

1

3,221,203

SINTERED METAL CONDUCTOR SUPPORT

Frank Rowland Ragland, Jr., Lancaster, Pa., assignor to Radio Corporation of America, a corporation of Delaware

Filed June 1, 1962, Ser. No. 199,404

9 Claims. (Cl. 313—271)

The present invention relates to electron tubes and particularly to a cathode-heater mount for such tubes, and method of making a tube having such mount.

Electron tubes having indirectly heated cathodes and designed to withstand impact shock, are provided with a ruggedized heater-cathode mount. In one example, an insulatingly coated heater wire is supported within a tubular cathode by imbedment in a sintered mass of metal powder engaging the inner wall of the cathode.

However, monolithic cathodes of this type have not been fully satisfactory. One deficiency of such cathode-heater structures is manifested in partial separation of the sintered metal body from the inner wall of the cathode and from an uncoated portion of heater wire. Such partial separation prevents desired heat transfer from the heater to the cathode at the areas where the separation occurs and interrupts necessary electrical continuity between the sintered metal body and the uncoated heater portion. The resultant difference in heat transfer occurring at such areas of separation and at other areas where contact between the sintered metal mass and the cathode has not been distributed, produces non-uniformities in the cathode temperature. Such non-uniformities in cathode temperature adversely affect the electron emission from the cathode.

A further deficiency of prior monolithic cathodes resided in the tendency of the insulation on the heater to crack, in response to vibrations of the heater against the sintered body. Such vibrations were free to occur in areas where the sintered body had separated from the heater.

An object of the invention is to provide a monolithic cathode-heater assembly in which a mass of sintered metal powder engages the inner wall of a tubular cathode and the outer surface of an uncoated portion and a coated portion of a heater, with freedom from discontinuities in the engagement.

Another object is to provide a novel method of making a monolithic cathode-heater assembly.

One example of a cathode-heater assembly in which the foregoing objects are realized, comprises a tubular cathode sleeve having on the inner wall thereof a relatively thin coating of sintered nickel particles, to which is effectively bonded a body of sintered nickel particles completely filling the space defined by an axial portion of the cathode, and imbedding a heater therein. The heater is also provided initially with a relatively thin layer of sintered particles on the outer surface of its insulating coating and on an uncoated end portion thereof to which the aforementioned body of sintered nickel effectively adheres.

The sintered coatings on the cathode wall and on the heater are firmly adherent to these elements and provide a surface to which the body or slug of sintered nickel particles firmly adheres. No separation occurs either between the sintered coatings and the cathode and heater, or between the coatings and the slug of sintered metal particles. In this way temperature differentials through the outer emitting surface of the cathode are eliminated, desired uniform emission from the cathode is preserved, and required electrical continuity between the portion of the heater free of insulation and the slug is assured.

A cathode-heater assembly of the foregoing type may

2

be made by sintering to the inner wall of the tubular cathode, nickel powder of relatively small particle size. A similar coating is sintered to the other surface of the coated heater including an uncoated portion thereof, prior to inserting the heater into the cathode. The heater having the sintered coating is then supported within the cathode, and nickel powder of relatively large particle size is poured into the cathode to completely fill the portion thereof occupied by the heater. The poured powder may be tamped into desired compactness and is heated to sintering temperature.

The invention will be better understood by more fully considering an example of a cathode-heater assembly, in connection with the accompanying drawing, wherein:

FIG. 1 shows a sectional elevation of a cathode-heater assembly; and

FIG. 2 is a sectional view, taken along the line 2—2 of FIG. 1.

The cathode-heater structure shown in FIGS. 1 and 2 includes a tubular cathode 10 having an electron emitting coating 12 on the outer surface of an axial portion thereof. The cathode 10 may be made of nickel, for example. A cathode support portion 14 terminates in a flange 16. The flange 16 is adapted to be sealed across an opening in an electron tube envelope (not shown).

Within the cathode 10 is disposed a heater assembly comprising a heater coil 18 having a core 19 made of tungsten for example, and provided with an insulating coating 20 thereon made of aluminum oxide, for example.

