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INDIRECTLY HEATED CATHODE OF INCREASED EFFICIENCY

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Fig. 1.

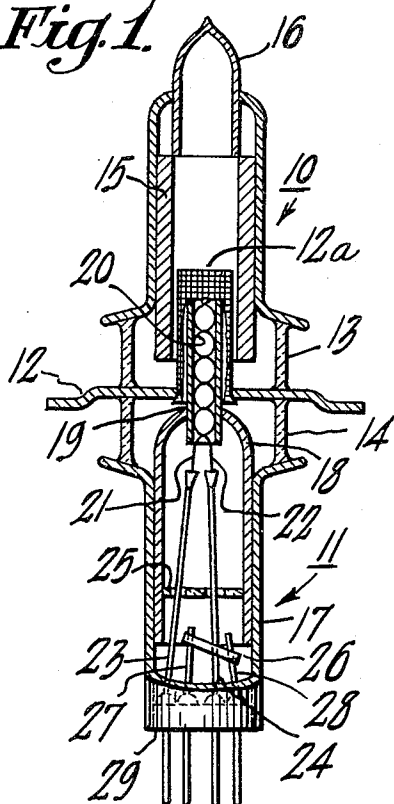


Fig. 3.

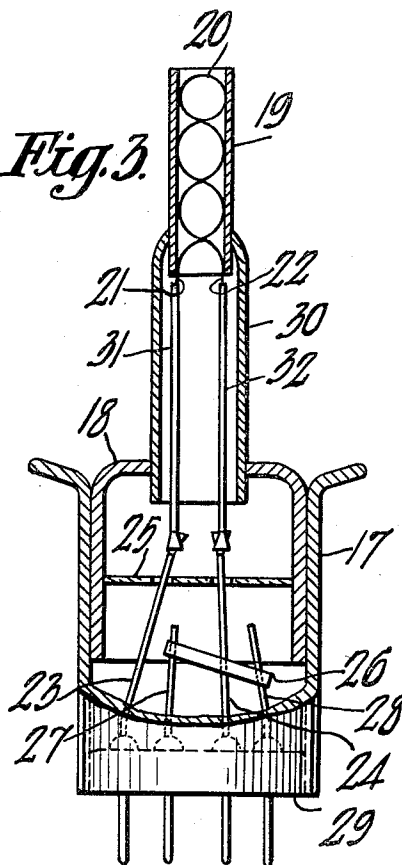
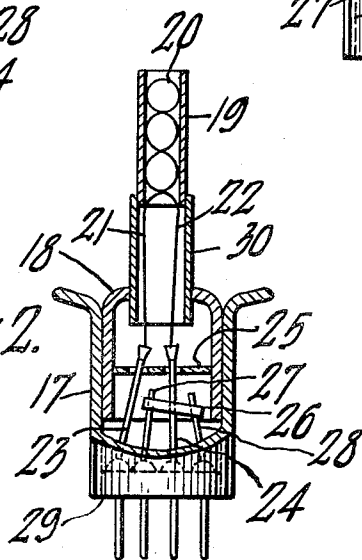


Fig. 2.



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INDIRECTLY HEATED CATHODE OF INCREASED EFFICIENCY

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6 Claims. (Cl. 313—37)

This invention relates to a cathode assembly, including a cathode of the indirectly heated type, of increased efficiency, and more particularly to a rugged cathode assembly characterized by reduced heat losses.

In some types of electron tubes, such as the "pencil type," the cathode is spaced appreciably from the header or stem through which heater leads extend. This appreciable spacing has rendered it necessary to use heater legs integral with the heater of considerable length for connecting the heater to the heater leads referred to. The heater structure employed in the "pencil type" tube aforementioned includes a double coil which is received within the sleeve, the legs of the heater extending outside of the sleeve. Since the heater legs are integral with the double coil and have the same diameter as the coil wire, they become heated to substantially the same degree as the coil and dissipate an appreciable amount of heat to the region surrounding them. The heat dissipated is not only the heat directly generated in the heater legs but also heat transferred by conduction by the heater proper to the legs. Such transfer is likely to occur because of the higher temperature of the heater proper, resulting from the greater heater concentration in the heater proper than in the legs, and the shielding effect provided by the cathode sleeve, which is absent from the region of the heater legs.

