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CATHODE HEATER HAVING AN ALUMINUM OXIDE AND TUNGSTEN COATING

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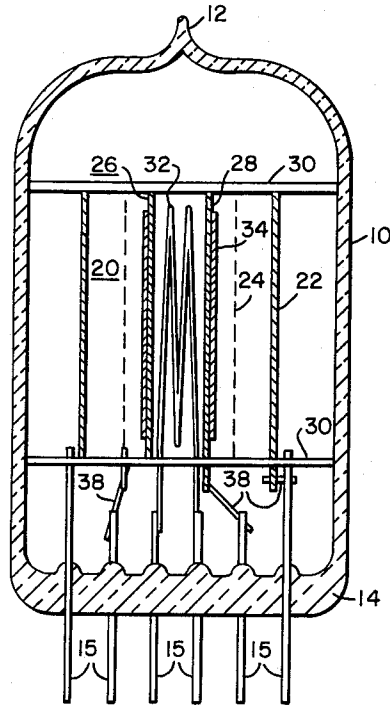


Fig. 1.

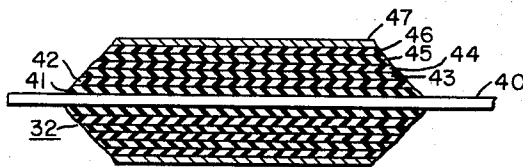


Fig. 2.

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1

2

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CATHODE HEATER HAVING AN ALUMINUM OXIDE AND TUNGSTEN COATING

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5 Claims. (Cl. 313—345)

The present invention relates to electron discharge devices of the type having an indirectly heated cathode and, more particularly, to an improved heater for use in such devices.

In conventional discharge devices utilizing an indirectly heated cathode, there is provided within an electrode cage assembly, a tubular cathode sleeve having on its outer surface a coating which becomes electron emissive when heated to the proper temperature. A filamentary wire is disposed within the tube and upon the application of an electrical potential to this wire, a current flows within the wire causing the filament to heat. The heat from the filament is radiated to the inner surface of the cathode sleeve, thus heating the coating to emission temperature. The heater may take on any of several forms, such as coiled, folded, etc., as are well known in the art.

The heater wire in a conventional device is coated with an electrically insulating material to electrically insulate the heater from the cathode sleeve and to insulate successive turns or folds of the heater one from the other. Aluminum oxide, which is most commonly used as the insulating material is subject to criticism. By virtue of the fact that aluminum oxide is white in color, the heat transfer to the cathode sleeve is rather poor and thus the wire must be raised to a very high temperature to heat the cathode to emission temperature. As the wire filament itself is normally of a material such as tungsten, the high temperature necessary often results in a recrystallization of the wire, thus making the wire very brittle and resulting in breakage thereof. The high temperature may also result in distortion, twisting, and sagging of the heater which in turn may result in heater short circuits occurring in cracks within the insulating coating which is also very brittle. Additionally, the white insulating coating is subject to color change occasioned by factors such as sublimation of other tube parts occurring during use of the device and this color change results in a different heat transfer which in turn necessitates a change of heater current during the life of the device. A further factor to be considered is the low efficiency of heat transfer which necessitates a higher heater current. Thus, the power requirements are increased and hence the efficiency of the device as a whole is decreased.

It is, therefore, an object of this invention to provide an improved electron discharge device.

A further object is to provide an improved indirectly heated cathode for use in electron discharge devices.

Another object is to provide a cathode heater of improved efficiency, lessened distortion and longer life.

A still further object is to provide an improved cathode heater which may be manufactured by methods common in the art.

Stated briefly, the present invention remedies the aforementioned deficiencies by providing a cathode heater having a multi-layer coating on the wire filament. The number of layers provided in this coating depends upon various circumstances such as the operating voltage of the final device. However, the present invention provides that the initial layer which is disposed directly upon the filament wire is of aluminum oxide. The last layer of the wire coating which has one surface exposed contains aluminum oxide admixed with a quantity of tungsten powder.

This tungsten powder, after the heater has been processed, results in an outer coating surface having a gray appearance and by virtue of this color a more efficient heat transfer from the heater to the cathode is effected. This increased efficiency in heat transfer permits the heater to be operated at a lower temperature, thus improving the overall efficiency of the device as well as reducing such factors as recrystallization, distortion, and sagging of the filament. Also, variance in color of the coating during tube operation is lessened and hence the necessity of changing the heater current is alleviated.

