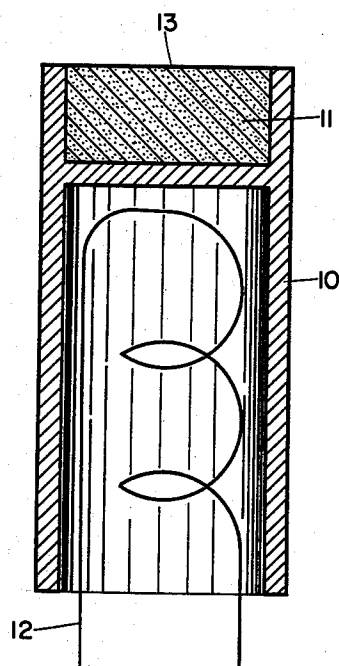


March 22, 1960

R. C. HUGHES
DISPENSER CATHODE
Filed Sept. 5, 1956

2,929,133



INVENTOR.
RAY C. HUGHES
BY *John W. Vogel*
AGENT

1

2,929,133

DISPENSER CATHODE

Ray C. Hughes, Ardsley, N.Y., assignor to North American Philips Company, Inc., New York, N.Y., a corporation of Delaware

Application September 5, 1956, Serial No. 608,130

6 Claims. (Cl. 29—182.5)

My invention relates to dispenser cathodes, and in particular to thermionic, dispenser cathodes of the type comprising an alkaline earth metal compound dispersed in a refractory metal matrix, and to methods of making such cathodes.

In my United States Patent 2,700,118, there is described a cathode comprising a pressed and sintered mixture of powdered refractory metal and barium aluminate. When heated by the usual filament at an elevated temperature, a reaction occurs between the aluminate and the refractory metal productive of free alkaline earth metal, i.e., barium, which is then supplied to a surface of the pressed body and forms a monatomic layer thereon. Such a surface covered with a monatomic layer of barium metal constitutes an excellent source of electrons.

The cathode described in said patent exhibits an important drawback, to wit, that after assembly in a discharge tube, it requires an aging period of about 24 hours before its emission reaches a maximum, stable value. This aging treatment makes more complex the manufacture of the cathode, and results in an attendant increase in cost and time consumption.

The chief object of my invention is to provide an improved cathode of the type described in which the aging time to realize full emission is materially shortened and preferably substantially eliminated.

Briefly, my invention involves the incorporation into the cathode mixture prior to pressing and sintering of a small amount of a reducing substance, such as carbon, capable of binding up any excess oxygen present in the pressed mixture during the sintering and activation thereof and forming therewith gaseous reaction products, which may then be driven off and thus removed from the resultant cathode. In this way, I have been able to manufacture cathodes which are capable of being fully activated on the pumping system, and thus reaching maximum emission within a minute or less.

My invention will now be described in connection with the accompanying drawing, the sole figure of which is a cross-sectional view of a cathode made in accordance with my invention.

Referring now to the drawing, there is shown therein a planar cathode comprising a cylindrical, H-shaped in cross-section, refractory metal support 10, for example, of molybdenum. In an upper chamber of the support defined by the H-shaped cross-section, there is secured a body 11 constituted of a pressed and sintered mixture of refractory metal and alkaline earth metal compound. The lower chamber formed by the support houses the usual heating filament 12. The upper, exposed surface 13 of the body 11 constitutes the electron emissive surface. While the invention is being described in connection with a planar cathode, it will be appreciated that the principles thereof are equally applicable to cylindrical or other types of cathodes for producing various shapes of electron beams.

The cathode shown may be manufactured in the following way. First, a refractory metal powder of the

2

proper composition is provided. For cathodes of this type, preferably an alloy of tungsten and molybdenum as described in a copending application, Serial No. 392,966, filed November 18, 1953, issued as Patent No. 2,899,592, is employed. A preferred form of this alloy is 75% molybdenum and 25% tungsten in weight percent. Of course, I wish it to be understood that my invention is not to be limited to cathodes made only of this particular alloy, as the results desired can be obtained with alloys in which the tungsten varies upwards from 10% and even including pure tungsten alone. The invention will also be operable with other refractory metals, such as tantalum, for example, or alloys of tantalum with molybdenum.

To make the alloy of tungsten and molybdenum, individual powders of tungsten and molybdenum are mixed together in the correct proportions and then alloyed by sintering for about 30 minutes at 2,000° C. in an inert atmosphere. The resultant mass is then pulverized back into powder form.

To this refractory metal alloy powder is added an alkaline earth metal compound capable of reacting therewith, when heated, to produce free alkaline earth metal. As the alkaline earth metal compound, I prefer to use barium aluminate, since with the latter material uniformly excellent cathodes have been produced.

The barium aluminate may be produced in the following way. To 5 moles of barium carbonate, which decomposes upon heating to barium oxide, is added 2 moles of aluminum oxide and 0.3 mole of calcium oxide. The mixture is then fused, and, upon solidification, pulverized into a powder. The composition of the resultant product is not precisely known, but it is believed to be a mixture of normal and basic aluminates of barium and calcium. For simplicity, I have referred broadly to the mass as barium aluminate, since the barium constituent is the essential one to produce an operative cathode. The calcium serves mainly to increase the emission and is preferably included, though satisfactory cathodes can be made without the addition of the calcium. The barium oxide preferably constitutes between 60 and 90% by weight of the aluminates, as is set forth in my aforementioned patent.