This heat dissipation by the cathode sleeve and heater consumes an appreciable part of the power intended to energize the heater. Because of this, either the heat transfer from the heater to the sleeve is inadequate for a desired emission, or added power to the heater is necessary to make up for the heat dissipation referred to.

In addition to undesirable heat dissipation, the relatively long heater legs heretofore employed in the "pencil type" tube have contributed to loss of ruggedness of the cathode assembly. The heater coil received by the cathode sleeve relies in part on a snug fit in the sleeve and in part on the heater legs for support. Where the heater legs are relatively long and of relatively small cross-section, as is the case when they are integral with the heater coil, they provide a relatively weak support for the heater coil. This support may be inadequate, and impacts incidental to normal use of a tube in which the assembly is used, may cause the heater coil to become displaced from the sleeve, thereby impairing further utility of the tube.

The lack of ruggedness of a support provided by relatively long heater legs integral with the heater, is also a disadvantage when mounting the heater in the cathode sleeve. Some force is usually involved in inserting a heater in a sleeve, especially when the transverse dimensions of a heater structure are such as to provide a relatively snug fit of the heater in the sleeve. Since this force is transmitted through the heater legs, collapse or buckling of the heater legs sometimes occurs during a mounting operation.

Accordingly, it is an object of the invention to provide an improved cathode assembly of the indirectly heated type.

A further object is to provide an indirectly heated cathode of increased efficiency.

Another object is to provide an indirectly heated cath-

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ode assembly wherein undesired heat losses by the cathode sleeve and heater, is reduced.

A further object is to provide an indirectly heated cathode assembly including an elongated heat isolating support for the cathode sleeve of such assembly resulting in increased spacing of the sleeve from lead-ins serving the heater of the assembly, and leads of novel construction between the heater and said lead-ins for reducing heat losses therefrom.

Another object is to provide a tubular heat isolating cathode sleeve support having a falling characteristic of heat conductivity at increasing temperatures thereof and leads within said support having relatively high heat radiating properties for raising the temperature of the support to thereby reduce its heat conductivity, whereby heat losses from said sleeve are reduced.

A further object is to provide an indirectly heated cathode assembly of increased ruggedness.

Briefly considered, the indirectly heated cathode assembly of the invention includes a tubular support for the cathode sleeve, having reduced heat conductivity and characterized by appreciably less heat conductivity in relation to applied heat, at relatively high temperatures than at relatively low temperatures. In combination with this tubular support the invention provides for a heater disposed within the cathode sleeve and having relatively short integral legs, and tubular leads having relatively large area surfaces connecting the short heater legs to heater lead-ins. The tubular leads extend within the tubular support and are substantially coextensive longitudinally therewith.

This combination is of appreciable advantage. The tubular structure of the leads provides relatively large heat radiating surfaces. Therefore, whatever heat is generated in the leads is readily radiated from their relatively large area surfaces, to the inner walls of the tubular support. The temperature of the tubular cathode support is therefore increased as a result of such radiation, which serves to decrease its characteristic of heat conductivity.

While one advantage of the tubular leads resides in their greater heat radiation, as aforementioned, further advantages of the tubular structure of the leads comprise increased ruggedness of support provided thereby, increased electrical conductivity thereby reducing heat generation therein as compared to conventional heater legs, and reduced heat conductivity as compared to conventional solid lead-ins. A tubular structure has a favorable characteristic of stiffness over a solid structure of equal diameter. This stiffness enables the leads to support firmly in a cathode sleeve a heater to which they are connected and facilitates insertion of the heater into a cathode sleeve.

The combination of the cathode sleeve tubular support and the tubular leads for the heater, therefore, substantially reduces heat dissipation both from the cathode sleeve as well as from the heater leads, thus permitting reduced heater power input without sacrifice of emission. Furthermore, the tubular leads referred to provide the desired support of the heater, particularly when such support is called upon to traverse an appreciable distance as is involved in a "pencil type" tube structure utilizing a tubular support for thermal isolation of the sleeve, as aforementioned.

Further objects and advantages of the invention will become apparent as the present description proceeds.

