Nov. 27, 1951 L. E. CISNE 2,576,251

ELECTRODE SPACER STRUCTURE FOR ELECTRON DISCHARGE DEVICES

Filed June 29, 1950 3 Sheets-Sheet 1

FIG. 1

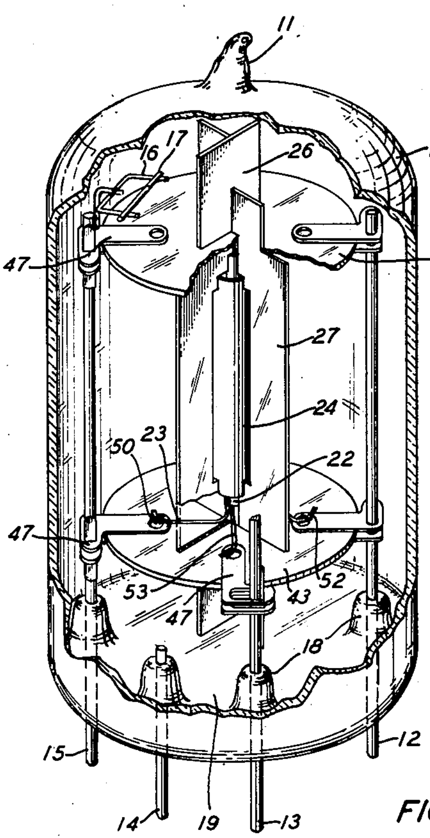

FIG. 2

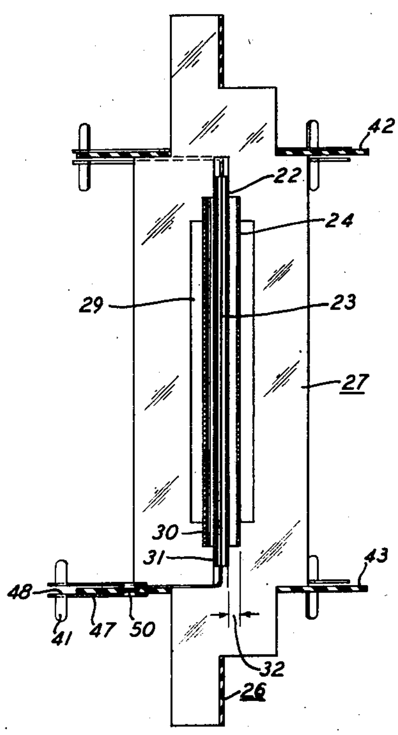

