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DISPENSER CATHODE

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FIG. 1.

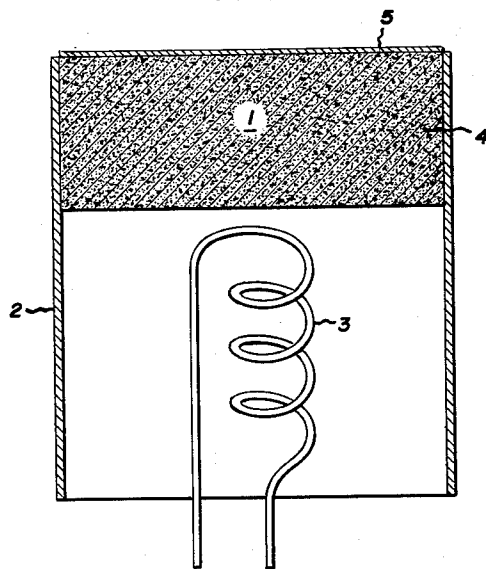
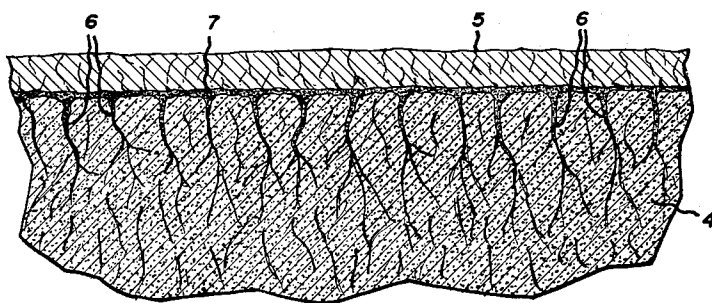


FIG. 2.



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DISPENSER CATHODE

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1 Claim. (Cl. 313—346)

My invention relates to electron emitters and pertains more particularly to a new and improved thermionic cathode of the dispenser type.

Dispenser-type cathodes usually comprise a porous refractory metal matrix impregnated with an activator compound adapted upon thermal dissociation or chemical reduction of the compound to provide an emissive material, or activator, which is usually an elemental alkaline earth metal, such as barium, and which migrates through the pores in the matrix to the surface of the matrix for thus being available thereon as an emissive film. Many such cathodes are limited in their applications by the evaporation rate of the emissive material from the matrix surface as well as the evaporation of the activator compound present in the pore ends at the matrix surface. That is, the evaporation rate of barium and like active, or emissive, materials is so great that it results in early depletion of the emissive material which, in turn, results in shortened cathode life. Also, the as yet unreduced activator compound present in the exposed pore ends at the surface of the matrix is subject to evaporation which also results in shortened cathode life. Further, when the cathode is used in an electron tube the high evaporation rate of the emissive material and activator compound can cause deposition of conductive coatings extending across insulator walls which can result in electrical short-circuiting between electrical contacts on opposite ends of the walls. Also, it can cause deposition of emissive coatings on grid elements and resultant undesirable grid emission. These undesirable effects can shorten effective tube life considerably. Heretofore, much development effort has been directed toward the provision of emitters characterized by low evaporation rates of the emissive materials. The present invention contemplates a new and improved dispenser cathode characterized by low evaporation of both emissive material and the activator compound, through which the emissive material is provided, and thereby is adapted to provide for prolonged cathode life and to minimize tube life-shortening effects on other elements in electron tubes.

Accordingly, a primary object of my invention is to provide a new and improved thermionic emitter of the dispenser type.

Another object of my invention is to provide a new and improved dispenser-type cathode adapted for reducing both the evaporation rate of the emissive material therein and the evaporation of the activator compound provided in the cathode to produce the emissive material.

Another object of my invention is to provide a new and improved dispenser-type cathode including improved means for prolonging the effective operating life of the cathode as well as the effective operating life of electron tubes incorporating such a cathode.

Further objects and advantages of my invention will become apparent as the following description proceeds and the features of novelty which characterize my invention will be pointed out with particularity in the claims annexed to and forming part of this specification.

In carrying out the objects of my invention I provide an emitter of the dispenser type comprising a porous refractory metal matrix having substantially uniformly distributed therein an activator compound adapted when heated to produce an emissive material without the production of a gaseous phase, and which emissive material

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is effective for migrating toward the surface of the emitter. Provided for reducing evaporation of the emissive material and any activator compound appearing in the surface pores of the matrix is a predeterminedly thin surface layer of a refractory metal selected from the group consisting of tungsten, tantalum and molybdenum. The surface layer is substantially less porous than the matrix and is essentially free of activator compound-containing pores. The surface layer permits migration of activator material thereto for emissive purposes but prevents the appearance on the outer surface thereof of excessive emissive material which would be subject to undesirable evaporation. Also, the surface layer effectively covers the activator compound present in the pore ends of the matrix for preventing evaporation thereof.