Referring to the drawing, in connection with a more detailed description of the invention,

Figure 1 shows a sectional elevation of a conventional "pencil type" electron tube;

Figure 2 is a view in sectional elevation of the cathode assembly of a "pencil type" tube wherein the cathode sleeve is supported on a sleeve made of a material of low heat conductivity for reducing heat dissipation from the

sleeve by conduction and wherein the structure requires relatively long heater legs from lead-ins to the heater proper; and

Figure 3 is a longitudinal sectional view of a cathode assembly according to the invention useful in a "pencil type" electron tube and wherein tubular leads are employed for connecting the heater lead-ins to the heater over the relatively long distance separating the heater and the lead-in as a consequence of the use of a low heat conducting support for the cathode sleeve.

The "pencil type" of electron tube, as shown in Figure 1, includes opposite end sections 10, 11 between which is mounted a disc 12. The disc 12 supports a grid 12a and is electrically insulated from the end sections referred to by means of glass tubes 13, 14. In section 10 is mounted a cylindrical anode 15 and the section is closed at its free end by exhaust tubulation 16.

Section 11 comprises a cathode assembly, and includes an outer tubular member 17 serving as a cathode lead-in. Within member 17 is fixed a tubular support 18 for the coated cathode sleeve 19. A heater 20 having legs 21, 22 is connected to lead-ins 23, 24 which in turn are adapted to be connected to a suitable power source, not shown, for raising the cathode sleeve to an electron emitting temperature. The lead-ins 23, 24 are held in spaced relation by an insulating spacer disc 25. Also included in the cathode assembly is a getter 26 mounted across lead-ins 27, 28, the getter being flashed by resistance heating thereof. The lead-ins 23, 24, 27, 28, are sealed through glass stem 29 which serves to close the free end of section 11 of the tube.

The foregoing tube structure is subject to several disadvantages. The sleeve support 18 is usually made of a metal having relatively high heat conductivity. Therefore, an appreciable amount of heat is conducted by it away from the cathode sleeve 19. Furthermore, the heater legs 21, 22, being integral with the heater 20 and of the same diameter as the heater wire, become heated during energization of the heater. The heat so generated in the legs referred to, serves no useful purpose and on the contrary, since it is dissipated by radiation, constitutes an undesired heat drain. To compensate for the heat lost by the sleeve 18 and legs 21, 22, as aforementioned, it is necessary to provide an increased power input to the heater 20. In addition, the structure, as shown in Figure 1, provides a relatively weak support for the heater. In this connection, it may be noted that the heater 20 and the legs 21, 22 thereof are usually made of wire having a diameter of only 4 mils. The legs therefore, are readily yieldable, not only during the operation of inserting the heater into the cathode sleeve during manufacture of the tube, but also in response to stresses tending to displace the heater from the sleeve during operation.

In attempting to remove the aforementioned difficulties, applicants interposed a tubular support 30, shown in Figure 2, between the cathode sleeve 19, and support 18, the tubular support having reduced conductivity. By way of example, the tubular support 30 may be made of an alloy known commercially as Kovar, and including nickel, iron and cobalt. This alloy is characterized by a relatively low order of heat conductivity. To further lessen heat conductivity by the support 30, its walls may be reduced to a foil thickness of 0.0005 inch.

However, several objections were found to characterize the improved structure shown in Figure 2. The interposition of the tubular or sleeve support 30 between the cathode sleeve and support 18 involved an appreciable increase in the spacing between the heater 20 and the lead-ins 23, 24. To traverse this increased spacing, the heater legs 21, 22 were made substantially longer than in the structure shown in Figure 1. This increased length of the heater legs increased the electrical resistance and consequently the temperature thereof to an appreciable degree resulting in severe losses in heater power. While the hot legs radiated some heat to the sleeve support, the

effect of such heat in reducing the heat conductivity of the support, was negligible in respect of the efficiency of the cathode assembly.

To fully solve the problem of undesired heat loss from the cathode assembly, applicants found it necessary to resort to a novel combination of the thermal isolation sleeve 30 with a novel lead structure connecting the legs of the heater to their associated lead-ins. As shown in Figure 3, a cathode assembly is provided according to the invention in which the heat insulating sleeve 30, which may be similar to the sleeve 30 shown in Figure 2, is interposed between cathode sleeve 19 and support 18. The heater legs 21, 22 are appreciably shorter than in Figures 1 and 2 and are connected to lead-ins 23, 24 by means of tubular leads 31, 32. The tubular leads may have an outer diameter of 10 mils and walls 2 mils thick. In one example, the tubular leads 31, 32 were 11 mm. long. One or both ends of the tubular leads may be flattened for welding or brazing to the heater legs 21, 22 and to the lead-ins 23, 24. Preferably the tubular leads referred to may have a coating of insulation thereon to prevent shorts.

