April 8, 1958 J. E. BEGGS 2,830,218

DISPENSER CATHODES AND METHODS OF MAKING THEM

Filed Sept. 24, 1953

Fig. 1.

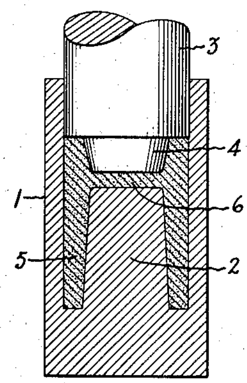


Fig. 2.

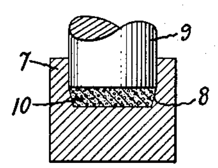


Fig. 3.

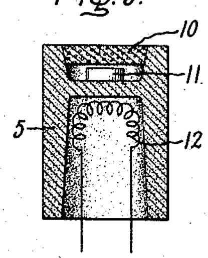
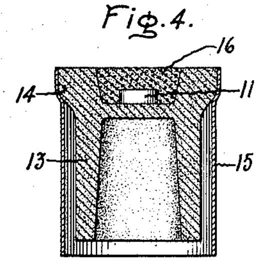


Fig. 4.



Inventor:
James E. Beggs,
by Paul A. Frank
His Attorney.

United States Patent Office 2,830,218
Patented Apr. 8, 1958

1

2,830,218

DISPENSER CATHODES AND METHODS OF MAKING THEM

James E. Beggs, Schenectady, N. Y., assignor to General Electric Company, a corporation of New York

Application September 24, 1953, Serial No. 382,085

12 Claims. (Cl. 313—346)

My invention relates to dispenser cathodes and to methods of making them.

Dispenser type cathodes having a porous metal cover for a reservoir of thermionic material are advantageously employed in many applications especially in view of the long life permitted by the reservoir of thermionic material and the ease with which the cathode surface may be machined for accurate spacing from other electrode surfaces. In order that the enclosed emission material be exposed only through the pores of the dispenser cover, it is necessary that the remainder of the holder be impervious and that the cover be very tightly fitted to the holder. Emission from the sides of the porous cathode cover rather than from the upper surface only has been found to impair the high frequency performance of discharge devices in which such cathodes are employed because of the different transit angles of different parts of the electron stream. Special care must also be exercised to provide a close fit without unduly increasing the cost of manufacture to prevent loss of the cathode material. Since it is also characteristic of the metal sinterings commonly employed as the porous cover or lid material that the pores may be closed by machining unless the material is quite frangible, it is furthermore important that the closure requirements should not require such a high mechanical strength for the cover that the cover surface cannot be successfully machined.

It is therefore an important object of my invention to provide an improved dispenser cathode.

It is another object of my invention to provide a simple dispenser cathode construction in which the porous cathode lid is securely sealed to the cathode container.

It is a further object of my invention to provide an improved method of making dispenser cathodes of the porous cover type especially suitable for use in high frequency discharge devices.

Briefly, in accordance with my invention, both the cathode holder and its porous cover are made of compacted refractory metal powders which are sintered together in their assembled position with the cathode activating material enclosed. The cathode holder sinters more readily than the cover by employing a refractory metal having a lower sintering temperature than tungsten or more densely pressing the powder part or both, so that the cathode holder is made sufficiently hard and impervious at the same sintering temepreature which leaves the porous cover sufficiently frangible to permit machining without closing the pores. Because it begins to sinter at a lower temperature, the cathode holder shrinks more than does the porous cover so that it both grips the cover tightly and is sintered to it.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and method of operation together with further objects and advantages thereof may best be understood by reference to the following description taken in connection with the accompanying drawing in which Fig. 1 illustrates apparatus for compacting a cathode holder;

2

Fig. 2 illustrates apparatus for compacting a powdered metal cathode cover;

Fig. 3 represents a dispenser cathode made in accordance with the teachings of my invention and employing the cathode holder and cover of Figs. 1 and 2; and

Fig. 4 illustrates another embodiment of a dispenser cathode made in accordance with the teachings of my invention.