For a better understanding of my invention reference may be had to the accompanying drawing wherein:

FIGURE 1 is a sectional view of a dispenser-type emitter constructed according to an embodiment of my invention; and

FIGURE 2 is a greatly enlarged, fragmentary and somewhat schematic sectional view of the surface region of an emitter constructed according to my invention.

Referring to the drawing, there is shown in FIGURE 1 a thermionic emitter of the so-called dispenser type generally designated 1 and constructed according to an embodiment of my invention.

The emitter 1 is supported in one end of a tubular cathode holder 2 which can advantageously be formed of a refractory material such, for example, as tungsten, tantalum or molybdenum. A heating element 3 is contained in the holder 2 and is adapted when energized to heat the emitter 1, thereby to effect a desired reaction between an activator compound and a reducing agent contained in the emitter for effectively chemically reducing the activator compound and producing an elemental activator for migration toward the surface of the emitter. The activator compound is adapted for producing the elemental activator without producing also a gaseous phase.

The emitter 1 is of the pressed type comprising a porous matrix 4 having a powdered mixture of an activator compound and a reducing agent for the compound substantially uniformly distributed therein. By way of example, the emitter 1 can be fabricated according to the teaching of my copending U.S. patent application Serial No. 135,547 filed September 1, 1961, and assigned to the same assignee as the present invention. Briefly, the emitter disclosed and claimed in the mentioned copending application comprises a compressed fused body of powdered constituents consisting essentially of (1) a refractory matrix material selected preferably from the group consisting of tungsten, tantalum, and molybdenum and the silicides, carbides and borides of these materials and combinations thereof; (2) an activator compound selected from the group consisting of barium orthosilicate and barium orthotitanate; and (3) a reducing agent selected from the group consisting of aluminum, zirconium and titanium and combinations thereof. According to my earlier teaching, the emitter is preferably manufactured by admixing uniformly the mentioned powdered constituents and then compressing the mixture with a predetermined pressure effective for fusing the powdered constituents into a compressed coherent body having a consistency and internal structure whereby the body is adapted for uniform migration to the surface thereof of elemental activator upon chemical reduction of the activator compound. The reducing agent and operating temperature control the rate of activator production in the body and thus have a desirable effect of reducing the rate of evaporation of the compound.

However, as in all dispenser type cathodes including a porous matrix, the emitting surface includes a myriad of pore openings or open ends in the labyrinth channels or interstices characteristic of a porous matrix. These pore openings contain quantities of the activator compound which is ordinarily substantially uniformly distributed throughout the matrix. Additionally, the outer surface of the matrix and the pore openings therein include quantities of emissive material resulting from chemical reduction of the compound in the pore openings and emissive material which results from reduction of the activator compound in other regions of the matrix and which has migrated toward the surface of the matrix. Thus, there is generally present at the matrix surface an excess of emissive material which is subject to undesirable evaporation. Also subject to undesirable evaporation is the as yet unreduced activator compound present in the pore openings in the matrix surface. The evaporation of these materials can result in the above-described undesirable effects of depletion of the emissive material and deposition of conductive coatings on insulators and emissive coatings on grids.

My invention is effective for reducing the appearance of excess emissive material on the active surface of a dispenser cathode and, thereby, reducing the evaporation rate of emissive material. Additionally, my invention is effective for avoiding the undesirable evaporation of activator compounds from an emitter. Specifically, and as seen in FIGURES 1 and 2, my invention involves the provision of a dispenser cathode comprising an emitter 1 of the pressed dispenser type including a porous refractory metal matrix 4 having an activator compound substantially uniformly distributed therein and an outer surface layer 5. The surface layer 5 is tightly adherent to the matrix surface and is of a predetermined material and thickness effective to allow migration therethrough of only enough emissive material to provide a satisfactory emissive surface and to prevent evaporation of activator compound present in the pore ends of the matrix 4.

More specifically, and as shown exaggeratedly in FIGURE 2, the porous matrix 4 includes at its upper surface myriad pore ends or openings 6 filled with activator compound and emissive material indicated at 7 as the dark material. The emissive material and activator compound in the pore openings as well as excessive emissive material on other portions of the matrix surface would, without my invention, both be subject to undesirable evaporation. In order to prevent this evaporation and to provide just sufficient active material on a surface to meet required emission needs, I have provided on the surface of the matrix a thin tightly adherent surface layer 5 which is formed of a refractory metal selected from the group consisting of tungsten, tantalum and molybdenum, is substantially less porous than the matrix 4 and is essentially devoid of any activator compound-containing pores. Preferably, the layer 5 is between approximately only 2 to 10 mils thick.

