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THERMIONIC CATHODE AND PROCESS OF ACTIVATION

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The present invention relates to thermionic cathodes containing or yielding a material of high electron emissivity, which during operation is present on the foundation material of the cathode as an adsorbed film of minute thickness. An example of such a cathode is a tungsten cathode containing thoria, with or without a reducing agent such as carbon, and operating with an adsorbed film of metallic thorium.

It is the object of my invention to improve the efficiency and life of such adsorbed film cathode in thermionic devices.

In the course of the preparation of cathodes of this type, examples of which are described in U. S. Patent 1,244,216, and U. S. Patents 1,747,061, -2, -3, and -4, the cathodes are subjected to a heat treatment at a temperature above the normal operating temperature in a thermionic device. By this treatment, known as "flashing", the electron emissivity of the cathode is increased and in fact without being flashed a thermionic cathode of the adsorbed film type, containing a material which is capable of furnishing a material of higher electron emissivity than the foundation material, would exhibit little or no improved electron emissivity compared with a cathode unassociated with such material. "Flashing" as described in these patents and as understood in the art involves heating with an abrupt rise of temperature to a desired value.

In accordance with my invention, the efficiency of adsorbed film cathodes is improved and their life is materially lengthened by carrying out the flashing of such cathodes in the presence of gas at substantial pressure, this gas being removed after flashing, if operation of the flashed cathode is desired at lower pressure or in a good vacuum.

The advantages and novel features of my invention will be better understood by consideration of the following specific example, namely, the flashing in the presence of gas of a thoriated cathode, such as described in United States Patent 1,244,216. Tungsten cathodes of filamentary, or other suitable form, containing thoria are heated conveniently by passage of current in a gas which does not unfavorably react with such filaments at substantial pressure to a temperature of about 3,000° Kelvin or higher for about one minute. The filament is so flashed that it attains at once the full temperature desired, and being heated as a whole by passage of current, it comes up to the desired temperature throughout its length. Hydrogen, argon and nitrogen are examples of gas suitable for the purposes of my invention.

The gas ordinarily should be at a pressure of the order of atmospheric pressure, but in any event should be high enough to materially retard vaporization of electrode material. The cathode thus flashed then should be activated by flashing at a lower temperature in vacuum in accordance with the usual practice. Activation may be combined with carburization of the cathode, a process described in United States Patent 1,529,597 of March 10, 1925.

Vapor containing carbon in chemical combination, for example vapor of benzol, or similar hydrocarbon, then is admitted and the cathodes are heated to incandescence to deposit carbon thereon.

The cathodes thus prepared when operated in vacuum electron discharge devices at a temperature of about 2,000° K. have a higher initial electron emissivity than cathodes which have not been subjected to a flashing treatment in gas, and have a life about two to ten times greater than cathodes not thus treated.

I believe the beneficial effect of flashing thermionic cathodes containing a material of higher electron emissivity than the main foundation material of the cathode, that is thoria in the described instance, is to be ascribed to change in crystalline structure of the metal which is affected by the high temperature treatment. I have found that the grain structure of the foundation metal is materially coarsened by the flashing. I believe that the diffusion of the material of high electron emissivity is very much slower in a coarse-grained metal than in a fine-grained metal. The life of such a cathode appears to be determined largely by the length of time consumed in the diffusion of the high emission material, for example thorium, from the interior of crystals to the exterior where it is gradually vaporized. In a coarsely grained metal structure the rate of diffusion of thorium or the like to the surface of the cathode is reduced sufficiently to cause the diffusing thorium to compensate for normal loss of thorium by evaporation from the surface without the excessive accumulation of thorium upon the surface. Metal treated by heating to about 3,000° K. in a gas has a grain size whose minimum is at least three times that of metal which has not been subjected to this high temperature. They are present also in the metal crystals of a very much greater relative size. The high temperature treatment in the presence of gas may also lead to other beneficial effects.

In vacuum the accumulation of reduced mate-

rial, for example, thorium, in a thoriated filament by flashing is limited to a definite equilibrium. When the flashing is carried out in the presence of a gas, a great accumulation of thorium appears to occur accompanied by the described increase in life when a cathode thus flashed is operated at lower temperature in a vacuum.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. The step in the method of activating a thoriated tungsten cathode which comprises incandescing said cathode in the presence of hydrogen gas at a pressure of the order of atmospheric pressure at a temperature of about 3,000° K.

2. The process of activating a thoriated filament of tungsten for use as a thermionic cathode which consists in flashing said cathode at a temperature of at least about 3,000° K. in hydrogen gas at substantial pressure, carburizing said cathode and thereafter evacuating gas from the environment of said cathode.

3. In the art of activating electron emissive cathodes comprising thoriated tungsten, the step which consists in flashing the cathode material at a temperature of about 3,000° K. in the presence of a gas, such as hydrogen, which does not react unfavorably with such material and which is at a substantial pressure sufficiently high to materially retard vaporization of the cathode material.

4. In the art of activating electron emissive cathodes comprising thoriated tungsten, the step which consists in flashing the cathode material at a temperature of about 3,000° K. in the presence of a gas, such as hydrogen, which does not react unfavorably with such material and which is at a pressure on the order of about one atmosphere.

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