The tubular leads 31, 32 may be made of any suitable material. Preferably they are made of a refractory metal such as tungsten, molybdenum or tantalum having relatively high melting point temperatures. This is because relatively high temperatures are usually used in processing the cathode after mounting in a tube. If relatively low temperatures should be feasible during such processing, other materials, such as nickel, may be employed for the tubular lead-ins referred to.

The tubular leads 31, 32 coact with the thermal isolation sleeve support 30 to increase the efficiency of a tube in which they are used, by decreasing appreciably undesired heat dissipation by the cathode assembly, thereby rendering a reduced power input to the heater 20 adequate for good operation of the tube. The increased cross-sectional area of the tubular leads over that of the heater legs serves to decrease their electrical resistance to thereby conserve the heater power. Whatever heat is generated in the leads is effectively radiated by their relatively large area surfaces to the support 30. As a consequence, sleeve support 30 is heated, and since its heat conductivity characteristic becomes less at higher temperatures, its utility as a thermal isolation means for the cathode sleeve 19 is increased. Therefore, the tubular leads 31, 32 not only contribute to increased efficiency of a tube in which they are used, by virtue of their increased conductivity, but also because they increase the effectiveness of the thermal isolation sleeve 30 in reducing heat conduction from the cathode sleeve.

Apart from their aforementioned coaction with the heat isolation shield 30 to improve the efficiency of a tube, the tubular leads 31, 32, have individual advantages. One of these advantages resides in a contribution of ruggedness to the cathode assembly. This is important where the heater is spaced appreciably from its lead-ins. Thus, the tubular leads provide a relatively rugged support for the heater 20 as a consequence of which it is restrained from displacement from the sleeve 19. Furthermore, the tubular supports provide a relatively stiff heater assembly which is of advantage when threading the heater into the cathode sleeve. In addition, the tubular construction of the leads, renders a flattening thereof at one or both ends, relatively easy, for welding or brazing to the heater legs and leads 23, 24. In one embodiment of the invention, only one end of the tubular leads is flattened for welding to the leads 23, 24, the other ends being open for receiving the free ends of the heater legs to facilitate fixing the heater legs to the tubular leads referred to. It will be noted from the dimensions previously given herein of the heater legs and tubular leads, that the heater legs are readily extendable into the end openings in the tubular leads. When the heater legs are once extended into the end openings in the tubular leads, they are effectively held in position without special holding means, while a weld-

ing or brazing operation takes place. In view of the foregoing advantage, this embodiment is preferred in practicing the invention.

It will be noted from the foregoing, that one advantage of the tubular leads 31, 32, is their relatively large area cross-section, as a result of which their electrical conductivity is increased. However, an increase in the cross-sectional area of the heater leads also increases their heat conductivity. Therefore, it is desirable to keep the cross-sectional area of the heater leads within prescribed bounds, even if this should involve appreciable heat generation therein, if the advantage of increased electrical conductivity is not to be negated by the disadvantage of excessive heat conductivity. Applicants have found that the tubular structure of the heater leads 31, 32 according to the invention, contributes appreciably in realizing the aforementioned advantage while reducing to tolerable limits the disadvantage of heat conductivity.

Thus, the relatively large radiating surfaces provided by the tubular structure effectively dissipate by radiation to the sleeve support 30 any heat generated therein, as a consequence of a reduced cross-section thereof desired for reduced heat conduction from the heater.

However, the cross-section of tubular leads 31, 32 according to the invention is such that most of the heat radiated by the tubular leads 31, 32 is heat conducted to them from the heater, the cross-section being such that a relatively high electrical conductivity results and reduced resistance losses take place.

Applicants have found that a heater assembly having a heat isolation support 30 of a wall thickness of about 0.05 mil, and tubular heater leads having an outer diameter of about 10 mils and a wall thickness of about 2 mils, is characterized by substantial increase in efficiency over structures having either relatively long heater legs or conventional lead-ins of increased length for reaching relatively short heater legs. In this connection, it may be mentioned that heater lead-ins usually employed in the type of electron tube aforementioned have a diameter of 16 mils and are solid in cross-section. A lead having this structure and connected directly to a heater would conduct a prohibitive amount of heat from the heater and in view of its smaller radiating surface in relation to its diameter, would contribute to reduced efficiency of the cathode assembly.

