March 4, 1958 C. C. CUTLER 2,825,832

THERMIONIC CATHODE STRUCTURE

Filed Dec. 3, 1953

FIG. 1

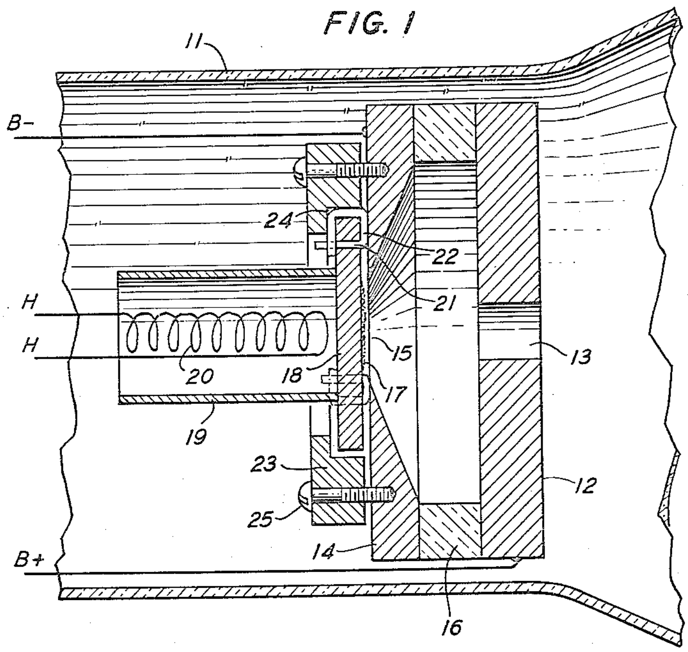


FIG. 2

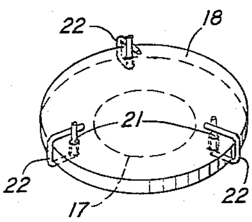


FIG. 3

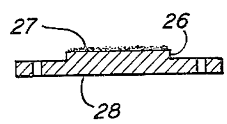


FIG. 4

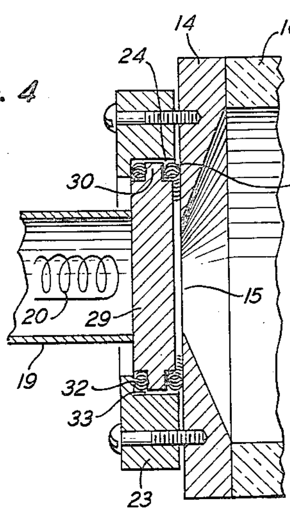
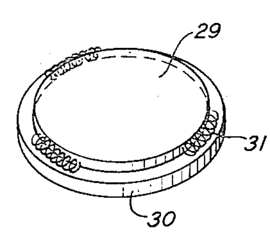


FIG. 5



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THERMIONIC CATHODE STRUCTURE

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7 Claims. (Cl. 313—38)

This invention relates to thermionic cathodes and more particularly to mounting the cathode structure in a high frequency thermionic electron discharge device.

The operating characteristics of high frequency electron discharge devices are dependent to a large extent upon the inter-electrode spacings. In order that a particular device have predetermined operating characteristics it is necessary that the inter-electrode spacings be accurately established during fabrication of the device and be maintained constant during operation of the device. This is necessary since the spacings are extremely small, and changes of small absolute magnitude therein result in relatively large variations in the operating characteristics. All this is particularly true of the cathode and its supporting structure. In addition the cathode should be thermally isolated from the other elements of the device so that the cathode may be heated to the temperature required for thermionic emission without undue power expenditure.