FIG. 3

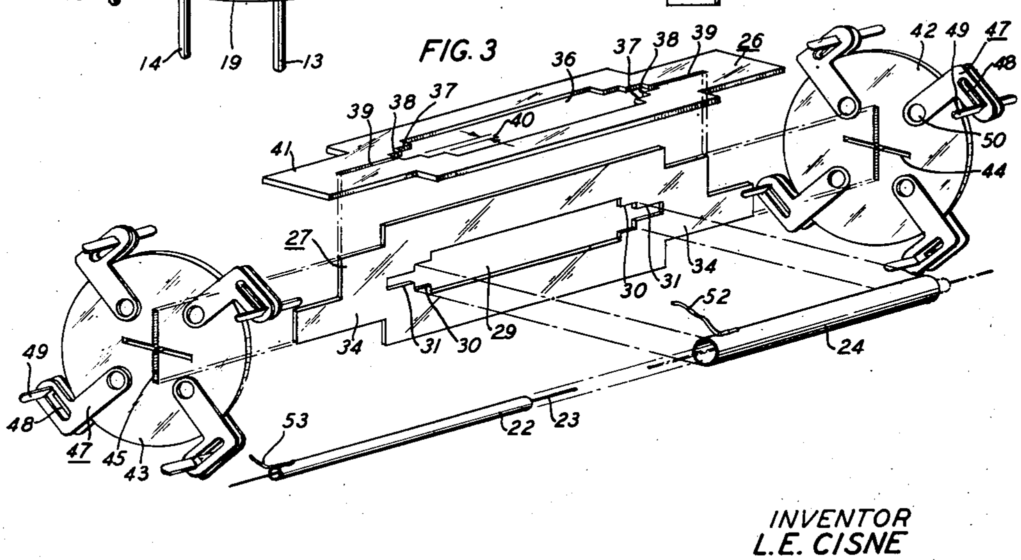

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FIG. 4

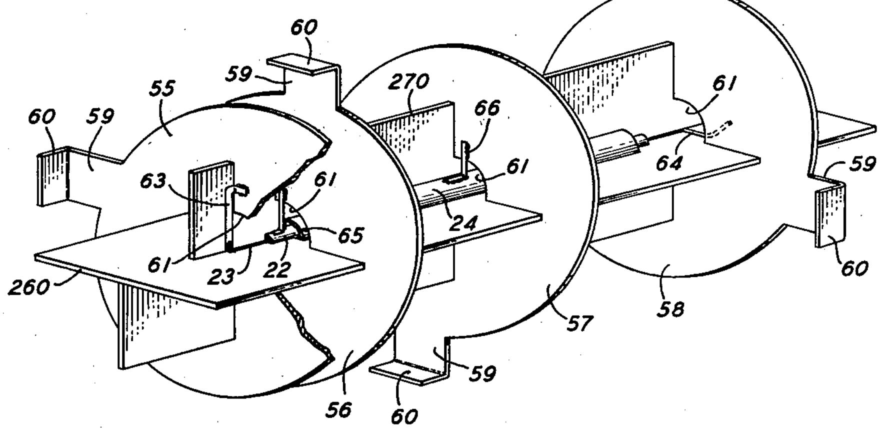
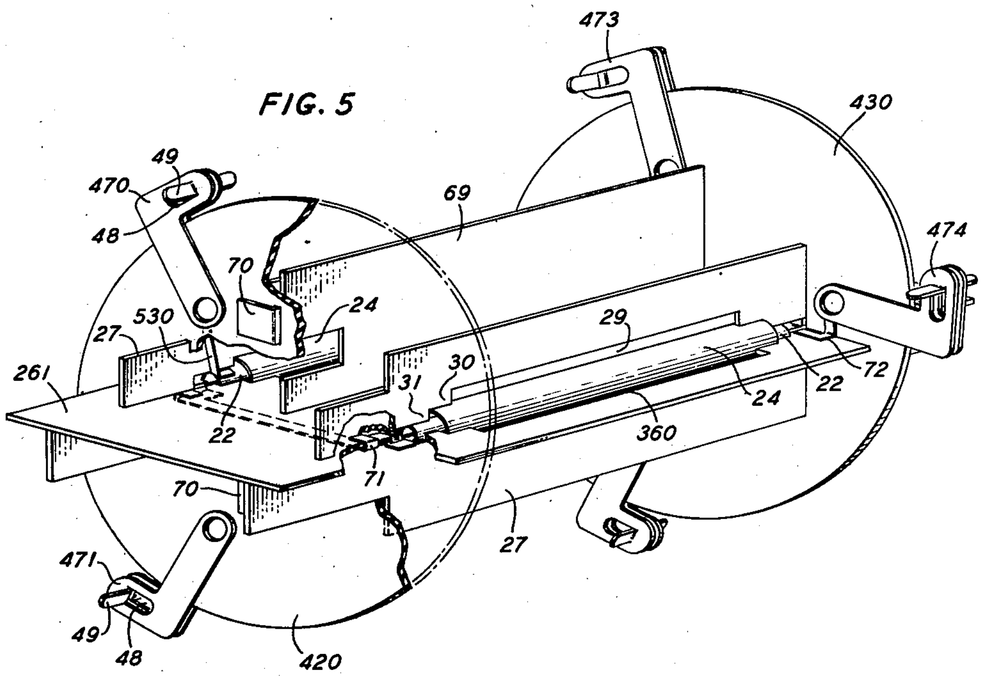


