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3,116,434

CATHODE ASSEMBLY

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2 Sheets-Sheet 1.

FIG. 1

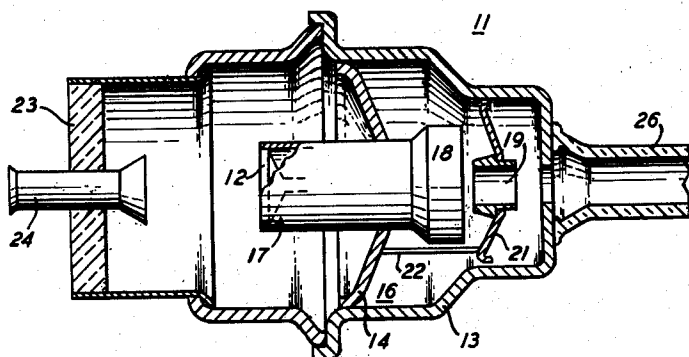
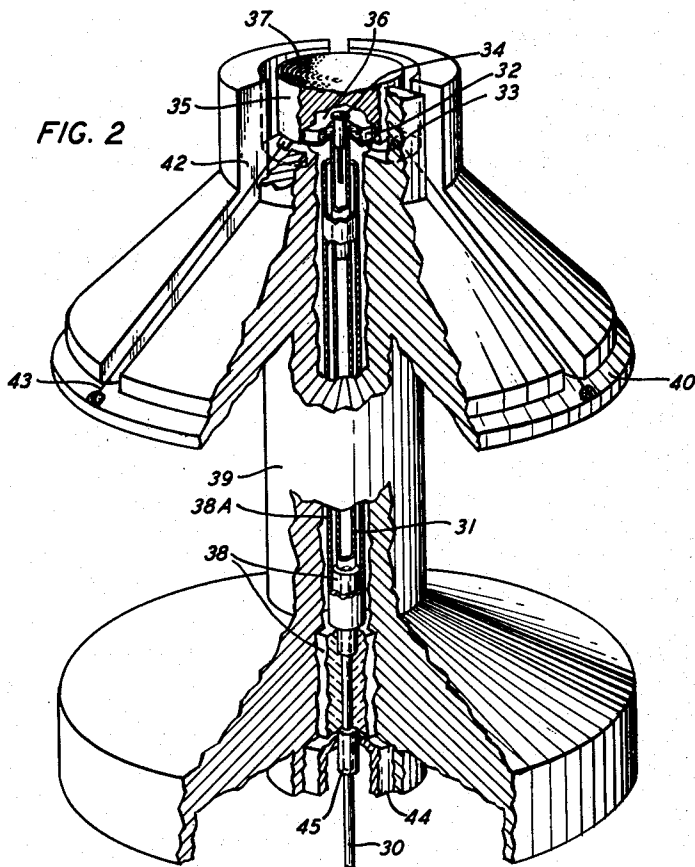


FIG. 2



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FIG. 3

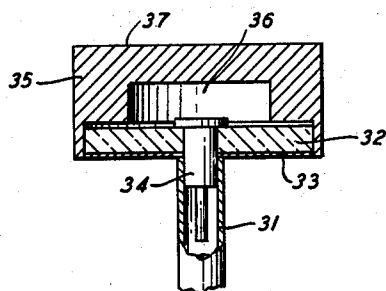
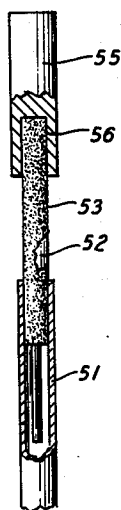


FIG. 4



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3,116,434

CATHODE ASSEMBLY

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4 Claims. (Cl. 313-270)

This invention relates to electron discharge devices and, more particularly, to a cathode structure for use in electron discharge devices of, for example, the traveling wave tube type.

Traveling wave tubes, in general, utilize the interaction between an electron beam and an electromagnetic wave traveling in close proximity to the beam to produce amplification of the wave. Such devices are well adapted for use in communications systems by virtue of the fact that they give high gain over an exceptionally broad band of frequencies in the microwave range. Accordingly, traveling wave tubes have proven to be quite useful tools in radio relay systems operating in the microwave range.