Referring now to Fig. 1 there is shown a molding machine for compacting or pressing a refractory metal part which constitutes a cathode holder of a dispenser cathode. This apparatus comprises a mold 1, suitably made of steel, having a cylindrical bore closed at its lower end and with a tapered central core extending from the closed bottom end of the mold, the upper surface of the core lying within the bore in a plane transverse to the bore axis. A piston or ram 3 is arranged to enter the bore of the mold 1 from its upper end and compact powdered material within the mold. The ram 3 has a tapered end portion 4 of reduced diameter terminated in a plane transverse to the axis of the bore.

To form the cathode holder, the mold 1 is filled with a powdered refractory metal before the ram is introduced. Molybdenum is preferably employed, although other metal powders such as nickel or tungsten may be used. The particle sizes are chosen so that with the ram pressure employed the cathode holder is so densely compacted that after sintering it is mechanically strong and substantially impervious to the diffusion of an activator material therethrough. When the ram 3 is lowered to the final position indicated in Fig. 1, the pressed or compacted powder part to be employed as a cathode holder is formed as a hollow cylinder 5 with a transverse inner partition 6, the recesses on either side of the partition being formed by the core 2 and the reduced end portion 4 of the ram. The upper recess is designed to be the reservoir for the active cathode material or cathode activator and the lower recess is preferably longer to enclose a cathode heater. The thickness of the cathode holder partition 6 is made less than the thickness of the cylinder walls to increase the effectiveness of the heater. After the cathode holder is pressed the ram 3 is withdrawn and the formed powder part 5 is removed.

Fig. 2 illustrates the apparatus for making or pressing the powder part which constitutes the cathode cover. The mold 7 has a cylindrical bore closed at the lower end and having a bevel or taper 8 from the bottom of the bore to a height representing the desired thickness of the pressed part. A cylindrical ram 9 is arranged to enter the top of the cylindrical bore and to compress powder filling the wall 7 to the desired thickness. The completed compacted powder cover 10 is a cylindrical disk having tapered side walls. The angle of taper corresponds to that of the upper portion of the cathode holder 5 so that the disk may fit within the upper recess of the cathode holder with its upper surface flush with the upper end of the holder. The refractory metal powder employed in the disk 10 is preferably tungsten, although other material such as molybdenum or tantalum may be substituted. The cover 10 however is not compacted so firmly or to such a high percentage of its maximum density as is the cathode holder 5 in order that for a given sintering temperature, the cathode disk may be relatively porous and frangible as compared with the cathode holder 5.

A completed cathode assembly is shown in Fig. 3. The assembly is formed by positioning a quantity of cathode activator material, suitably in the form of a pellet 11 on the upper surface of the partition 6 of the cathode holder 5. The cathode cover 10 is then fitted into the top of the upper recess in the holder thus enclosing the cathode activating material. At this stage the pressed powder parts 5 and 10 are both relatively soft and porous and must be handled carefully to avoid breakage. Either or both may also be presintered to some degree to facilitate handling, if so desired. The assembly is then heated in a furnace to a temperature sufficient to sinter both pressed powder parts. With the holder 5 made of molybdenum powder and the cover 10 made of tungsten powder a temperature of 1400° C. or generally in the range of 1300° to 2000° C. is sufficient to sinter the powdered assembly. The cathode holder 5, because it is more firmly compacted and because the molybdenum has a lower sintering temperature becomes substantially impervious upon firing whereas the tungsten cover 10, while sintered, remains relatively porous. Because of its lower sintering temperature, the cathode holder 5 shrinks more than does the cover 10 during the sintering process and thus tightly encompasses the edge of the lid and becomes sintered to it. Accordingly, no openings larger than those of the pores themselves remain between the interior of the enclosed recess and the exterior of the cathode assembly. The sintering process is preferably carried out in vacuum or in a hydrogen atmosphere to minimize oxidation of the cathode. Other reducing or inert atmospheres may also be employed, the choice depending to some extent upon the particular cathode activating material enclosed within the cathode.