FIG. 5



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ELECTRODE SPACER STRUCTURE FOR ELECTRON DISCHARGE DEVICES

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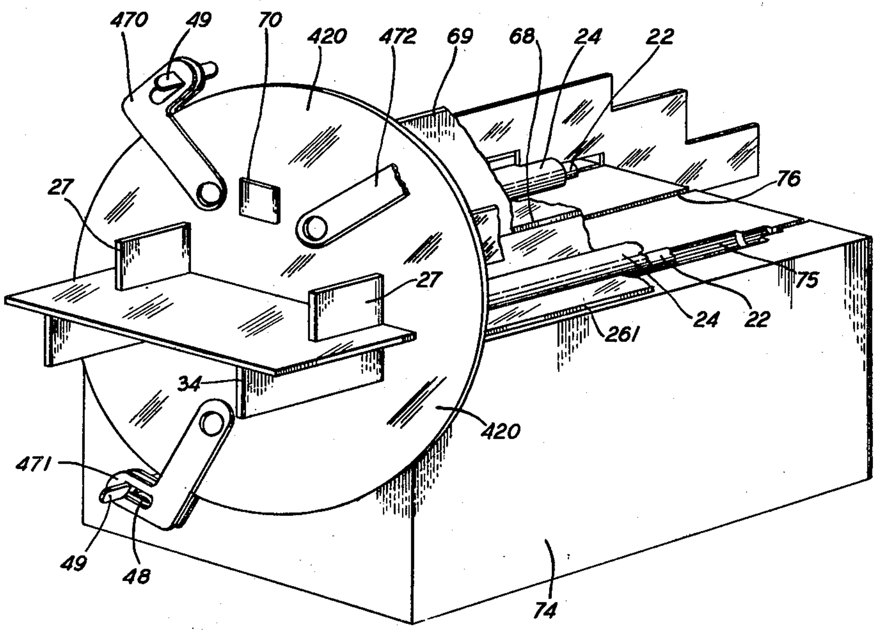
FIG. 6



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2,576,251

ELECTRODE SPACER STRUCTURE FOR ELECTRON DISCHARGE DEVICES

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Application June 29, 1950, Serial No. 171,111

16 Claims. (Cl. 313—268)

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This invention relates to electron discharge devices and particularly to such devices having precise interelectrode spacings.

In certain such electron discharge devices it is desirable to reduce the spacing between certain electrodes, such as the cathode and anode, or either of these and the control electrode, to a very minute distance in order to obtain favorable electrical characteristics. While this may possibly be done with accuracy in experimental models difficulty is encountered in specifying very small interelectrode spacings in commercial production because of the large dimensional tolerances that may be present in the commercially produced parts. Thus the close spacing desired between the electrodes has been limited by the pile-up, or possible addition, of the dimensional tolerances introduced by the supporting members. The change in the spacing from the desired norm between any two electrodes due to the variations introduced by the support members may be referred to as the deviation in that interelectrode spacing, or the eccentricity if coaxial electrodes are employed, other variations in the spacing being associated with the exactitude of the dimensions of the electrodes themselves. The total maximum deviation from the normal interelectrode spacing must be kept within a small enough percentage of the total spacing so that the electrical characteristics of the device will be substantially the same for devices with different deviations.

As the maximum deviation is dependent on the support members and thus is constant regardless of the interelectrode spacing, this small percentage has been attained in the past by maintaining the total interelectrode spacing large. In order to be able to specify commercially a very small interelectrode spacing, it is necessary that the tolerances that might affect the interelectrode spacing be also maintained within very close limits. Thus it is necessary to reduce the maximum possible deviation to a minimum by providing a support structure which introduces a minimum number of dimensional tolerances and in which the tolerances necessarily present and introduced by the support members can be held within very fine limits. This reduction in the number of dimensional tolerances introduced by the supporting members and in the size of the individual possible deviations reduces the maximum deviation in the spacing between the electrodes that must be anticipated in the commercially produced devices and thereby allows the specifying of a closer interelectrode spacing.

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It is one general object of this invention to reduce the interelectrode spacings that may be attained in electron discharge devices.

Another object of this invention is to reduce the number of dimensional tolerances introduced by the support members mounting the electrodes and which must be added together to obtain the maximum deviation in the interelectrode spacing that must be anticipated.

A further object of this invention is to control within very close limits the deviation introduced by the dimensional tolerances of the support members.

A still further object of this invention is to provide an improved electrode mount for electron discharge devices that is easy to fabricate and assemble and which securely positions the electrodes both transversely and longitudinally.