The powdered alloy and aluminate composition are then intimately mixed in the proportions of about 9 parts of the refractory metal alloy to about 1 part of the aluminate, considerable variation in these proportions being possible, and the mixture fired at 1,700° C. for about ½ minute to fuse the alkaline earth metal compounds. The fused compounds, in this case the aluminates, flow and are dispersed over the metal alloy particles resulting in a more uniform distribution of powders, which tends to eliminate voids and improve the smoothness of the surface of the sintered body, which is subsequently formed. The fired mixture is then crushed and finely ground, and then to the resultant powder is added up to 1% by weight of powdered carbon. The addition of even a trace of carbon has a beneficial result, but, since best results are obtained with an amount of carbon equal to about 0.1% of the total weight of all the powders, this is the preferred quantity utilized. The resultant powder mass is again intimately mixed, and pressed into the upper chamber of the support 10. Then the support containing the pressed mixture is sintered at about 1,700° C. for about ½ minute to produce a strong, rugged construction as depicted in the drawing.

The resultant cathode is then removed from the furnace, the filament 12 mounted in the lower chamber, and the cathode assembled into the envelope of an electric discharge tube. The tube is then placed on a pumping system and evacuated. While pumping out, the various electrodes are degassed by the usual high frequency

heating. The cathode, in turn, is degassed and activated by simply heating it at a temperature about 100° C. higher than the desired operating temperature. Since the usual operating temperature is about 1,000° C., the temperature employed for degassing, called the activation temperature, is chosen to be 1,100° C. In less than about one minute of heating on the pumping system, full emission from the cathode is realized, after which the tube may be tipped-off and thus permanently sealed. If a getter is present, it may then be flashed, and the tube is ready to be used. No aging is necessary, as compared to similar cathodes made without the carbon in which aging times of 24 hours was necessary to achieve full emission from the cathode.

While I am not precisely sure as to the exact role played by the carbon in the cathode of my invention, I believe that the following is the reason for its remarkable and beneficial behaviour though I wish it to be understood that I do not mean to be limited in any way insofar as the scope of the invention is concerned by the following explanation. The long aging required with the prior art cathodes is believed due to an excess of oxygen being present in the body after the final sintering operation. This oxygen is believed to act somewhat like a poisoning agent, and the aging technique essentially accomplishes the gradual evolution of this oxygen, as evidenced by a gradual rise in emission. In my invention, on the other hand, apparently the strong reducing tendencies of the carbon causes it rapidly to combine with any excess oxygen, forming gaseous reaction products, such as CO and CO₂. These gases are then rapidly evolved at the activation temperature and removed from the envelope by the pumping system. Thus, the completed tube is believed to contain a cathode substantially free of carbon. The addition of a small amount of carbon already improves the activation of the cathode. The 1% upper limit of the carbon is believed due to the fact that an excess of carbon remaining in the cathode, namely, carbon not reacting with oxygen and being driven off as a gas, is harmful and causes a drop in emission. Hence, the optimum quantity of carbon is just that amount capable of completely tying up the excess oxygen and thus being removed as a gas, leaving no harmful residues. This amount has been found to be about 1/10 of one percent.

Another interesting and completely unexpected result of the invention is an increase in emission of up to 30% as compared to prior art pressed cathodes made without the carbon. This increase in emission as yet has no logical explanation.

While I have described my invention in connection with specific embodiments thereof, I wish it to be understood that I do not intend to be limited thereby, as other obvious modifications will readily occur to those skilled in this art all within the scope of the invention as defined in the appended claims.

What I claim is:

1. A method of manufacturing a dispenser cathode comprising providing a powder mixture of refractory metal, a fused mixture of barium oxide and aluminum oxide wherein the former constitutes between 60 and 90% by weight of the fused mixture, and more than zero and up to about 1% by weight of carbon, and thereafter pressing and sintering said mixture to form a coherent body.

2. A method as set forth in claim 1 wherein the powder mixture contains as the refractory metal an alloy of tungsten and molybdenum, and also contains a small amount of calcium aluminate.

3. A method as set forth in claim 1 wherein the carbon is present in an amount of about 0.1% of the mixture.

4. A method of manufacturing a dispenser cathode comprising providing a mixture of powders of refractory metal and a fused mixture of barium oxide and aluminum oxide wherein the former constitutes between 60 and 90% by weight of the fused mixture, heating said mixture at a temperature at which the mixture of barium oxide and aluminum oxide fuses and is dispersed over the metal powder, thereafter pulverizing the mixture to form a powder again, thereafter mixing with the thus-formed powder more than zero and up to about 1% by weight of carbon, and thereafter pressing and sintering the mixture to form a strong, compact body.

5. A thermionic cathode comprising a pressed and sintered mixture of barium aluminate, a refractory metal and more than zero and up to about 1% by weight of carbon, wherein the barium aluminate comprises a fused mixture of barium oxide and aluminum oxide with the former constituting between 60 and 90% by weight of the fused mixture, and means for heating the mixture at an elevated temperature.

6. A cathode as set forth in claim 5 wherein the mixture contains as the refractory metal an alloy of tungsten and molybdenum, a small amount of calcium aluminate, and about 0.1% of carbon.

References Cited in the file of this patent

UNITED STATES PATENTS

45	1,552,310	Kayko	Sept. 1, 1925
	1,720,000	Ramage	July 9, 1929
	1,883,898	Halliwell	Oct. 25, 1932
	1,895,354	Taylor	Jan. 24, 1933
50	2,179,960	Schwarzkopf	Nov. 14, 1939
	2,246,166	Dawihl	June 17, 1941
	2,700,118	Hughes et al.	Jan. 18, 1955

FOREIGN PATENTS

55	164,234	Australia	July 20, 1955
----	---------	-----------	---------------