Unilateral Conductivity of Tubes having a Salt Electrode

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One of us, while studying the spectrum of chlorine, found that a tube having sodium chloride as one electrode allows to pass an electric current easily in one direction, but not in the other. This unilateral conductivity possessed by such a tube seemed to be worthy of study, and the condition of the tube for the perfect rectification was examined, and some of the results obtained will be described below.

The tube used in this study was a half litre bulb provided with two side tubes having platinum electrodes, and a well dried sodium chloride was put in one of the side tubes just enough to cover the top of the platinum wire. Such a tube was connected to a pump, and residual air, with gases evolved by heating the wall of the tube and also evolved by discharges, was pumped out. As exhaustion proceeded, the discharge from an induction coil began to get difficult to pass when the platinum electrode was cathode. But when the salt electrode was made cathode current passed very easily, showing that the tube exhibits an unilateral conductivity.

In order to see the mode of rectification of a high tension alternating current by such a tube, the method of a glow oscilloscope and a falling plate camera was adopted. A tube thus prepared was connected in series with the oscilloscope in the secondary circuit of a Bilitzen transformer of ¼ K. W. giving about 6000 volts, and the lengths of the glow along the wire electrodes of the oscilloscope were

photographed by a falling plate camera. Photographs thus obtained are shown in the annexed figures. Fig. 1, represents the form of the alternating current itself given by the transformer, and Fig. 2 shows

FIG. 1.

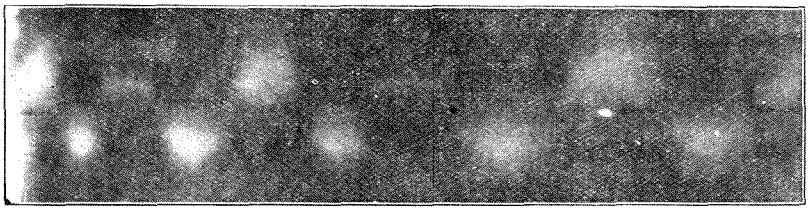
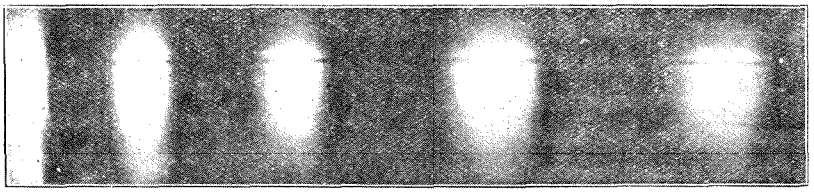


FIG. 2.



the current form rectified by the tube. This shows clearly that the tube allows current in one direction but hinders it in the other.

If the quantity of the salt at the electrode was increased the rectifying property of the tube began to be affected, and when it exceeded a certain amount, the tube showed a tendency to lose the unilateral property, provided the other electrode had a small surface.

Thus the quantity of the salt at the electrode seems to play an important rôle in the process of rectification, the proper amount of the salt being such that it just covers the platinum wire.

The salt electrode, when rectifying the current, got very hot, and the tube allowed the current only from the colder electrode to the hotter one. In this respect the salt electrode seems to behave like a Wehnelt cathode. The salt electrode and the glass wall surrounding it were coloured, exhibiting a beautiful violet tint. This would be due to the sodium which had been decomposed by the discharge from the salt electrode; in fact, the above colour resembles that of the colloidal solution of sodium in alcohol. The chlorine set

free in consequence of the decomposition of the salt would diffuse out into the tube.

The mode of the unilateral conductivity possessed by the tubes may be explained in the following way. An electric current in such a tube would chiefly be carried by positive and negative ions, but very scantily by free electrons. For the latter have a very strong affinity toward chlorine and would soon unite with it to form negative ions of chlorine, so that the free electrons left in the tube would be very few.

If the salt electrode was made anode, negative ions of chlorine would proceed to the salt electrode, where they would unite with free sodium, forming sodium chloride. By this process the free chlorine ions in the tube would be cleared away and the vacuum would improve, the discharge becoming thereby difficult. But if the salt were made cathode, the chlorine ions would proceed toward the other electrode and the greater part of them would unite with the electrode and disappear from the tube. On the other hand, the salt molecules at the cathode would be bombarded by the coming positive ions of residual gases and consequently would be decomposed into sodium and chlorine atoms. Beside this, plenty of electrons would have been liberated at the hot sodium lying in the neighborhood of the electrode just as in the case of a Wehnelt cathode. The chlorine thus set free would soon catch electrons, and become negative ions, so that the supply of chlorine would continue so long as the process was going on, and the current would thus flow.

The unilateral conductivity was not only limited to the electrode of sodium chloride, but potassium chloride, barium chloride etc. behaved in a similar way, the explanation given above being perhaps equally applicable.

Summary

1. Vacuum tubes having a salt electrode were found to have the property of rectifying high tension alternating currents, and the conditions of perfect rectification were examined.

2. An explanation of the process of rectification was afforded.

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