These and other objects of this invention are achieved in one illustrative embodiment of this invention wherein coaxial cylindrical anode and cathode members are mounted by two crossed insulator mounting members which have stepped cut-out portions engaging the cathode and anode and supporting them, the cathode and anode being separated by a single critical dimension on each insulator which alone might introduce a dimensional deviation or eccentricity into the interelectrode spacing.

In one illustrative embodiment of this invention, the crossed mounting members are locked in position by end insulating spacer members which have crossed slits therein so that they fit onto the crossed insulators. The end spacers carry a plurality of conducting ears to which lead wires are connected to provide both support and electrical connections for the electrode assembly.

In another illustrative embodiment of this invention, the crossed mounting members are locked in position by a plurality of spacers of a conducting material, the spacers being positioned along the crossed mounting members and encompassing them. Connections may be made by the lead wires directly to spacers.

In still another illustrative embodiment of this invention, two coaxial cathodes and encompassing anodes may be positioned by a single base insulator mounting member and individual second mounting members fitted onto the base mounting thereby providing crossed mounting members for each anode and cathode. A conducting plate fits into the base mounting member between the two electrode assemblies and serves as a shielding member. End insulating spacers having a plurality of conducting ears thereon may be provided to lock the mounting members and for connection to lead wires.

It is one feature of this invention that a plurality of electrodes be positioned by normally disposed insulating members having apertures therein against portions of which the electrodes bear, these portions accurately positioning and supporting the electrodes.

It is another feature of this invention that an electrode system be supported by normally disposed planar insulating members having stepped portions therein to position the electrodes.

It is a further feature of this invention that the interelectrode spacing be determined by a single dimension on each mounting member, all of the defining elements of which dimensions may be determined at the same time in a single operation of a cutting tool, thereby allowing the electrodes to be positioned with a minimum of possible deviation or eccentricity in the interelectrode spacing.

It is a still further feature of this invention that the crossed insulating mounting members may be locked spacer members having crossed slots therein into which the mounting members fit. These spacer members may be of a conducting material, in which case connections are made directly to them from the coaxial electrode system elements, or be of insulating material, in which case conducting means are supported thereby to which electrical connection may be made. In accordance with one feature of this invention, leads are secured to either the conducting spacers or the conducting means carried thereby to support the electrode system and mounting means and to provide electrical connection to external elements.

It is a still further feature of this invention that twin electrode assemblies may be mounted by normally disposed mounting members, one such member being common to the two assemblies, and each mounting member having an aperture with stepped portions to position the electrodes, the interelectrode spacing in each case being determined by a single dimension on each mounting member whereby the possible deviation or eccentricity in the interelectrode spacing is reduced to a minimum.

A complete understanding of this invention and of the various features thereof may be gained from consideration of the following detailed description and the accompanying drawing, in which:

Fig. 1 is a perspective view of an electron discharge device illustrative of one embodiment of this invention, portions of the vessel and various members having been broken away to show the internal elements of the device more clearly;

Fig. 2 is a sectional view of the coaxial electrode system and support mount of the embodiment of Fig. 1, one conducting ear being advanced in position and shown in section;

Fig. 3 is an exploded perspective view of the support mount and electrodes of the embodiment of Fig. 1;

Fig. 4 is a perspective view of an electrode system and support assembly illustrative of another embodiment of this invention, a portion of one of the spacer members having been broken away;

Fig. 5 is a perspective view of another embodiment illustrative of this invention comprising twin electrode assemblies, portions of various members having been broken away; and

Fig. 6 is a perspective view of a mounting jig for the embodiment of Fig. 5, portions of the support mount and electrode assemblies having been broken away to show the mounting jig more clearly.

Referring now to the drawing, the illustrative embodiment shown in Fig. 1 comprises a vessel 10 which may be of glass, having an exhaust tubulation 11 at one end and a plurality of leads extending through seals 18 in the base 19. In the embodiment illustrated five leads are employed, leads 12, 13, 15, and one which is not visible providing electrical connections and support for the electrode elements, as further described below, and lead 14 providing a positioning guide for the proper mounting in a suitable tube socket. A getter support wire 16 and a getter 17 may be mounted by lead 15 adjacent the top of the vessel 10.