One end 22 of the heater coil 18 is free from insulation and is in electrical contact with a body or slug 24 of sintered metal powder that engages a coating 26, of sintered metal powder, on the inner surface of the portion of the cathode 10. The outer surface of the portion of the heater coil 18 imbedded in the metal body 24, is also provided initially with a coating 27 of sintered metal powder. The coatings 26 and 27 on the inner surface of the cathode 10 and on the outer surface of the heater coil 18 serve to bond effectively the cathode and heater coil 18 to the sintered body 24, and thereby prevent discontinuities in the engagements between the coatings and the sintered body. For best results, the particle size of the metal powder constituting the coating 26, 27 should be smaller than that of the metal powder making up the slug 24.

The other end 28 of the heater coil 18 is fixed as by mechanical crimping or swaging to the upper end portion 30 as viewed in the drawing, of a heater lead or support rod 32. The rod 32 extends into the material of the sintered body 24 and has an insulating coating 33 thereon, such as aluminum oxide, for electrically insulating the rod from the body 24. The joint between the rod 32 and coil 18 and the portion of the rod imbedded in the body 24, are also covered with insulating material. The rod 32, made of molybdenum, for example, is insulatingly fixed to flange 16 by means of a metal disk 34 brazed to the rod 32 and sealed to an insulating ring 36 which is in turn sealed to the radially extending portion of flange 16. Opposite surfaces of the ring 36 are suitably metallized to permit brazing of the ring to the disk 34 and flange 16. In the resultant structure flange 16 may serve as a lead-in conductor to the cathode 10 and to the bare end 22 of the heater coil 18. The rod 32 may serve a similar function with respect to the end 28 of the heater coil 18.

In the resultant monolithic structure the sintered body 24 is firmly adherent to the cathode 10 and to the heater coil 18, and no separation between the body 24 and the cathode and heater, is likely to occur. The reason for this is believed to be as follows: The initial application of coatings 26 and 27 results in a relatively strong bond between such coatings and the cathode 10 and coil 18 re-

spectively. Such strong bond is believed due to the fact that when the coatings 26, 27 are sintered to their respective substrates, i.e., the cathode 10 and coil 18, their relatively thin character assures freedom from stresses during the sintering operation, which stresses might tend to separate the metal particles of the coating from their substrates. Thus, each particle of the coatings in contact with a substrate and initially sintered to the substrate, is free from forces tending to separate the particle from its substrate, during the sintering operation. During such operation the particle is relatively soft and might yield to such forces in the form of a separation from the substrate.

Such separation is likely to occur when a relatively large body 24 of metal particles is directly sintered to the cathode 10 and heater 18. This is because the body 24 tends to contract during the later stage of a sintering operation and while the metal particles thereof are relatively soft. Such contraction tends to pull the body 24 away from the cathode 10 and coil 18. Thus, certain of the metal particles of the body 24 that have not formed a solid fixed bond with cathode 10 and coil 18, will separate from these elements in response to such pulling action. However, such pulling away of the sintered body does not occur when the body is in the form of a relatively thin coating.

While a tendency to pull away on the part of the body 24 is also present when the coatings 26, 27 are used, the bonds between the metal body 24 and the relatively rough surfaces of the coatings, are substantially stronger than between the body 24 and the relatively smooth surfaces of the cathode 10 and the heater coil 18.

In one example, the coatings 26, 27 had a thickness of about 5 mils. The method of applying the coatings, to be described in the following, assures adherence to this thickness value, within acceptable tolerances. In the example referred to, the sintered body had a diameter of about 1/4 inch and an axial length of about 1/4 inch.

An advantageous method is provided for making the improved monolithic cathode-heater structure described in the foregoing. In practicing the method, a paint including metal particles, of nickel for example, is applied to the inner axial portion of the cathode 10, to be occupied by the slug 24.

The paint includes nickel powder having a particle size passing through a 325 mesh and collecting on a 400 mesh. These mesh values are in terms of the number of mesh strands per lineal inch. To 6.9 cc. of metal powder thus selected, is mixed 10 cc. of a binder consisting of 64.5 grams of nitrocellulose including 35% by weight of alcohol, 1950 cc. of diatom, and 850 cc. diethyl oxalate. The resultant paint may be applied to the inner surface of the cathode 10, by a brush or in any other suitable way. The painted cathode is then heated in line hydrogen at a temperature from 1100° C. to 1200° C. for about 30 minutes.