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

For a better understanding of the invention, reference may be had to the accompanying drawings, in which:

FIGURE 1 is an elevational view, in section, of an electron discharge device embodying the present invention; and,

FIG. 2 is a fragmentary sectional view, greatly enlarged, of a heater wire coated in accordance with the present invention.

With reference now to FIG. 1, there is shown an electron discharge device embodying the present invention. The device comprises an envelope 10 including at one end thereof a tipped off exhaust tube 12. The lower end of the envelope 10 is closed off by means of a button stem header 14. A plurality of lead pins 15 extend and are sealed through the header 14. Disposed within the envelope 10 is an electrode cage assembly indicated generally at 20. The cage assembly 20 includes an anode 22, a grid 24 and a cathode 26. These three elements may take on various configurations but in the illustrated embodiment are shown to be concentric circular tubular members.

The cathode 26 is comprised of a metallic tubular member 28 having a coating 34 provided on the outer surface thereof. This coating 34 may be any suitable electron emissive coating. Disposed within the cathode 26 is a heater 32 of the present invention. The heater 32 is shown to be of a folded configuration although, as will be apparent, any suitable configuration may be utilized.

The various elements of the cage assembly 20 are supported within the envelope 10 by means of a pair of insulating discs 30, one of which is located at either end of the electrodes. Suitable connector means 38 are provided to connect the various electrodes to the several pins 15 to provide for electrical connection to the electrodes from the exterior of the envelope 10.

It is to be understood that the above configuration is purely for purposes of illustration and that the heater of the present invention may be used in any suitable discharge device having a greater or lesser number of electrodes and any other suitable construction configuration. The device as thus far described is that of standard design such as is very well known in the art.

With reference now to FIG. 2 there is shown a greatly enlarged view, in section, of the coated heater 32 shown in FIG. 1. The heater 32 is comprised of a wire 40 which is a suitable electrically resistive material, for example, tungsten. The diameter of the wire 40 will, of course, vary greatly depending upon such factors as the operating voltage of the heater. However, as an illustration, in customary receiving type tubes the wire diameter will be in the range of from 1.2 to 7.5 mils. The wire 40 is provided with a coating which is made up of a plurality of layers 41 through 47. Although seven layers are shown in the illustrated embodiment, it is understood that a greater or lesser number of layers

could be used depending upon various parameters such as layer thickness and operating conditions.

In the illustrated embodiment of FIG. 2 layers 41 through 46 are comprised substantially of aluminum oxide. The aluminum oxide layer or layers may be applied by any method conventional in the art. One conventional method of applying the aluminum oxide layers is to prepare a binder solution of aluminum nitrate and deionized water in a ratio of approximately 454 grams of aluminum nitrate crystals to 325 cubic centimeters of deionized water. A slurry is then formed by combining, in approximately the following proportions, the following materials:

Powdered aluminum oxide	-----g	100
Aluminum nitrate solution	-----cc	24
Deionized water	-----cc	11
Methanol	-----cc	11

These proportions provide a slurry of the proper consistency for coating a filament with the methanol also serving as a wetting agent.

While the particle size of the aluminum oxide utilized may vary from tube type to tube type, it is comparatively uniform in any particular slurry and normally is a particle size in the range of from approximately 7 to 20 microns.

The aluminum oxide slurry is then placed in a suitable receptacle and is kept under constant agitation to maintain the suspension. The wire 40 is then passed through the slurry at which time a coating is placed upon the wire. Depending upon certain factors such as the speed at which the wire is passed through the slurry, the thickness of the coating will vary. However, this coating or layer is normally approximately 0.5 mil thick. After the wire has been coated, it is passed through an air furnace having a temperature in the range of from 700 to 800° C. at which time the water and the nitrate are driven from the layer. This process is repeated the requisite number of times to provide a coating of desired thickness around the wire 40.

The final layer 47 around the wire 40 differs from the previous coats as follows. To a thinned down version of the normal insulator coating of layers 41 through 46 there is added powdered tungsten of high purity. This powder has a particle size averaging about 1 micron with the range of particle size being from approximately 0.5 to 2 microns. While the amount of tungsten added may vary somewhat, it has been found that an amount of tungsten equal to approximately 40 percent by weight of the aluminum oxide (i.e. a ratio of approximately 5 to 2 aluminum oxide to tungsten) contained in the slurry provides very good results. The purpose of the tungsten powder is to provide a darker colored coating and it has been found that if the amount of tungsten goes much below the percent figure then the coating does not have sufficient color to function well. At amounts much in excess of 40 percent, it has been found that the greater amount of metal within the coating tends to make the coating electrically conductive which is undesirable. A suitable formula for the last layer slurry is as follows: 100 grams of aluminum oxide to 40 grams of tungsten to 200 cubic centimeters of the aqueous solution of aluminum nitrate and methanol.

