VARIATION WITH TEMPERATURE OF THE WORK FUNCTION OF OXIDE-COATED PLATINUM

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Abstract

A series of tests was made with standard Western Electric VT2 vacuum tubes, in which the filament was held at a higher temperature for a period of five minutes and then returned to a lower reading temperature (950°C) and the electron current measured with a plate potential of 110 volts. It was found that the previous heating of the filament caused a temporary increase in the electron current over the normal value for that temperature, and that this effect increased with temperature up to about 1130°C, after which point it began to fall off. The results of another series of tests indicate that positive ion emission from the filament begins at a temperature somewhat above that which produced maximum electron current. These results are in agreement with the theory that the thermionic activity of oxide-coated platinum filaments is probably due to a film of metallic barium and strontium produced by reduction of the oxides.

THE results of experiments performed by Langmuir and Kingdon,[1] Ives,[2] and Killian,[3] seem to indicate that the decrease in the work function of hot tungsten in the presence of the vapors of the alkali metals, or when thorium oxide is present as an impurity in the tungsten, is due to the formation of a film of those metals on the surface of the tungsten. In the work leading up to the present paper, similar experiments have been tried with platinum filaments coated with the oxides of barium and strontium.

The electron current in a standard Western Electric VT2 tube with 110 volts between filament and plate-grid was measured over a range of "activating" temperatures from 950°*C* to 1200°*C*. By "activating" temperature is meant the temperature at which the filament was held for a period of five minutes previous to the taking of the reading. All the readings were actually taken at the temperature of 950°*C*. In this way, the relative amounts of activation produced at different temperatures could be shown without subjecting the filament to the injurious effect of heavy plate current at high temperatures. Since the emission from these filaments has been shown to obey Richardson's equation, we may attribute any change in the emission produced by the heating to changes in the work function.

[1] Langmuir and Kingdon, Science **57,** 58 (1923); Proc. of Roy. Soc. **107,** Jan. 1, 1925
[2] Ives, J. of Franklin Inst. Jan., 1926.
[3] Killian, Phys. Rev. **27,** 578 (1926).

The method of manipulation was as follows: The filament was brought up to reading temperature (950°*C*) and held at that point until the plate current became constant. The plate voltage was then turned off and the filament was maintained at the activating temperature for a period of five minutes, then returned to reading temperature. The plate current was found to be higher then before, but if allowed to stand for a few minutes (five to ten minutes) it would come back to the normal value. As soon as it became constant again the process was repeated for another temperature. By this means it was found that the electron emission increased with "activating" temperature up to approximately 1100°*C* as measured by an optical pyrometer. Beyond that point the plate current began to fall off with further increase in temperature.

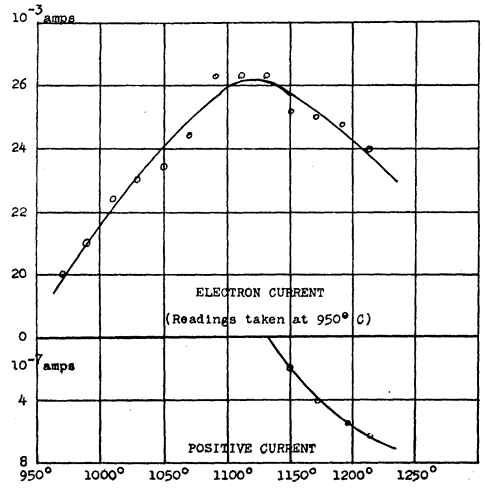

Fig. 1.

A series of tests was then made to determine whether any production of positive ions occurred at various temperatures. Some difficulty was experienced in this because of the fact that in a vacuum tube which has had some use a very thin film of metal may distill over from the filament onto the insulation and cause a slight leakage between filament and plate. A tube was selected in which this effect was not noticeable, and a set of readings for the positive and negative emissions were taken immediately after each other. The results of this experiment are shown in the graph. It will be noticed that the maximum electron emission occurred for an "activating" temperature of about 1120°*C*. This value is preferable to that obtained in the first series because of refinements introduced in the

method of temperature measurement. It will be noticed further that positive ion emission began slightly above 1130°C.

These results are in agreement with the theory that the activity of the oxide-coated platinum filament is probably due to a film of metallic barium and strontium produced by reduction of the oxides, just as the activity of tungsten filaments varies with the coating of alkali metals. The extent of this chemical change apparently depends upon the temperature of the filament, and the amount of metallic film present at any temperature represents the equilibrium condition between formation and evaporation at that temperature. At low temperatures the metal evaporates as neutral atoms, but as the rate of evaporation begins to exceed the rate of production, a part of the filament may be left without a coating of the metal and its work function is higher than the ionizing potential of the escaping atoms. When this condition is produced some of the evaporating electrons will be deprived of one electron, and they then appear as positive ions. Similar considerations have been applied by Langmuir and Kingdon, and Ives to the emission of positive caesium ions from tungsten.

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