The paint for providing a sintered coating on the heater 18 includes nickel powder of the same particle size as in the previous example, but the amount of binder used should be sufficient to produce a thin creamy consistency. The paint so produced is placed in a beaker, and the heater structure comprising the coil 18 and rod 32, are immersed in the paint to completely cover the heater but not below the insulating coating 33 on rod 32, as viewed in the drawing. The heater 18 is then removed from the beaker and shaken to remove excess coating material, leaving a relatively thin coating of the paint adhering to the heater. The heater with the relatively thin coating adhering to it, is then heated in line hydrogen at a temperature of from 1100 to 1200° C. for about 30 minutes.

The heating step in the two foregoing examples serves to drive off the binder and to sinter the particles of the nickel powder to each other and to the cathode 10.

Thereafter the cathode 10 is supported in a jig (not

shown) in inverted fashion and the heater end of the heater structure is extended into the cathode 10, so that the heater coil 18 is disposed within the axial portion of the cathode to be occupied by the slug 24. The jig is provided with a suitable stop surface (not shown) against which the coil end of the heater structure abuts.

Thereafter, nickel powder having a particle size passing through a 200 mesh screen but collecting on a 325 mesh screen, is poured into the cathode and over the heater coil, including the end portion 22 thereof, free of insulating coating until the axial portion of the cathode occupied by the heater coil 18, is filled.

The parts thus assembled are placed in an oven containing line hydrogen and heated to a temperature of from 1100° C. to 1200° C. for about 45 minutes. This heat treatment serves to sinter the particles making up the body 24 to each other and to the sintered coatings on the cathode and heater coil.

A first solder ring (not shown) made of equal amounts by weight of gold and copper, is then placed on the radial portion of the flange 16. The insulating ring 36 is threaded over the rod 32 until it seats on the first solder ring. A second solder ring (not shown) similar to the first solder ring, is placed on the disk 34, and the disk 34 is then extended over the rod 32 into seated relation on the second solder ring. A third body of solder is interposed between the rod 32 and the disk 34. The parts so assembled are heated in line hydrogen to a temperature of about 940° C. The disk 36 is thus fixed to the flange 16 and the disk 34 to the disk 36, with the rod 32 solder sealed in the aperture in the disk 34.

Thereafter, the emitting coating 12 is applied to the outer surface of the cathode 10, throughout an area that is substantially co-extensive with the heater coil 18. The coating may comprise the usual triple carbonates of barium, strontium and calcium.

In view of the relatively large amount of nickel powder required to form the body 24, it is important that the powder have a carbon content of less than .005% by weight. Such powder may be made by firing nickel powder having a particle size passing a 200 mesh screen and collecting on a 325 mesh screen, in line hydrogen at from 740 to 760° C. for about 30 minutes. Any sintered agglomerates are then ground and the resultant powder sifted to obtain the particle size referred to in the preceding sentence.

What is claimed is:

1. In an electron tube, a subassembly comprising:

- (a) a tubular cathode,
- (b) an insulated heater wire within said cathode, and
- (c) a body of sintered metal powder engaging said heater wire and said cathode, said body including relatively thin layers of sintered metal powder adjacent to the inner surface of said cathode and adjacent to the outer surface of said heater wire, said relatively thin layers having a particle size smaller than the size of the particles of the metal powder of the remainder of said body, whereby said body adheres firmly and uniformly to said cathode and to said insulated heater wire.

2. In an electron tube, a cathode heater mount subassembly comprising:

- (a) a tubular cathode including an axial portion having on the outer surface thereof a coating of electron emitting material, said axial portion defining an inner space,
- (b) a heater wire within said space, said heater wire having a coating of insulating material thereon, one end portion only of said wire being free of said insulating coating,
- (c) the inner surface of said axial portion of the cathode and the outer surface of said coated heater wire and said one end portion of the wire, having

