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DISPENSER CATHODE

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FIG. 1.

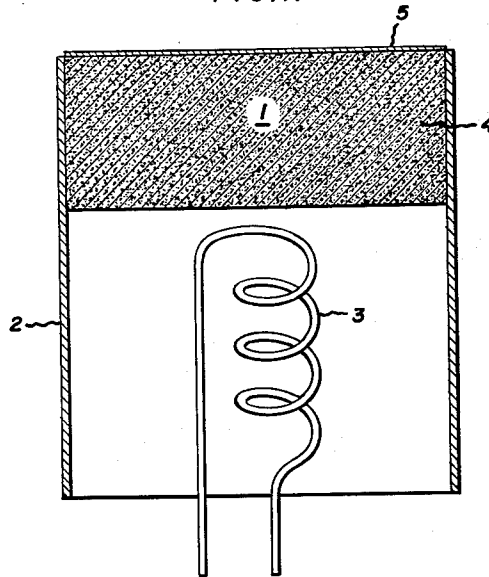
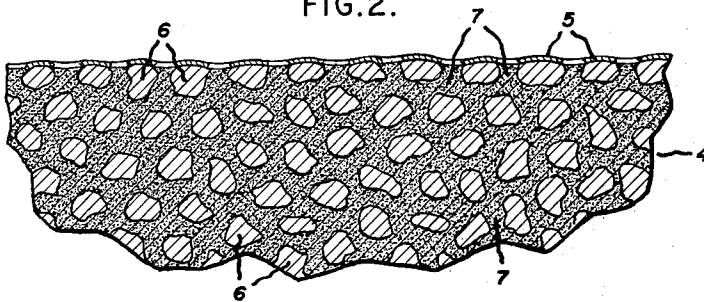


FIG. 2.



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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.

Some dispenser-type cathodes comprise a porous refractory metal matrix impregnated with a barium compound adapted upon thermal dissociation of the compound to provide elemental barium which migrates through the pores in the matrix to the surface of the matrix thus being available thereon as an emissive film. Such cathodes are often limited in their applications by the evaporation rate of the barium from the matrix surface. That is, the evaporation rate can be so high as to cause early depletion of the barium source and resultant short cathode life. Also, excessive evaporation of barium can result in conductive short-circuiting depositions on the walls of tube insulators as well as undesirable deposition of emissive coatings on tube grids.

Much effort has heretofore been expended toward the development of means and methods for reducing the evaporation rate of emissive materials in dispenser cathodes. The present invention contemplates the provision of a new and improved dispenser cathode including an active surface characterized by substantial affinity for barium and thus adapted for retaining for a greater period that barium which has migrated to the surface to appear thereon as an electron source. This prolonged retention of the barium serves to reduce substantially the evaporation rate.

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 barium dispenser-type cathode adapted for reducing the evaporation rate of the barium.

Another object of my invention is to provide a new and improved barium dispenser-type cathode including new and improved means for delaying depletion of the barium and thus prolonging cathode life.

Another object of my invention is to provide a new and improved barium dispenser-type cathode including new and improved means for minimizing barium evaporation and thereby minimizing any tendency toward the undesirable deposition of conductive coatings on insulators and emissive coatings on grid elements included in electron tubes incorporating the 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 claim 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 matrix formed of compressed and sintered refractory metal particles of a predetermined average diametral dimension and having distributed therein an activator compound adapted when heated to produce elemental barium without the production of a gaseous phase. Provided on the surface of the matrix is a tightly adherent coating of elemental platinum. The platinum affords an external active surface over which the migrating barium can readily diffuse for effecting a substantial emissive cathode area. Additionally, the platinum has a substantial affinity for barium with the result that the barium is retained on the platinum for a substantial period of time which has

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the desirable effect of reducing the evaporation rate of the barium from the active surface. Further, the platinum is of a predetermined thickness relative to the size of the matrix particles and, thus, the coating is rendered predeterminedly porous to avoid closing the pore openings in the surface of the matrix through which the barium must migrate for diffusion over the platinum coating.

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

FIGURE 1 is a sectional view of the 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 metal 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 thermal dissociation of barium from the compound for migration toward the surface of the emitter.

