes, Cl_I and Cl_{II}, with negative charge were conspicuous.[1] When CS_2 or SO_2 was introduced into the tube, negatively charged sulphur atoms were found.

(2). Negatively charged molecules of elements.

In the case of CS_2 a very faint line due to C_2^- was observed. (Fig. 1 in Plate I.) Negatively charged molecules of oxygen are very seldom noticed. These facts are in accordance with Thomson's results.

(3). Negatively charged molecules of Compounds or Radicles.

Contrary to Thomson's result, we have often met with some cases in which the molecule of a compound has been found with a negative charge. When H_2O_2 gas was present in the tube, the negatively charged molecules of H_2O made appearance. This line was ascribed at first to OH^-, but repeated measurements of the value of $\frac{e}{m}$ show the line to be H_2O^-. (See Fig. 2 in Plate I.). In the case where CS_2 gas was present, particles of SO^- and SO_2^- were observed (See Fig. 1 in Plate I.). With the vapour of nitric acid the line of NO^- has appeared. (See Fig. 3 in Plate I). In some cases a trace of CN^- could be observed. Now it is here highly desirable to notice that the molecules and radicles SO, SO_2, NO, are all chemically very active, and at the same time strongly eleetro-negative.

All the main beads of the negative parabolas due to the above-mentioned atomic ond molecular carriers of the negative charge are found on a vertical line. The distance of this line from the vertical line through the origin is nearly equal to the corresponding distance for the positive parabolas. This fact leads us to infer that, as J. J.

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[1] $Cl_I = 34$, $Cl_{II} = 36$. See M. Ishino, l. c.

Thomson has suggested, the maximum kinetic energy of these negatively charged particles is equal to that for the corresponding positive ones. The amount of this kinetic energy is determined by the potential difference between the anode and cathode of the discharge-bulb.

The appearance of the negative particles may be explained by the following consideration.

Being once positively charged in front of the cathode, the negative particles acquire their high speed under the action of the intense electric field. After passing through the cathode each of the particles get neutralized, and then capture an electron, and becomes negatively charged. In the case under consideration, the captures of electrons by SO, SO_2 and NO are due to their strong electro-negative behaviour.

(4). The second bead on the parabola due to negatively charged atoms.

In addition to the main bead of a negative parabola, the second one is also sometimes observed on the prolongation of the parabola to the origin. The features are shown in Fig. 1, Fig. 4 and Fig. 5, Plate I, in which are present the lines due to C^-, O^- and S^-. Similar beads also occur in the parabolas of Cl_I^-, Cl_{II}^-, which are shown in Fig. 1 in Plate in the paper[1] by one of the authors. The position of the second bead is about midway between the vertical line passing through the first main bead and that through the origin.

The existence of these second beads suggest to us that in the discharge bulb the particles producing the beads possess double positive charges but by passing through the cathode, they lose these and capture one electron.

The prolongation of the negative parabola to the origin is generally so faint, that it was not easy to take the photograph of the second bead. The above mode of explanation is strongly supported by the following facts. When the negative second beads are present, we generally find on the positive side of the same photographic plate the corresponding positive second beads. Besides we find the lines for which the value of $\frac{e}{m}$ is twice that of the second beads. These lines begin from the vertical line for the main beads and they are

1 Loc. Cit.

due to the particles which have still retained their double positive charges after passing through the cathode.

(5). The third bead on the negative parabola.

In Fig. 5 and Fig. 6 in Plate I, it is clearly seen that in the parabolas due to H^-, O^-, Cl^- etc. there are the third beads, the distance of which from the vertical line through the origin being twice that of the main beads of the parabolas. It is a very striking fact that whenever these third beads make appearance, the parabolas due to the corresponding molecules with positive charge always occur associated on the positive side of the plate.

Judging from this we see that the negatively charged particles which produce the above third beads are probably the atoms resulting from the splitting up of the positively charged molecules after passing through the cathode.

(6). The secondary line due to the negatively charged particles.

It is seen in Fig. 5, 6, 7 and 8 in Plate II, that the parabolas due to the atoms of H^-, O^-, Cl^-, S^- are sometimes accompanied by the secondary lines. These lines are, like those in the case of positively charged particles, probably due to the particles which are charged only for a short time while they are travelling in the electric and magnetic fields.

SUMMARY.

We have found some new facts relating to the negatively charged particles in the positive ray tube. Some negatively charged molecules of compounds previously unknown were observed.