Ordinarily, in order to achieve high power gain in a traveling wave tube while maintaining the tube length within reasonable limits, a high density electron beam is required. To achieve sufficient electron emission from the cathode to provide a beam of the necessary density has, heretofore, required a high expenditure of power in the cathode heater circuit. This large expenditure of power arises, in part, from the necessity of providing a firm support for the cathode, which in turn results in an increase in thermal conductance from the cathode through the support. The heat conducted away from the cathode through the thermal paths thus created is wasted power, since it serves no useful function. Heretofore, efforts to reduce thermal conductivity by decreasing the number or extent of the thermal paths have had a direct effect on the strength and rigidity of the support. In the case of traveling wave tubes in overland communications systems, where large amounts of power are generally available and the tubes are relatively immobile, a compromise between heat losses and rigidity of cathode support is fairly simple to reach. On the other hand, where the traveling wave tube is used in airborne equipment, such as missiles, very limited amounts of power are available and yet the cathode must be supported by a structure capable of withstanding enormous acceleration and vibrational forces. Under such conditions, there can be little or no compromise, the cathode must have a small power drain and it must be strongly supported.

It is an object of this invention to minimize the power drain of the cathode of an electron discharge device.

It is another object of this invention to enable the cathode of an electron discharge device to withstand large acceleration and vibrational forces without detriment to the proper functioning of the device.

One cathode for a traveling wave tube which satisfies successfully the above criteria is supported within the tube by stressed wires which simultaneously provide substantial structural support while ensuring a minimized heat loss. Such a structure is disclosed in copending application Serial No. 95,677, filed March 14, 1961 for L. G. Lyon, L. Rongved and J. W. West. Although the cathode structure disclosed therein performs quite satisfactorily, it is difficult to fabricate and its use is restricted to tubes designed for fulfilling prescribed requirements with little regard to cost.

Accordingly, a further object of this invention is a relatively inexpensive cathode structure which is more suitable to a wider variety of tubes.

These and other objects of the present invention are achieved in an illustrative embodiment thereof which

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comprises a cathode assembly for use in the electron gun of a traveling wave tube. The cathode assembly comprises an elongated tubular electrically conductive member of low heat conductivity having one end mounted in a ceramic block. In turn this ceramic block is mounted in a tubular metallic support member. The other end of the elongated tubular member has mounted thereon an electrically insulating member of high heat conductivity having a vapor-deposited layer of a high melting point metal. Mounted on the electrically insulating member is an electron emitting cathode button. The end of the tubular support member adjacent the emitting button has a flange or flared skirt. The cathode is supported within the support member by stressed wires which are welded to the button and the outer periphery of the skirt.

It is one feature of the present invention that the heating element comprise a thin film of a high melting point metal on an electrically insulating but heat conducting base.

It is a further feature of the present invention that the cathode is supported within the support member partially by stressed wires welded both to the button and the outer periphery of the skirt.

Another feature of the present invention is that the cathode button and the heating element are in physical contact thereby maximizing heat transfer by conduction to the former.

These and other features of the present invention will be more readily apparent from the following detailed description, taken in conjunction with the accompanying drawing, in which:

FIG. 1 is a sectional view of the electron gun end of a traveling wave tube showing the location of the cathode structure of the invention;

FIG. 2 is a perspective view partially in cross section of the cathode structure of one embodiment of the invention;

FIG. 3 is a cross-sectional view of the cathode button structure of the embodiment of FIG. 2; and

FIG. 4 is a cross-sectional view of a second cathode button structure in accordance with this invention.

It is to be understood that the figures are not necessarily to scale, certain dimensions being exaggerated for illustrative purposes.

Turning now to FIG. 1, there is depicted the electron gun end 11 of a traveling wave tube for purposes of illustrating the position of the cathode assembly 12 of the present invention. Inasmuch as the various parts of a traveling wave tube are well known in the art, for purposes of clarity the entire tube has not been shown in detail. That portion 11 of the traveling wave tube which is shown comprises a metallic envelope portion 13 within which is mounted, by means of a mounting member 14, the electron gun assembly 16. Gun assembly 16 comprises a cathode shield 17, within which is mounted the cathode assembly 12 of the present invention, and further comprises a beam forming electrode 18 and an accelerating anode 19 which is maintained in spaced relation to the beam forming electrode by member 21 and post 22. For simplicity, the various voltage leads to the electrodes of the gun 16 have not been shown since they are conventional and form no part of the present invention. The base end of the envelope portion 13 is sealed by means of plate 23 of glass or other suitable material and tubulation 24. The gun end of member 11 is sealed to a glass envelope portion 26 which contains the helix, not shown, of the traveling wave tube.