The emitter 1 is of the pressed type comprising a porous matrix 4 formed of a compressed powdered refractory metal having a powdered barium 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 S.N. 135,549 Affleck, filed September 1, 1961, now Patent No. 3,176,180, 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 mixture of powders consisting essentially of (1) a refractory matrix material selected from the group consisting of tungsten, tantalum and molybdenum, the silicides, borides and carbides of such metals and combinations thereof; and (2) an activator compound selected from the group consisting of barium silicide, barium iodide and barium aluminide, which compounds are adapted when heated to produce elemental barium without also the production of a gaseous phase. According to my earlier teaching the emitter is preferably manufactured by admixing uniformly the mentioned powdered constituents and compressing a quantity of the resultant mixture with a pressure effective for fusing the powdered constituents into a compressed coherent body comprising a porous matrix having the activator compound substantially uniformly distributed therein. Also, the body is characterized by a consistency and internal structure whereby the body is adapted for uniform migration to the surface thereof of elemental barium upon thermal dissociation of the barium from the compound. Furthermore, the disclosed emitter is characterized by a low effective work function and a reduced barium evaporation rate. The present invention is effective for reducing the barium evaporation rate still further, thereby to prolong the cathode operating life and better to insure against undesirable deposition of conductive and emissive coatings on other elements in a tube structure incorporating the cathode.

Specifically, and as seen in FIGURES 1 and 2, my invention involves the provision of a dispenser cathode comprising an emitter of the pressed dispenser type including a refractory metal matrix 4 having a barium activator compound substantially uniformly distributed therein and an outer surface 5 of platinum tightly adherent to the outermost metal particles constituting the matrix surface.

As shown exaggeratedly in FIGURE 2 to facilitate explanation of the invention, the matrix 4 comprises compressed fused particles 6 of refractory metal and the barium compound indicated by the darkened regions 7 is dispersed in the pores or interstices of the matrix. Upon heating of the emitter, elemental barium becomes dissociated from the compound and migrates through the interstices toward the external surface of the matrix. Additionally, this production of barium is effected without the incidental production of a gaseous phase which, if present, can introduce outgassing problems. In the absence of my present invention the barium would diffuse over the exposed surfaces of the outermost particles constituting the matrix surface and the evaporation rate of the barium would be determined by the mean life time of a barium atom on tungsten or the other refractory metal of which the matrix particles are formed.

In my present structure the evaporation rate of the barium is reduced substantially by providing on the exposed surfaces of the outermost, or surface, matrix particles a coating of platinum which affords a satisfactory emissive surface, from the standpoint of desirable barium diffusion thereover, and one which has a substantially greater affinity for barium than the matrix material and thus serves to hold or retain the barium for a greater length of time. As illustrated in FIG. 2, in a preferred form of my invention the platinum coating 5 may be described as interrupted or perforate with the solid or coextensive portions extending over the metal particles 6 and interrupted portions or openings extending over portions of the emissive material existing between adjacent metal particles. By way of example, the mean life time of a barium atom on a platinum surface is approximately sixty times longer than on tungsten. Thus, barium is held a substantially longer period by a platinum active surface than by tungsten and the evaporation rate of the barium is substantially reduced where the platinum surface is provided on a tungsten matrix. The same is true where platinum is provided on any other matrix material upon which the mean life time of a barium atom would be shorter than on platinum.

In order to insure a continuous replenishment of the barium on the platinum surface it is necessary to insure against closing, or clogging, of the pore ends or openings at the surface of the matrix 4. Otherwise, barium migrating from the interior of the matrix 4 will be prevented from reaching the platinum surface and diffusing thereover. On the other hand, the surface of the matrix must be sufficiently coated with platinum to provide both a substantially emissive area and the desirable affinity for barium whereby the barium evaporation rate is reduced. Accordingly, it is necessary that the platinum be applied carefully and in a predetermined preferred thickness. It is also desirable to avoid the use of more platinum than is necessary because of the high cost thereof.

In determining the preferred thickness it can be assumed that the dimensions of pore openings in the matrix, and through which the barium must migrate to the surface of the platinum coating, are in essentially the same dimensional range as the particles of refractory metal constituting the matrix. For example, the matrix particles indicated at 6 in FIGURE 2 preferably have an average diameter of about 5 microns and one can assume that the pore openings are of approximately the same dimension. Therefore, in order to insure against clogging of the pores and resultant restriction of barium migration it can be concluded that the platinum coating on the outermost surface particles should not be greater than the diameters of such particles. Expressed in another manner, and as shown clearly in FIGURE 2, the platinum layer 5 should constitute coatings extending over only the exposed surfaces of the matrix particles 6 constituting the surface of the matrix and the thickness of these coatings should be no greater than the average diameters of the matrix par-

ticles or the pores to insure that the pores will remain open or be unobstructed.