Next the second and third beads on the primary negative parabolas were discovered; and finally the secondary lines due to negatively charged particles were found.

In conclusion the author's thanks are due to Professor T. Mizuno for the interest he has taken in this investigation.

Plate I.

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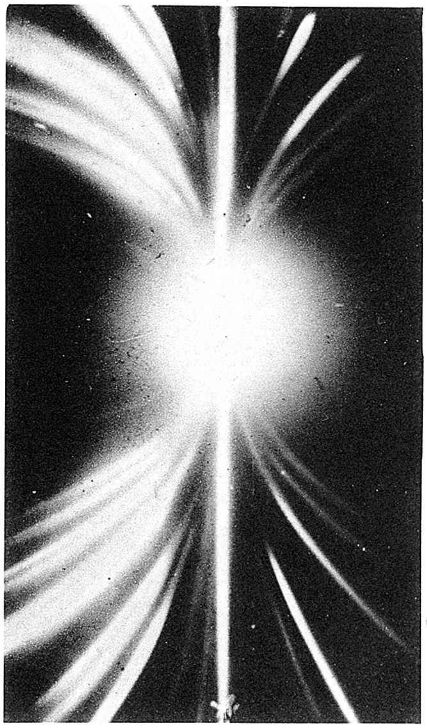

Fig. 1.

Parabolas of C_2^-, S^-, SO^-, SO_2^-
Secondary lines of S^-, O^-

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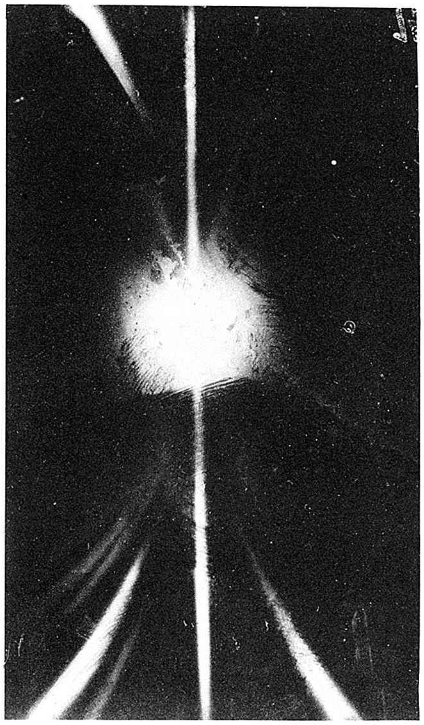

Fig. 2.

Parabolas of H_2O^-

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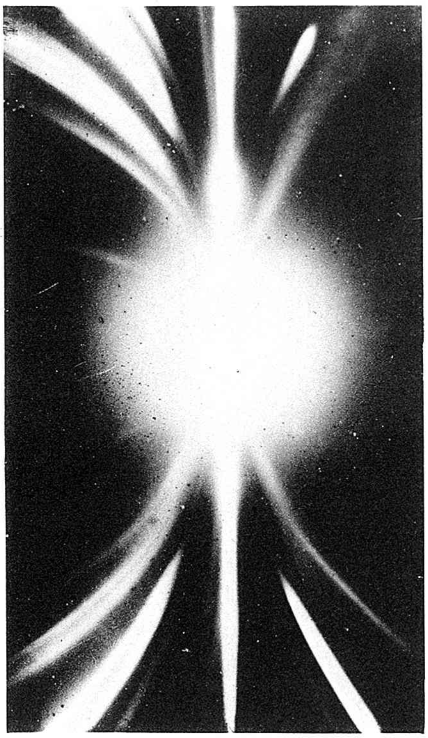

Fig. 3

Parabolas of NO^-, O^-.
Secondary line of O^-.

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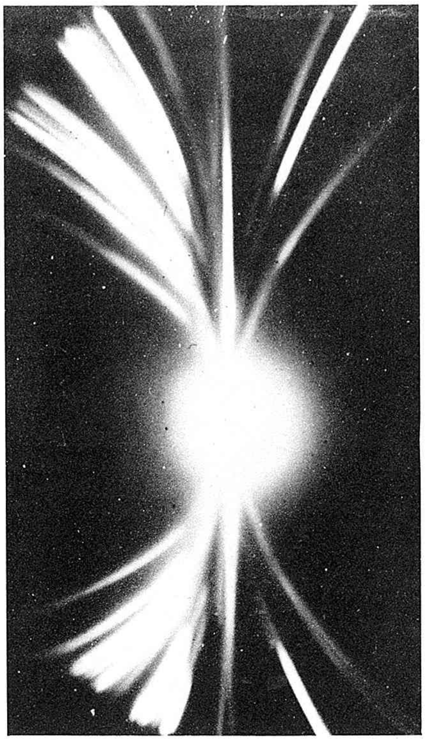

Fig. 4.