5

6

- thereon a relatively thin coating of sintered metal powder of relatively small particle size, and
- (d) a body of sintered metal powder of relatively large particle size engaging said thin coating of sintered metal powder on said cathode and on said heater wire surfaces. 5
3. In an electron tube, a subassembly comprising:
- (a) a tubular cathode having a surface portion defining a predetermined inner space,
- (b) a heater assembly within said space, said heater assembly comprising a heater wire, a heater lead electrically connected to one end of said wire, said wire having another end portion, all portions of said heater lead within said space and all portions of said wire except said another end portion thereof having thereon a coating of insulating material, and 10
- (c) a body of sintered metal powder of relatively large particle size within said space,
- (d) said inner surface portion of said cathode and the outer surfaces of said coated heater lead, coated portion of said heater wire and uncoated portion of said heater wire, having thereon a coating of sintered metal powder of relatively small particle size, for firmly anchoring said body to said inner surface portion and to said heater assembly for uniform heat transfer to said cathode from said heater wire. 15
4. In an electron tube, a subassembly comprising:
- (a) a tubular cathode,
- (b) a body of sintered metal powder within said cathode, and 20
- (c) a heater wire imbedded in said body, all portions of said wire except one end portion thereof being insulated from said body,
- (d) the inner surface of said cathode and the outer surface of said heater wire having relatively thin coatings of sintered metal powder anchoring said body to said cathode and to said heater wire, with freedom from discontinuities between said body, and said cathode and heater wire. 25
5. In an electron tube, a subassembly comprising:
- (a) a tubular cathode,
- (b) a body of sintered metal powder filling the space defined by an axial portion of said cathode,
- (c) a heater assembly imbedded in said body, said assembly comprising a heater wire and a portion of a heater lead electrically connected to one end portion of heater wire, said lead portion and all portions of said heater wire except the other end portion thereof, having thereon a coating of insulating material, said coated lead portion and all portions of said heater wire including the coated and uncoated portions thereof, having thereon a relatively thin coating of sintered metal powder, said body being sintered to said coating, for providing uniform heat transfer from said heater wire to said cathode. 30
6. In an electron tube, a subassembly comprising:
- (a) a tubular cathode having electron omitting material on an axial portion of the outer surface thereof, 35

- (b) a heater wire coil disposed substantially co-axially within said axial portion of the cathode.
- (c) an electrical conductor portion within said axial portion and connected to one end of said coil,
- (d) a body of sintered metal powder electrically connecting the other end of said coil to said cathode,
- (e) said conductor portion and said wire coil, except said one end of the coil, having thereon a coating of insulating material,
- (f) said body being in intimate and continuous engagement with all surface portions of the inner surface of said axial portion of the cathode, and with the outer surfaces of said conductor portion and heater coil, for uniform heat transfer from said heater coil to all parts of said portion of the outer surface of the cathode.
7. In an electron tube, a subassembly comprising:
- (a) a cathode having a surface portion to be heated,
- (b) a body of sintered metal powder engaging an opposite surface portion of said cathode substantially co-extensive with said first named surface portion, and
- (c) a heater wire having an insulating coating thereon and spaced from said opposite surface portion, said body engaging said insulating coating, the particles of said metal powder adjacent to said insulating coating and to said opposite surface portion, being smaller than the particles of the remainder of said body.
8. In an electron tube, a subassembly comprising:
- (a) a body of sintered metal particles of predetermined size,
- (b) an electrical conductor imbedded in said body,
- (c) said conductor having thereon a coating of sintered metal particles of smaller size than said predetermined size, for providing a shock resisting electrical continuity between said conductor and body.
9. In an electron tube, a subassembly comprising:
- (a) a body of sintered metal particles,
- (b) an electrical conductor having an insulatingly coated portion and a free end portion free of insulation, imbedded in said body,
- (c) said free end portion having thereon a coating of sintered metal particles,
- (d) said sintered coating being sintered to said body for desired shock proof electrical continuity between said body and conductor.

References Cited by the Examiner

UNITED STATES PATENTS

2,062,124	11/1936	Flaws	117—231
2,143,915	1/1939	Jobst	313—340
2,542,657	2/1951	Gall	313—340
2,722,491	11/1955	Anderson	117—231
2,879,583	3/1959	Booth et al.	29—25.13
2,935,782	5/1960	Rangabe	29—25.13

DAVID J. GALVIN, *Primary Examiner.*GEORGE N. WESTBY, *Examiner.*

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,221,203

November 30, 1965

Frank Rowland Ragland, Jr.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 18, for "monolithi" read -- monolithic --;
column 2, line 3, for "other" read -- outer --.

Signed and sealed this 6th day of December 1966.

(SEAL)

Attest:

ERNEST W. SWIDER

Attesting Officer

EDWARD J. BRENNER

Commissioner of Patents