A cylindrical cathode 22, which may be of nickel, molybdenum, tungsten, or other known cathode material and may be coated with a suitable electron emitting material and a cylinder anode 24, which may advantageously be of nickel, tantalum, zirconium, or other known anode material, are supported by two crossed insulator support or mounting members 26 and 27. The anode 24 is slightly shorter than the cathode 22 which it encompasses and with which it is coaxial. A heater 23, which may advantageously be a filament of tungsten, an iron-nickel alloy, or other known heater material, is placed within the cylindrical cathode 22.

The insulating mounting member 27 has an aperture 29 centrally therein, the aperture having two parallel sides with stepped portions 30 and 31 at each end, as best seen in Figs. 2 and 3. The member 27 further has a stepped outer ear 34 at each end. The distance between the stepped portion 30 and the stepped portion 31 is the dimension 32, clearly seen in Fig. 2, which is of prime importance in controlling the accuracy of the spacing between the cathode 22 and the anode 24, as explained further below.

The insulating mounting member 26 has a similar aperture 36 centrally therein, the aperture having two parallel sides with stepped portions 37 and 38 at each end and an end slit 39 at each end. The distance between the stepped portions 37 and 38 is the dimension 40, clearly seen in Fig. 3, which dimension is also of prime importance in controlling the accuracy of the spacing between the cathode 22 and the anode 24, as explained further below. Mounting member 26 also has end ears 41 at each end. The mounting members 26 and 27 may advantageously be of mica or other planar insulating material.

The crossed insulating members 26 and 27 are locked in position by end insulating spacers 42 and 43, which may also advantageously be of mica or other planar insulating material. Spacer 42 is provided with crossed slits 44 and spacer 43 with crossed slits 45 through which the outer ears 34 and 41 of the mounting members 27 and 26 extend, as described more fully below.

As best seen in Figs. 2 and 3, when the electrode system and support mount are assembled, the cathode 22 is positioned against the stepped end portions 31 and 38 of the mounting members 27 and 26, respectively, and the anode 24 is positioned against the stepped end portions 30 and 37, the mounting members 27 and 26, respectively. The accuracy of the spacing between the anode and cathode is thus determined by the accuracy of the dimensions 32 and 40. In the assembling, the mounting member 26 is slid over the mounting member 27, the outer ears 34 extending through the end slits 39 and being positioned in place when the stepped portions of the outer ears 34 are against the end ears 41. The end spacers 42 and 43 are then slid over the crossed mounting members 26 and 27, the end ears 34 and 41 extending through the slits 44 and 45.

The compact electrode assembly and support is positioned in the vessel 10 by means of the leads 12, 13, 15, and a fourth lead, not shown, and conductive ears 47 secured to each of the end spacers 42 and 43. Each conductive ear 47 is substantially L-shaped and has an aperture 48 therein along the base of the L, the material priorly positioned in the aperture being bent back to form a connecting surface 49 normal to the plane of the ear 47. The ears 47 are mounted by the end spacers 42 and 43 in pairs, being welded together as at 50 through apertures in the spacers although the ears may be attached by other means as is known to the art. A pair of such ears 47 is provided for each lead on each end spacer making a total of sixteen such ears for the illustrative embodiment depicted in Fig. 1.

The leads 12, 13, 15, and the one not visible in the perspective view of Fig. 1 extend through the apertures 48 and are connected to the connecting surfaces 49 as by welding. The electrode assembly and support means are thus positioned by the encompassing leads secured to each end spacer.

Electrical connections are made from the heater, anode, and cathode to the leads, the connections being made to one of the conductive ears on the inner side of the end spacers 42 and 43. Thus as shown in Fig. 1, one end of the heater filament 23 is connected to the lead 15 through the conductive ear 47 to which it may be secured at the welded point 50. The other end of the heater filament 23 may be electrically connected similarly to the lead in back in the perspective of Fig. 1 and not visible, while the anode 24 may be electrically connected through a tab 52 and a conductive ear 47 to the lead 12 and the cathode 22 may be electrically connected through a tab 53 and a conductive ear 47 to the lead 13.