Turning now to FIGS. 2 and 3, there are shown respectively a perspective view partially in cross section of the cathode assembly 12 of the present invention and an enlarged view in cross section of the cathode button structure included therein.

Cathode assembly 12 comprises a Nilvar wire 30 connected to an elongated tubular electrically conducting member 31 of Nilvar or other suitable material of low heat conductivity. To the upper end of member 31, more clearly viewed in FIG. 3, is mounted a member 32 of sapphire or other suitable material which is electrically insulating and has high thermal conductivity having a thin film 33 of rhenium or other high melting point metal such as platinum, molybdenum, tungsten or the like on its underside. The sapphire member is mounted to member 31 conveniently by a molybdenum pin 34. Mounted on the sapphire member is a cathode button 35 of nickel or other suitable cathode material. Typically, the cathode button has a stepped annular recess 36 for receiving the sapphire member 32 and molybdenum pin 34. The emitting surface 37 of cathode button 35 advantageously is coated with electron emissive material such as barium and strontium carbonate.

The opposite end of member 31 is mounted in a ceramic insulator 38 for spacing said member from the encompassing coaxial elongated shield 38A and a tubular metal support member 39. The upper end of support member 39 is provided with a conical flange or skirt 40. Access to the interior of the support member is provided by grooves 42 at 120 degree spacing about the flange. A stressed wire 43 typically of Nilvar is positioned within each groove extending to the cathode button. The wires are welded to the periphery of the flange 40 at one end and to the cathode button at the other end for further support of the cathode button. The base of the support member 39 is of enlarged diameter for further support and for fixing the assembly within the cathode shield 17 of FIG. 1. Retaining members 44 and 45 typically of nickel and Nilvar respectively are mounted within the enlarged portion of the base for further fixing the elements of the assembly.

In operation, the amount of heat developed for a given current input and sapphire element diameter and length is controlled by the thickness of the rhenium film. The thinner the rhenium film, the higher the film resistance, the lower the current drain, and the more heat developed for a given power input. Rhenium film resistances of from 100 to 5,000 ohms have been used to provide temperatures of from 600 degrees centigrade to 1500 degrees centigrade with a power input of from 0.086 to 12 watts. The intimate contact between the rhenium film, the sapphire member 32, and the cathode button insures maximum heat transfer by an efficient conduction mechanism rather than the radiation mechanism of the prior art. Moreover, the intimate contact between the rhenium film and the cathode button insures a current path traversing a major portion of the rhenium film maximizing the development of heat therein. In addition, the heating element and cathode button are isolated thermally from the remainder of the assembly by electrically conducting elements which exhibit poor heat conductance and are characterized by lower electrical resistance than the rhenium film.

The shape of the conical skirt is not particularly important in accordance with this invention. However, it must adapt the assembly to the encompassing elements. Moreover, it is advantageously of reduced mass for minimizing the support requirements and increasing the natural frequency of the assembly. Typically, the natural frequency of a support structure for a cathode assembly should be in excess of several thousand cycles per second for satellite and aviation applications. Accordingly, the diameter of the skirt usually is fixed by the configuration of the gun end of the tube and shaped along the angle found optimum for the stressed wires.

A typical natural frequency for the support structure of an assembly in accordance with this invention is calculated at about 10,000 cycles per second. By minimizing the mass of the structure, forces of from 350 to 1,000

times the force of gravity at 10,000 cycles per second are withstood successfully.

The stressed support wires typically are of Nilvar. However, any low coefficient of expansion metal should be suitable. For each different material a different angle may be required for the support wires to insure that the forces to which the wires are subjected are exclusively tension and compression forces. For the combinations of material (sapphire, nickel and Nilvar) in these structures the angle turns out to be 45 degrees.

A typical structure as shown in FIG. 2 with the cathode button structure of FIG. 3 had an emitting surface of 0.150 inch; a total length and width of 0.830 and 0.680 inch, respectively. The structure dissipated 450 watt of power and withstood 350 times the force of gravity (calculated).