It will be apparent from the foregoing that the invention provides an electron tube of increased efficiency. To this end the cathode assembly of the tube is provided with a thermal isolation support for the cathode sleeve and the heater is provided with tubular leads coacting with the support referred to, to reduce heat losses from the assembly. In addition, the tubular structure of the leads contributes to ruggedness of the cathode assembly and facilitates manufacture of the assembly. These features of the invention contribute to an improved electron tube.

What is claimed is:

1. A cathode assembly for an electron tube comprising a cathode sleeve, a heater within said sleeve and having relatively short legs extending from one end thereof, a support fixed to said one end of said sleeve, a lead-in for said cathode sleeve connected to said support, lead-ins for said heater spaced from said heater legs and said support, and leads connecting said legs to said lead-ins, at least a portion of said leads being adjacent said support, said support being made of a material having a coefficient of thermal conductivity that becomes smaller with increases in temperature of said support, said leads being tubular for good heat radiation, whereby appreciable heat transfer from said leads to said support takes place for reducing the heat conductivity of said support.

2. A cathode assembly comprising a cathode sleeve, a metallic support for said cathode sleeve made of an alloy of nickel, iron and cobalt having reduced heat conductivity at elevated temperatures, a wire heater in said cathode sleeve, lead-ins for said heater, said support being

disposed between said heater and said lead-ins, and tubular leads connected to said lead-ins, said leads having a smaller cross-section than said lead-ins and being connected to said heater, whereby said leads are heated by resistance losses and by conduction from said heater, said leads being relatively close to said support, whereby said support is heated by said leads for reducing its heat conductivity and improving the efficiency of said assembly.

3. A cathode assembly of increased efficiency comprising a cathode sleeve, a first elongated metallic support having one end engaging an end of said cathode sleeve, a second elongated metallic support having one end engaging said first support adjacent to the opposite end of said first support, a heater wire within said cathode sleeve, said heater wire having legs extending adjacent to said first support, and tubular metallic leads of larger cross-sectional area than said legs and extending adjacent to said second support, whereby said first support is heated by said legs and said second support is free from heat from said tubular leads, said first support being made of a metal having a relatively low coefficient of heat conductivity at relatively high temperatures, said second support being made of a metal having a relatively high coefficient of heat conductivity at relatively high temperature.

4. A cathode assembly for an electron tube comprising a cathode sleeve, a metallic support for said sleeve, said support having a relatively low coefficient of heat conductivity at relatively high temperatures and engaging one end of said sleeve, a heater within said sleeve, said heater having two legs extending from said one end of the sleeve, two lead-ins spaced from said legs and adapted to be connected to a power supply, and two tubular leads having relatively large radiating surfaces connecting said legs to said lead-ins and being substantially co-extensive with and relatively close to said support, whereby heat generated in and conducted to said tubular leads is effectively transferred to said support, for improved efficiency of said assembly.

5. A cathode assembly for an electron tube comprising a cathode sleeve, a metallic support having relatively low coefficient of heat conductivity fixed to one end of said sleeve, whereby heat conductivity from said sleeve is reduced, a heater within said sleeve having legs extending from said one end thereof, lead-ins for said legs spaced from the legs, and cylindrical leads having a larger radius than said legs connecting said legs to said lead-ins, said metallic support being made of a material having a relatively low coefficient of heat conductivity at relatively high temperatures, said leads being substantially co-extensive with said metallic support and adjacent thereto for effective heat transfer by radiation to said support, whereby said support is heated by said leads for reduced heat conduction from said sleeve.

6. In combination: a cathode sleeve; a tubular metallic support having a relatively low coefficient of heat conductivity at relatively high temperatures engaging one end of said cathode sleeve; a heater within said sleeve having legs extending from said one end thereof; solid electrical conductors spaced from said legs; and tubular leads having a cross-sectional area intermediate that of said legs and said conductors connecting said legs and conductors and being substantially coextensive with and disposed within said tubular support and adjacent the inner walls thereof and electrically insulated therefrom, whereby said leads radiate heat to said tubular support for reduced heat conduction through said support.

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