While the tungsten containing slurry may be applied to the previous coatings in the same manner as the previous coatings were applied it has been found that the tungsten containing slurry is more difficult to keep in the suspension state and that the standard bubble coating device serves better to keep the uniformity of the suspension. After the tungsten containing slurry has been applied to the aluminum oxide layers, the coated heater is again passed through the air furnace as set forth above. The wire is then passed through a hydrogen furnace having a temperature normally in the range of from 800 to 1100° C. at which time any remaining nitrate is re-

moved and at which time the aluminum oxide and the aluminum left from the aluminum nitrate, which may now also be in the form of aluminum oxide, is sintered to provide an adherent coating around the wire 40. The last layer 47 also includes, of course, the powdered tungsten to provide a final coating which is a dark tungsten rich layer having very good heat transfer properties. The final tungsten containing layer is also approximately 0.5 mil thick.

Heaters made by the aforementioned description have proven to be very successful in that for the same cathode temperature, the wire temperature required is approximately 200 to 300° C. less. Thus, the same heater design made with the tungsten layer coating may have a reduced wire weight of about 13%.

It is thus seen that there has been described an improved heater coating which by virtue of its darker color results in a high thermal emissive device which allows the heater to be operated at a lower temperature. This lower temperature reduces distortion, twisting, and recrystallization and hence results in longer heater life. It is also seen that there is little change from normal methods of coating application needed to produce a heater in accordance with the present invention.

While there have been shown and described what are at present considered to be the preferred embodiments of the invention, modifications thereto will readily occur to those skilled in the art. For example, more than one tungsten containing layer may be provided if this is found desirable in a particular case. It is not desired, therefore, that the invention be limited to the specific arrangements shown and described and it is intended to cover in the appended claims all such modifications as fall within the true spirit and scope of the invention.

I claim as my invention:

1. A heater adapted to be disposed in a heat transfer relation with a cathode of an electron discharge tube, said heater comprising an electrically resistive wire having a multi-layer coating thereon, said coating including a first layer consisting essentially of aluminum oxide disposed upon said wire and a last layer having its outer surface exposed to said cathode, said last layer consisting essentially of aluminum oxide admixed with tungsten powder, said tungsten powder being of a particle size ranging from between 0.5 to 2 microns, said tungsten powder being present in the amount of approximately 40% by weight of said aluminum oxide.

2. A heater adapted to be disposed in a heat transfer relation with a cathode of an electron discharge device, said heater comprising an electrically resistive wire having a multi-layer coating thereon, said coating including a first layer consisting essentially of aluminum oxide disposed upon said wire and a last layer having its outer surface exposed to said cathode, said last layer consisting essentially of aluminum oxide admixed with tungsten powder in a ratio by weight of approximately 5 to 2, said tungsten powder being of a particle size ranging from between 0.5 to 2 microns.

3. An indirectly heated, electron emissive thermionic cathode comprising an electrically resistive wire having a multi-layer coating thereon, said coating including at least one layer of aluminum oxide in contact with and covering said wire and at least one layer having its outer surface exposed to said cathode consisting essentially of aluminum oxide mixed with powdered tungsten, said powdered tungsten being present in an amount of approximately 40% by weight of said aluminum oxide, said powdered tungsten being of a particle size not in excess of 2 microns.

4. A heater comprising a wire having a plurality of coatings thereon, said coatings including at least a first coating of aluminum oxide in contact with said wire and at least one last coating disposed about said aluminum oxide coating, said last coating consisting essentially of

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aluminum oxide and powdered tungsten, said powdered tungsten being present in said last coating in an amount of approximately 40% by weight of said aluminum oxide, said amount of powdered tungsten being sufficient to provide said last coating with a darkened, thermal emissive surface and insufficient to establish electrical leakage across said last coating, said powdered tungsten being of a particle size not in excess of 2 microns.

5. A heater comprising a wire having a plurality of coatings thereon, said coatings including at least a first coating of aluminum oxide in contact with said wire and at least one last coating disposed about said aluminum oxide coating, said last coating consisting essentially of aluminum oxide and powdered tungsten in a ratio by weight of approximately 5 to 2, said powdered tungsten being of a particle size not in excess of 2 microns.

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