Dimensional tolerances are usually introduced into an electron discharge device for each electrode separately and for each electrode positioning means. For this reason the determination of the spacing between any two electrodes is limited by the provision that must be made for the maximum possible pile-up of these dimensional tolerances, which will occur if each dimension deviates from the norm by its maximum allowable individual tolerance and all of these deviations are of the same sign so that they add together. When it is desired to diminish the spacing between the anode and cathode of an electron discharge device to a very minute value, such as .004 inch or less, possible dimensional variations of $\pm.0025$ inch resulting from the total pile-up of tolerances effect a perceptible percentage change in the interelectrode spacing causing changes in the electrical characteristics of the device. In accordance with this invention, the maximum total eccentricity may be maintained as low as $\pm.00025$ inch or approximately one-tenth of that priorly attainable.

Referring again to the drawing, a single dimension controls the interelectrode spacing for each mounting member 27 and 26, namely, the dimensions 32 and 40. The steps 30 and 31 of mounting member 27 and the steps 37 and 38 of mounting member 26, and any additional steps that would be provided if other electrodes are employed between the anode and the cathode, can be formed at the same time on their respective mounting members so that all the steps of one aperture are formed at one time. Indeed, both apertures 29 and 36 may be formed by a single operation at the same time, the different end portions of the apertures, i. e., the slits 39, being formed in a second operation. Further not only is there but a single dimension which will introduce an eccentricity in the interelectrode spacing, but that dimension may be very accurately controlled in a simple punching operation, when the mounting members are of mica. Close interelectrode spacing is thus made possible by the reduction of both the number of dimensional tolerances to introduce an eccentricity into the spacing and the tolerance of the single dimension controlling the spacing.

Referring now to Fig. 4 there is shown one modification of the device illustrated in Fig. 1, wherein crossed mounting members 260 and 270 are locked in position by spacer members 55, 56, 57, and 58 of a conducting material, such as nickel. Each of the spacer members 55, 56, 57, and 58 has an aperture 61 centrally therein and an ear 59 integral therewith, the end of the ear being bent normal to the spacer member and comprising a surface 60 to which the leads 12, 13, 15, and the one not shown in Fig. 1 may be secured by welding. The ears 59 and surfaces 60 are positioned 90 degrees apart so that each is secured to the proper lead. As the mounting members 260 and 270 are advantageously of the same width each of the spacer members 55, 56, 57, and 58 may be identical, the different spacer members being merely mounted at different angles. Electrical connections may be made from the elements of the coaxial electrode system directly to the spacer members by means of tabs. Thus one end of the heater filament 23 may advantageously be attached to a tab 63 carried by the mounting member 270, the tab being in turn secured to the spacer 55 and the other end of the heater filament 23 to a tab 64 carried by the mounting member 260, the tab being in turn secured to the spacer 58. Similarly, the cathode 22 may be connected to the spacer 56 by a tab 65 and the anode to the spacer 57 by a tab 66. The ears 59 may be secured to the leads by any desired lead orientation for ease in connection to the external circuits.

Referring now to Fig. 5 there is illustrated another embodiment of this invention in which twin electrode assemblies are mounted and supported by insulator mounting members 27 and a base insulator mounting member 261, corresponding to the insulator mounting member 26 in the embodiment of Fig. 1. Elements identical in this embodiment with that of Fig. 1 have been referred to by the same reference character. Thus the anode 24 and cathode 22 are supported in accurate coaxial relationship by the stepped end portions 30 and 31 of the apertures 29 in the mounting member 27, a minimum eccentricity that must be allowed for being attained because of the single dimension 32 positioning the two electrodes, whereby exceedingly close inter-electrode spacing may be achieved. Mounting member 261 is provided with two apertures 360 corresponding to the apertures 36 and identical therewith.

Mounting member 261 has a slit 68, best seen in Fig. 6, approximately mid-way between the twin electrode assemblies. A metallic shielding member 69 extends through this slit and is positioned normal to the mounting member 261. End insulating spacer members 420 and 430, corresponding to end members 42 and 43 of the embodiment of Fig. 1, have crossed slits therein and fit over the crossed mounting members 27 and 261 to lock them in position. The shielding member 69 is also locked in position by tabs 70 extending through the spacer members 420 and 430 and bent over against their outer surfaces.