The cathode activating material 11, which may suitably be barium carbonate, functions in a manner known in the art to activate the upper surface of the cathode cover 10. Upon heating of the carbonate, as occurs during the sintering process, the barium carbonate dissociates, reducing to barium oxide. Further heating is believed to cause the barium oxide to react with the tungsten, producing barium. The barium atoms slowly migrate along the tortuous, indirect paths defined by the pores, eventually diffusing through to the outer surface of the cathode cover 10 and forming a monatomic layer whose effect is to reduce the work function of the tungsten from around 4.5 electron volts to a value from 1.6 to 2.0 electron volts. In this type of cathode, it is believed that the barium oxide alone is not the emitter but rather than the barium layer together with the tungsten base provides the efficient electron emitting surface characterizing this general type of cathode. For that reason the barium carbonate placed in the reservoir of the cathode has been referred to as a cathode activating material and the term as used herein is intended to include other materials having the same end effect. For example, other compounds which may be reduced to provide metallic barium may be employed or metallic barium itself may be employed. Other alkaline earth metals either singly or in combination may also be employed either in the form of the metals themselves or compounds which may be reduced to provide them.

In operation of a cathode incorporating my invention, the upper surface of the cathode including the upper surface of the cathode cover 10 is milled or otherwise machined to the exact dimensions required. The porous disk 10 is relatively frangible and hence the machining operation, which in effect scrapes off an upper layer, can be effected without compressing or smearing the material and filling in the pores, which would, of course, adversely affect the operation of the cathode. It will be appreciated that despite the relative softness of the cathode cover 10 no difficulties are encountered in handling the material since it is integral with the mechanically stronger cathode holder 5. A cathode heater 12 is suitably mounted within the lower recess of the holder 5.

After the discharge device is evacuated and the heater is operated at a temperature around 1200° C. the cathode activation mentioned above is completed, the activation having been begun during the sintering process. Despite the exposure of the cathode to air during assembly of the discharge device the cathode is not poisoned or permanently damaged but instead may be reactivated or the activation continued by further heating until the desired monatomic barium layer on the tungsten is obtained as evidenced by stable emission.

A modification of my invention is indicated in the drawing at Fig. 4. Here the cathode holder 13 corresponds to the holder 5 of Fig. 3 and is made by the same method. The particular holder 13 of Fig. 3 also has an enlarged diameter or flange 14 at its upper end to facilitate the addition of a cylindrical metal foil heat shield and support 15. The body 11 of the cathode activating material is closely surrounded by the packed powder parts. This is accomplished after withdrawal of the ram 3 from the holder mold by placing the cathode activator charge in the upper recess without removing the cathode holder 13 from the mold. A quantity of powdered tungsten or other suitable refractory metal as employed in making the porous cover 10 of Figs. 2 and 3 is then placed in the mold and compressed into the upper recess of the cathode holder. The molded tungsten powder part 16 thus formed fills all the space in the upper cavity recess not occupied by the charge or pellet 11 of cathode activating material. No handling of the pressed powder part 13 is involved and after sintering the assembly as described in connection with Fig. 3 the upper surface of the cathode assembly is machined to provide the desired smoothness and thickness dimension. The unitary sintered assembly possesses the advantages also discussed in connection with Fig. 3 in that the porous portion 16 is sintered to the holder with the emitting surface restricted to its upper surface and the paths for the cathode activating material to the cathode surface restricted to the pores of the portion 16.

While I have shown and described various embodiments of my invention it will of course be understood by those skilled in the art that other modifications may be made without departing from the principles of my invention. I therefore contemplate by the appended claims to cover any such modifications that fall within the true spirit and scope of my invention.

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

1. A dispenser cathode comprising a sintered integral refractory metal body having a recess receiving a quantity of thermionic emitting material, a sintered face portion closing said recess, said face portion of the body being porous relative to the remainder of said body to provide for the gradual egress of emitting material from said recess.

2. A dispenser cathode comprising a substantially impervious sintered refractory metal recessed holder, a thermionic activator material positioned therein, and a porous sintered refractory metal face member in said recess sintered to said holder and enclosing said material.