These several requirements have been met in prior devices by either complicated cathode supporting structures or by structures made of materials having different temperature coefficients of expansion or both. An attempt is made in the latter structures to compensate in one portion of the supporting structure for the heat produced expansion in another portion. This compensation is complicated by the fact that the range of temperatures over which the device is often called upon to operate will vary with the supply voltage producing the heating. It is further complicated by the fact noted above that the component size and spacing are very small. In addition, the preparation of the supporting structure involves fastening the supporting components together and to the cathode by some means, most often by welding, and often involves pre-forming the cathode to a particular shape in manufacture.

It is therefore an object of the present invention to mount an electron emitting cathode with respect to other elements of an electron discharge device so that the spacing between the cathode and the other elements is maintained substantially constant regardless of the temperature of the emitting cathode.

It is a further object of the invention to dispose and mount an electron emitting cathode more accurately and simply during manufacture than is possible with prior mountings.

A more specific object is to provide a mounting for a cathode in a discharge device of the type requiring the production of an accurately controlled electron beam which eliminates the necessity of special pre-forming of the cathode structure or of welding a supporting structure to the cathode, while at the same time maintaining a high degree of heat concentration at the cathode.

In accordance with one embodiment of the invention to be described, the cathode takes the form of a flattened disc having a plurality of apertures spaced near its peripheral edge. This edge is loosely received within a cavity formed by rigid support members, which may, in the case of the cathode ray tube, comprise in part the focusing electrode itself. Thin, wire-like elements of low heat conductivity material are looped through each of the apertures to bear against the inside of the cavity. Thus, as the cathode is heated it is free to expand in a radial direction but is restrained at a substantially constant distance equal to the diameter of the wires from the supporting structure. Furthermore, since the cathode is touched at a minimum number of points, and then only by the low heat conductivity wires, little heat conduction is experienced away from the cathode. In another embodiment of the invention the loops are replaced by helical members of material similar to the wires located on either side of the cathode within the cavity.

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These and other objects, the nature of the present invention, its various advantages, and its features will appear more fully upon consideration of the various specific illustrative embodiments shown in the accompanying drawings and described in the following detailed description.

In the drawings:

Fig. 1 is a cross-sectional view of a portion of an electron discharge device, in accordance with the invention, showing the mounting of the cathode and illustrating the relationship of the cathode to other elements of the device;

Fig. 2 shows in perspective view the cathode portion of the assembly of Fig. 1;

Fig. 3 is a cross-sectional view of an alternative cathode shape in accordance with the invention;

Fig. 4 is a cross-sectional view of a second embodiment of the invention illustrating a modification of the cathode support of Fig. 1; and

Fig. 5 shows in perspective view the cathode portion of the assembly of Fig. 4.

Referring more specifically to Fig. 1, an illustrative embodiment of the invention is shown in the form of an electron gun of a beam-type tube such as a cathode ray tube or a traveling wave tube. Enclosed within portion **11** of the evacuated outer casing or bulb of the tube, and supported therein by suitable means is an anode ring **12** of conventional design having an aperture **13** in the center thereof to allow for passage of the produced electron beam to portions of the tube not shown which, however, would be located above the structure shown in Fig. 1. Anode **12** is biased at a high positive potential relative to focusing electrode **14** as indicated by the conductive leads marked B+ and B—.

Electrode **14** may be as illustrated, an element of conventional design comprising a ring of conductive material having a generally conical taper extending toward the center opening **15** thereof and in a direction away from anode **12**. Electrode **14** is separated and supported from anode **12** by ring **16** of insulating material, such as a suitable ceramic or porcelain material.

Coaxially arranged with aperture **13** of anode **12** and aperture **15** of electrode **14** is the cathode assembly in accordance with the invention. This assembly comprises an emissive layer **17**, such as an oxide of one of the rare earths, for example, barium or strontium. Layer **17** is carried by a flattened disc or button-like plate **18** of a high melting point, high heat conductivity, electrically conductive material such as nickel or iron. Integrally connected to plate **18** and coaxially arranged therewith is a tubular heat shield **19** of material similar to plate **18**. Shield **19** surrounds a conventional tungsten heating element **20**.