The minimum effective thickness of the platinum coating can be determined from the evaporation rate of platinum at the normal cathode operating temperature. From the text "Scientific Foundations of Vacuum Technique" by Saul Dushman the following data is obtained for the evaporation rate of platinum:

$$\log W = C - .5 \log T - B_T$$

where W = evaporation rate—gm./cm.²/sec.

T = temperature—°K.

$C = 9.44$ (constants for platinum)

$B = 27.28$ (constants for platinum)

At a temperature of 1250° K. the evaporation rate is 1.1×10^{-14} gm./cm.²/sec. Assuming there are 3.5×10^{14} atoms per monolayer, then a monolayer weight 1.1×10^{-8} gm., and the time to evaporate a monolayer is 10^7 sec. or 2.8×10^3 hours. Therefore, it can be seen from the foregoing that at 1250° K. a monolayer of platinum will give adequate coverage. For longer life and higher operating temperatures additional thickness would be required; however, in no case should the thickness be such as to obstruct the pore openings and prevent the supply of barium to the platinum surface. As a general rule, and in accordance with my invention, the thickness of the platinum layer should preferably not exceed the diameter of the surface pores in the matrix nor be less than a monolayer.

The platinum surface 5 can be effectively applied to the matrix in any suitable manner effective for providing the required thickness and desirable tight adherence to the matrix particles. For example, the platinum can be evaporated onto the matrix surface. Also, a thin layer of platinum can be electroplated on the matrix surface. However, in no case should the resultant platinum layer exceed the thickness prescribed above.

By way of example of the effectiveness of my above-disclosed invention, a device has been constructed and tested including a compressed emitter formed in the manner described in my above referenced copending application and composed of 90% tungsten and 10% barium silicide by weight. Before application of a platinum outer layer to this emitter it was found to have a work function of

$$\phi = 1.81 + 4.7 \times 10^{-4} T \text{ ev.}$$

and an evaporation rate given by

$$\log W = 13.3676 - \frac{21,627.3}{T}$$

On the surface of the above-discussed system a layer of platinum in the above-prescribed thickness range was evaporated. This cathode system under test exhibited the same thermionic properties as one without a platinum layer but the evaporation rate was reduced 5 orders of magnitude. Specifically, after evaporation of the platinum on the cathode surface the work function was

$$\phi = 2.09 + 1.1 \times 10^{-4} T \text{ ev.}$$

and the evaporation rate

$$\log W = 2.6405 - \frac{14,011.5}{T}$$

Thus, it will be seen from the foregoing that I have provided through the use of a minimum amount of platinum an improved dispenser-type cathode characterized by a substantially low barium evaporation rate and thereby adapted for prolonged cathode operating life and reduced adverse effects resulting from evaporation of barium on the elements in tubes incorporated in the cathode. It will also be seen from the foregoing that my improved cathode affords all of the desired attributes of prior art dispenser type cathodes including, for example, a substantial continuous supply of activator at an emissive surface.

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

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

A thermionic emitter comprising a porous refractory matrix consisting of a compressed body of refractory metal particles selected from the class consisting of tungsten, tantalum, molybdenum, the silicides, borides, and carbides thereof, and combinations thereof, a quantity of barium activator compound distributed in said matrix and effective upon thermal dissociation for producing elemental barium for migration toward the surface of said matrix, said barium activator compound being selected from the class consisting of barium silicide, barium iodide, and barium aluminide, a reducing agent, and a tightly adherent porous platinum coating having coextensive portions extending over the metal particles at said surface

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of said matrix to provide a surface over which the barium can diffuse, said coating being at least a monolayer of platinum thick at operating temperatures to effect prolonged retention of barium thereon and thereby reduce the evaporation rate of said barium, and said coating having a thickness less than about 5 microns and sufficiently less than the diameter of pore openings at said surface of said matrix to prevent obstruction of said pore openings and thereby insure availability of barium for diffusion over said platinum coating.

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