3. A dispenser cathode comprising a sintered substantially impervious hollow tubular refractory metal member having a transverse partition therein to define a recess in each end of said tubular member, a thermionic activator material positioned in the recess at said one end, a porous sintered refractory metal plug in said one end sintered thereto and integral therewith, and a cathode heater positioned in the other recess in said tubular member.

4. A dispenser cathode comprising a sintered substantially impervious hollow tubular refractory metal member having a transverse partition therein to define a recess in each end of said tubular member, a thermionic activator meterial positioned in the recess at one end thereof, a porous sintered refractory metal cover completely filling the remainder of the space in said one end and sintered thereto and integral therewith, and a cathode heater positioned in the other recess in said tubular member.

5. The method of making a dispenser cathode which comprises forming a recessed cathode container member from a densely packed refractory metal powder having a given sintering temperature, positioning a quantity of thermionic activator material within the recess of said container, positioning a container cover of less densely packed refractory metal powder having a sintering temperature higher than said given temperature in said recess, and heating the assembly to sinter the refractory metal powders and join the said cover and said container together.

6. The method of making a dispenser cathode which comprises forming a recessed cathode container member from a packed refractory metal powder having a given sintering temperature, positioning a quantity of thermionic activator material within the recess of said container, positioning a container cover of a packed refractory metal powder having a higher sintering temperature than said given temperature in said recess, and heating the assembly to sinter the refractory metal powders and join said cover and said container together.

7. The method of making a dispenser cathode which comprises forming a recessed cathode container member from a densely packed refractory metal powder, positioning a quantity of thermionic activator material within the recess of said container, positioning a container cover of less densely packed refractory metal powder in said recess and sintering the assembly to join said cover and said container together.

8. The method of making a dispenser cathode which comprises forming a recessed cathode container member from a densely packed refractory metal powder, positioning a quantity of thermionic activator material within the recess of said container, positioning a container cover of less densely packed refractory metal powder in said recess, and heating the assembly to sinter the refractory metal powder and at least partially activate the cathode.

9. The method of making a dispenser cathode which comprises forming a cathode container member having a recess therein from a densely packed refractory metal powder, positioning a quantity of thermionic activator material within the recess of said container, packing the remainder of the recess with a refractory metal powder less densely packed than said container member powder, and heating the assembly to sinter the refractory metal powders to provide a cathode body which is relatively impervious except for the sintered powder in the recess.

10. The method of making a dispenser cathode which comprises forming a cathode container member having a recess therein from a refractory metal powder having a given sintering temperature, positioning a quantity of thermionic activator material within the recess of said container, packing the recess with a refractory metal powder having a sintering temperature above said given sintering temperature, and heating the assembly to sinter the refractory metal powders to provide a cathode body which is relatively impervious except for the sintered powder in the recess.

11. The method of making a dispenser cathode which comprises forming a recessed cathode container member from a densely packed molybdenum powder, positioning a quantity of thermionic activator material within the recess of said container, positioning a less densely packed tungsten container cover of powder in said recess, and heating the assembly to sinter the powders whereby the container and cover are integrally sintered together.

12. The method of making a dispenser cathode which comprises forming a recessed cathode container member from a densely packed molybdenum powder, positioning a quantity of thermionic activator material within the recess of said container, forming a less densely packed tungsten container cover of powder in said recess, and heating the assembly to sinter the powders whereby the container and cover are integrally sintered together.

References Cited in the file of this patent

UNITED STATES PATENTS

2,121,589	Espe	June 21, 1938
2,460,739	Francis	Feb. 1, 1949
2,543,728	Lemmens et al.	Feb. 27, 1951
2,643,332	Diemer	June 23, 1953
2,663,069	Esperson	Dec. 22, 1953
2,673,277	Lemmens et al.	Mar. 23, 1954
2,700,118	Hughs et al.	Jan. 18, 1955

OTHER REFERENCES

"A New Thermionic Cathode for Heavy Loads," by Lemmens et al., published in Philips Technical Review, vol. 11, No. 12, pp. 341–350, June 1950.