Located around the periphery of plate **18** and displaced toward the center from the edge thereof by a convenient distance, are a plurality of apertures **21** extending through the thickness of plate **18**. This is most clearly seen in the perspective view of Fig. 3. If, for example, the diameter of plate 18 is in the order of .150 inch, a convenient distance from the edge thereof for apertures 21 would be in the order of .015 inch. The diameters of the apertures may then be in the order of .012 inch.

Before assembling the cathode structure a short length of wire-like element 22 of material having a low coefficient of heat-conductivity and a high melting point is looped through each of apertures 21. Suitable materials for wires 22 may be tantalum, stainless steel or other low heat conductivity material. However non-metallic materials may also be used as will be described hereinafter. Preferably three such aperture-wire combinations may be employed, but more may satisfactorily be provided if desired.

After wires 22 are inserted as described, plate 18 is located relative to aperture 15 of electrode 14 as defined above so that wires 22 bear against the lower surface of electrode 14, as shown. Thus, wires 22 provide a separation between electrode 14 and plate 18 substantially equal to the dimeter of wires 22 and this dimension may be critically selected by proper choice of the wire diameter. Upon this assembly is placed a clamping ring 23, which may be of any rigid material, and is provided with annular recess 24. The depth of recess 24 is substantially equal to the thickness of plate 18 plus twice the diameter of wires 22. Ring 23 is held against electrode 14 by any suitable means, which may be, for example, small machine bolts extending into tapped holes in electrode 14. Thus, recess 24 together with the lower face of electrode 14 forms a cavity within which wires 22 are pressed against the inside surface thereof. The slight resilience of wires 22 will hold plate 18 securely at a substantially constant distance from focusing electrode 14. As the cathode is heated, however, plate 18 is free to expand laterally in a radial direction. In order to accommodate this expansion the diameter of recess 24 should be substantially equal to the heated diameter of plate 18 plus twice the diameter of wires 22. Therefore, upon heating the cathode the emissive layer 17 thereof on plate 18 will be substantially centered with respect to aperture 15. Since the only physical contact between plate 18 and its supporting structure comprising ring 23 and electrode 14 is through the point-like contact of the several low heat conductivity wires 22, little heat transfer is experienced away from the cathode structure 17—18—19.

In the embodiment illustrated cathode 17—18—19 is operated at the potential of electrode 14 as is common in cathode ray-type tubes. However, if electrical isolation is desired, wires 22 may be made of drawn quartz strings or other insulating material having a low heat conductivity and a suitable amount of resilient flexibility. Alternatively, either ring 23 or a portion of electrode 14 or both may be of insulating material, such as a suitable ceramic material. Also, the present cathode support is equally suitable for use in an electron discharge device employing a control grid. In this application a conventional support of the control grid replaces electrode 14 in the structure illustrated. Furthermore, the cathode may be heated by electron bombardment in which case the principles described in United States Patent 2,509,053, granted May 23, 1950, to C. J. Calbick may be employed.

The plane shape of cathode plate 18 is merely shown by way of example. The form thereof is susceptible to variation as shown in Fig. 3, in which a plate 26 having apertures 28 is provided wtih a raised portion in the center thereof which carries the electron emissive coating 27.

In Fig. 4 an alternative embodiment of the invention is shown as a modification of the structure of Fig. 1 with corresponding reference numerals employed to designate similar components. Modification will be seen to reside in the cross-sectional shape of cathode plate 29 which is now provided wtih a tongue-type extension 30 from its periphery. A perspective detail of plate 29 is shown in Fig. 5. A plurality of helical members 31 each composed of several turns of fine wire of material similar to the wires 22 of Fig. 1 are disposed at spaced locations around the circumference of plate 29. Thus members 31 bear upon the inside surface of cavity 24 formed by the recess between tongue 30, plate 29 and the corner between clamp 23 and electrode 14. A similar plurality of helical members 32 are placed on the other side of tongue 30 within the cavity 33 formed by the recess in clamp 23, tongue 30 and plate 29. Helical members 31 and 32 serve a similar function, with similar advantages, to wire elements 22 of Fig. 1.