The cathode button structure of FIGS. 2 and 3 is for a relatively large diameter electron beam. Frequently a beam of much smaller dimensions is required and the button structure may be modified accordingly. One cathode button structure designed for a cathode emitting surface considerably smaller and requiring less support than that of FIGS. 2 and 3 is illustrated in FIG. 4. The cathode assembly is substantially the same as that of FIG. 2 except for the dimensions. Accordingly, only the button structure is shown. The elements of the figure are numbered for convenience to correspond to reference numerals of like elements of FIGS. 2 and 3. The cathode assembly comprises an elongated tubular electrically conducting member 51 to the upper end of which, as viewed in FIG. 4, is mounted a sapphire member 52 having a vapor-deposited layer 53 of rhenium or other high melting point metal thereon. Typically the end portions of member 52 are coated with a layer of molybdenum and the rhenium coats the center portion overlapping the molybdenum. The sapphire member is mounted conveniently within the upper end of member 51. Mounted on the sapphire member is an emitting cathode button 55 adapted by an annular recess 56 to receive sapphire member 52. The opposite end (not shown) of member 51 is mounted in the narrower end of a stepped ceramic insulator for spacing said member from a proximate shield and a remote support member in an arrangement analogous to that shown in FIG. 2.

The advantages to a cathode assembly of the type described are apparent from the foregoing and from an examination of the current path through the assembly and a comparison of the heating element of the assembly to the tungsten coil of the prior art. The current path through the assembly of FIG. 2 is, consecutively, the Nilvar lead in wire 30, the Nilvar support element 31, the film 33, the cathode button 35, and the stressed wires out to the flange 40 for completing the circuit. Since sapphire is electrically insulating, no current passes through it. Accordingly, at this point in the circuit the rhenium film conducts all the current and the heat which develops is transferred efficiently thereby to the cathode button. It is characteristic of cathode heating elements that their temperatures are in excess of the temperature of the cathode button which is maintained advantageously at about 750 degrees centigrade. A typical cathode heater is a tungsten resistance coil which heats the cathode sleeve by radiation and then the cathode button by conduction. Such a coil typically is at a temperature in excess of 1,055 degrees centigrade for maintaining the cathode button at 750 degrees centigrade. The rhenium film of the present invention need only be heated to about 790 degrees centigrade to supply a corresponding button temperature.

The benefits of such a low operating temperature are many. Specifically, ancillary chemical reactions are minimized by employing the lower temperature. Moreover, the supporting guide wires are subjected to reduced stresses at the reduced temperature. In addition to these advantages which enhance the lifetime of the cathode as-

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sembly of the present invention, it should be emphasized that the present assembly has an important structural advantage in that the heating element is a tough adhesive film which can withstand tremendous acceleration and vibrational forces. In contradistinction, prior art tungsten coils are fractured by comparatively modest forces. A further advantage of an assembly in accordance with this invention is its adaptability to requirements for minute size. For example, it is a much simpler matter to reduce the diameter of the sapphire element and evaporate rhenium on its surface than to fabricate a helix of reduced diameter from a tungsten wire.

No effort has been made to exhaust the possible embodiments of the invention. It will be understood that the embodiments described are merely illustrative of the preferred form of the invention and various modifications may be made therein without departing from the scope and spirit of the invention.

What is claimed is:

1. For use in an electron discharge device, a cathode structure comprising an elongated tubular support member, an elongated cylindrical metallic member mounted within said support member, a member of insulating material mounted on one end of said cylindrical metallic member, a thin coating of high melting point metal on said member of insulating material, a metallic cathode button mounted on said member of insulating material, and a plurality of stressed wires extending from said support member to said cathode button.

2. For use in an electron discharge device, a cathode

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assembly, said assembly comprising an elongated tubular support member of a conductive material, an elongated member of a conductive material of low heat conductivity mounted within said support member, an insulating member of high heat conductivity mounted on said member of a conductive material of low heat conductivity, a thin layer of a high resistance high melting point material on said insulating member, an electron emitting element in intimate contact with said insulating member and said thin layer, a coaxial conical flange about said support member, spaced radial grooves in said conical flange, and a stressed wire within each radial groove, the ends of said wire connected to the periphery of said flange and to said electron emitting element.

3. For use in an electron discharge device, a cathode structure in accordance with claim 2 wherein said elongated electrically conductive member is Nilvar and said member of insulating material is sapphire.

4. For use in an electron discharge device, a cathode structure comprising an elongated tubular support member, an elongated Nilvar member mounted within said support member, a sapphire member mounted on said Nilvar member, a layer of rhenium between about 200 and 5,000 Angstrom units thick on said sapphire member, an electron emitting element in intimate contact with said sapphire member, and a plurality of stressed wires extending from said electron emitting element to said support member.

No references cited.