By being less porous than the matrix 4 the surface layer 5 is less pervious to migration of the emissive material therethrough. Or, in other words, the layer 5 presents migration paths which are substantially more difficult for the activator to traverse. Thusly, less excessive activator, or emissive material subject to vaporization, is appearable on the external surface of the layer 5. Also, by being essentially devoid of any activator compound-containing pores, the layer 5 does not present exposed pore endings containing activator compound subject to evaporation. In other words, the layer 5, which is continuous, effectively covers the activator compound-containing pore ends in the surface of the matrix and prevents the evaporation of any activator compound contained therein.

As indicated above, the surface layer 5 must, in addition to covering the compound-containing pore ends in the matrix surface, be of a material and thickness effective

to allow migration therethrough of an adequate amount of emissive material and to prevent the appearance on the outer surface thereof of excessive activator which would be subject to evaporation. A surface layer 5 formed of tungsten and to have a thickness of between approximately only 2 to 10 mils has been found highly satisfactory. Additionally, tungsten was found preferable due to the relative ease of fabrication and ease of migration of barium on the surface thereof.

The tungsten layer, when applied as a continuous metallic sheet having a thickness in the just described range, is substantially less porous than the matrix, which is formed of pressed refractory metal powders, but is sufficiently porous to allow migration of a sufficient amount of activator therethrough for providing a continuously replenished supply of emissive material on the external surface of the layer 5. Expressed in another manner, the layer 5 is sufficiently thick to provide a continuous coating preferably no greater than 10 mils thick on the matrix surface. An appreciably thicker surface layer would unduly inhibit migration of the active material to the active surface. Additionally, the use of an activator compound which is adapted for producing upon heating an elemental activator without also producing a gaseous phase prevents outgassing difficulties or adverse effects, such as bellying, on the outer layer 5. In manufacturing the above-disclosed cathode structure the outer layer 5 can be formed in any suitable manner as by pressing a thin disk of tungsten, tantalum or molybdenum on the surface of the pressed emitter, by vapor deposition or by electroplating.

By way of example of the effectiveness of my present invention I have been able to lower by a factor of two the evaporation rate of barium in a cathode composed of a tungsten matrix with Ba_2TiO_4 (10% by weight) as the barium source. More specifically, a cathode of the just mentioned type is characterized by a work function of

$$\phi = 1.92 + 1.3 \times 10^{-4} T \text{ ev.}$$

and the evaporation rate (gm./cm.²/sec.) is expressed as

$$\log W = .5843 - \frac{13,010.3}{T}$$

With an outer layer 5 formed of tungsten and in the above-prescribed thickness provided on the surface of the emitter the work function was found to be

$$\phi = 1.83 + 2.5 \times 10^{-4} T \text{ ev.}$$

and the evaporation rate was reduced to

$$\log W = .5843 - \frac{13,348.9}{T}$$

Thus, it will be seen from the foregoing that I have provided an improved dispenser type cathode adapted for reducing substantially the evaporation of activator material from the emissive surface of the cathode and for avoiding the evaporation of activator compound and thus is adapted for increasing the operating life of the cathode and of tubes incorporating such a cathode. It will also be seen from the foregoing that I have provided a dispenser type cathode which affords all of the desired attributes of prior art dispenser type cathodes including, for example, a substantially continuous supply of activator and a system for continuously replenishing the activator at the emissive surface.

While I have shown and described a specific embodiment of my invention I do not desire my invention to be limited to the particular forms shown and described and I intend by the appended claim to cover all modifications within the spirit and scope of my invention.

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

A thermionic emitter consisting essentially of

- (a) a refractory matrix material selected from the class consisting of tungsten, tantalum, molybdenum, and the silicides, carbides and borides thereof, 5
 - (b) an activator compound selected from the class consisting of barium orthosilicate and barium orthotitanate and dispersed throughout said matrix, 10
 - (c) a reducing agent selected from the class consisting of aluminum, zirconium, titanium and combinations thereof and dispersed throughout said matrix, 15
 - (d) a thin, continuous, tightly adherent, surface layer of porous tungsten provided on and covering the surface of said matrix, 20
- (1) said tungsten layer being effective for covering any barium compound-containing pore ends in said surface of said matrix,
 - (2) said layer being substantially less porous than said matrix,

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- (3) said layer being essentially free of barium compound-containing pores,
- (4) said layer characterized by being between about 2 to 10 mils in thickness,
- (5) whereby evaporation of barium compound from said pore ends in said matrix is prevented and barium is permitted to migrate to the outer surface of said layer in controlled amounts.

References Cited by the Examiner

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