In all cases, it is understood that the above described arrangements are simply illustrative of the small number of the many possible specific embodiments which can represent applications of the principles of the invention. Numerous and varied other arrangements can readily be devised in accordance with these principles by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. A cathode structure for electron discharge devices comprising a flattened cathode member having an electron emissive surface extending in a transverse direction, at least two rigid support members with means for constraining said members relative to one another in a longitudinal direction, said members forming a cavity to loosely receive said cathode around the peripheral edge of said cathode, and a plurality of thin wire elements interposed longitudinally and transversely between said support members and said cathode, said elements bearing at least in a longitudinal direction against the inside of said cavity.

2. The combination of claim 1 wherein said cathode member has a plurality of apertures extending through the thickness thereof, and wherein each of said elements comprises a loop of low heat conductivity material passing through each of said apertures.

3. The combination of claim 1 wherein each of said elements comprises a helix of low heat conductivity material, a portion of said elements being located within said cavity on one side of said cathode and the remainder of said elements being located within said cavity on the other side of said cathode.

4. In an electron discharge device of the type having a rigid electrode with regard to which a flattened thermionic cathode is to be supported and spaced, a member having an annular recess deeper than the thickness of said cathode and wider than the plane dimension of said cathode, said member being supported contiguous to said electrode with said cathode disposed within said recess, said cathode having a plurality of apertures extending through the thickness thereof, and a wire-like loop of low heat conductivity material passing through each of said apertures to bear against said electrode on one side of said cathode and against said member on the other side of said cathode.

5. In an electron discharge device, a flattened disc of high heat conductivity material having a coating of thermionic material, a tubular shield of high heat conductivity material having one end coaxially connected to said disc, a thermionic heating element located within said shield to raise the temperature of said coating to the temperature of thermionic emission, rigid support members forming an annular cavity to loosely receive said disc around the peripheral edge of said disc, said disc having a plurality of apertures extending through the thickness thereof and spaced around the peripheral edge thereof, and a thin wire element of low heat conductivity material looped around the edge of said disc and through each of said apertures, said disc having a heated diameter substantially equal to the diameter of said cavity less twice the diameter of said wires, said disc having a thickness substantially equal to the width of said cavity less twice the diameter of said wires.

6. In an electron discharge device, a flattened disc of high heat conductivity material having a coating of thermionic material extending in a transverse direction, a tubular shield of high heat conductivity material having one end coaxially connected to said disc, a thermionic heating element located within said shield to raise the temperature of said coating to the temperature of thermionic emission, said disc having a tongue-like extension extending out from its periphery, at least two rigid support members with means for constraining said members relative to one another in a longitudinal direction forming an annular cavity to loosely receive said tongue, and a plurality of helical members of low heat conductivity material located on both sides of said tongue, said disc excluding said tongue having a diameter substantially equal to the diameter of said cavity less twice the diameter of said helix, said tongue having a thickness substantially equal to the width of said recess less twice the diameter of said helix so that said helical members bear at least in a longitudinal direction against the inside of said annular cavity.

7. A cathode structure for electron discharge devices

comprising a flattened cathode member having an electron emissive surface extending in a transverse direction, a plurality of thin wire elements each of said elements having transversely extending portions in contact with said cathode, and having one longitudinally extending portion spaced from said cathode, at least two rigid support members forming a cavity to loosely receive said cathode around the peripheral edge of said cathode, means for constraining said members relative to each other in a longitudinal direction with said members bearing upon each of said wire elements in a longitudinal direction and otherwise forcing said one longitudinally extending portion of each of said elements to substantially conform transversely to the inside of said cavity.

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