Parabolas of Cl_I^-, Cl_{II}^-, O^-, C^-.
Second beads of C^-, O^-, Cl^-.
Secondary lines of O^-, Cl^- (?)

Plate II.

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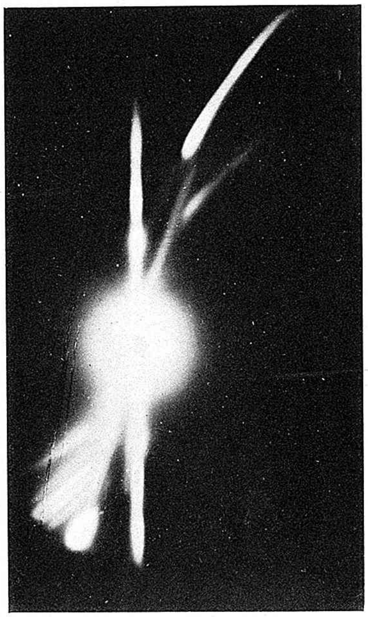

Fig. 5.

Second beads of O^-, Cl^-.
Third beads of O^-, Cl^-.
Secondary line of O^-.

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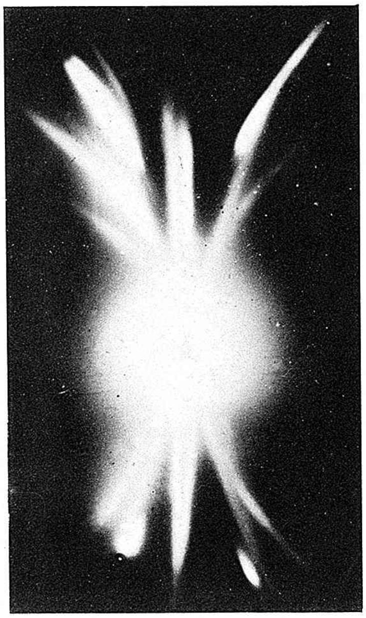

Fig. 6.

O^-, Cl^-.
The third beads of O^-, Cl^-.
Secondary line of O^-.
Parabolas of H_2O+, $O+$.

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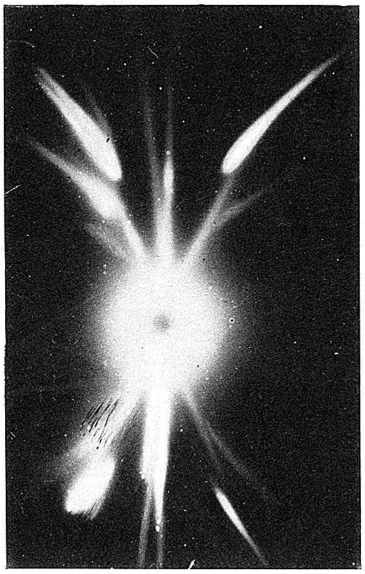

Fig. 7.

Parabolas of O^-, Cl^-.
Third beads of O^-, Cl^-.
Secondary line of O^-.
Parabolas of H_2O+, $O+$.

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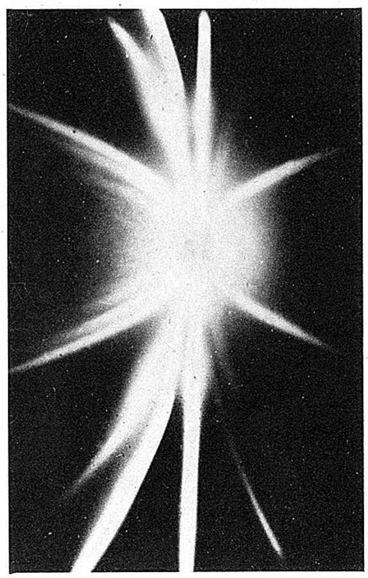

Fig. 8.

Secondary line of H^-