Pairs of conductive ears 470, 471, 472, 473, 474, and one not visible in the views illustrated, similar to the ears 47, are supported by the end spacer members 420 and 430. The twin-electrode assembly may be supported by these ears, each ear being secured to a separate lead as in a vessel similar to that illustrated in Fig. 1. Connections may be made from each element to an ear, the two heater filaments 23 being shown connected in parallel by strips 71 and 72, strip 72 being connected to ears 474 on end spacer member and strip 71 being connected to ears 472, shown partially in Fig. 6, on end spacer member 420. Similarly, one cathode member 22 may be connected to ears 470 as by a tab 530, a connection being made from its anode 24 to ears 473. Connections may be made from the other cathode 22 to ears 471 on end spacer member 420 and from other anode 24 to the ears on spacer member 430 which are not visible in the perspective view illustrated in Fig. 5. Another pair of conductive ears may be secured to either end spacer 420 or 430 to provide connection from the external circuit to the shielding member 69 as may be desirable for certain circuit applications of this device.

Fig. 6 shows one mounting jig and assembling procedure for the twin-electrode assembly illustrated in Fig. 6, the principles however being equally applicable to the embodiment of Fig. 1. As shown there, a mounting jig or block 74 has a plurality of grooves 75 in one face, the grooves being shaped to receive the cathode and anode members 22 and 24. A central slit 76 is also provided in the face of the block 74 between the grooves 75. In assembling, the cathode 22, with the heater element 23 therein, is slid into the anode 24 and both members are positioned in aperture 29 in the mounting member 27. The mounting member is then slid into the groove 75, the cathode and anode being supported by the groove. When both mounting members 27 are in place, the mounting member 261 is dropped over them, the stepped outer ears 34 of the mounting members 27 fitting in the slits 39 in mounting member 261. The cathode and anode members 22 and 24 are then securely positioned in both apertures 36 in mounting member 261 and apertures 29 in mounting member 27 by the stepped end portions 30, 31, 37 and 38, as described above. The metallic shielding member 69 is then placed in slit 68 in mounting member 261 and in slit 76 in the face of the block 74. The end spacer members 420 and 430, which advantageously have priorly had attached thereto the pairs of conductive ears 470, 471, 472, 473, and 474, are then slid over the ends of the mounting members 27 and 261 and the tabs 70 on the metallic shield member 69, which tabs are then bent over against the face of the spacer end members. The block 74 advantageously has a depression opposite the bottom pairs of ears, such as ears 471 on spacer end member 420, so that the spacer end members may be pressed against the sides of the block 74. Connections may then be made between the pairs of ears and the various electrode elements of the assembly. The twin-electrode assembly and mounting members may be then removed from the jig 74 and lead wires slid into the apertures 48 in the conductive ears, the leads being then secured, as by welding, to the conducting surface 49, as described above.

It is to be understood that the above-described arrangements are illustrative of the application of the principles of the invention. Numerous other arrangements may be devised by those skilled in the art without deviating from the spirit and the scope of the invention. Thus while the invention has been disclosed with reference to a diode, it is not limited thereto but is also applicable to such devices employing more than two elements. Such other elements may take the form of control electrodes, screen electrodes, or suppressor electrodes as is known in the art for employment in affecting the electron discharge in such a device by externally applied voltages. Further while this invention has been illustrated by coaxial cylindrical anode and cathode members, the invention is not limited to the support and positioning of such particular electrode members or to their being of the form and configuration disclosed.

What is claimed is:

1. An electrode assembly for an electron discharge device comprising a pair of crossed insulator members positioned at right angles to each other, each of said members having an aperture therein along the line of intersection of said members, a plurality of electrodes positioned in said insulator members in said apertures, said electrodes bearing against portions of said apertures and being positioned thereby, and means locking said crossed insulator members.

2. An electrode assembly for an electron discharge device in accordance with claim 1 wherein said locking means comprises insulator end spacer members having crossed slits therein fitting onto said crossed insulator members.

3. An electrode assembly for an electron discharge device comprising a first electrode, a second electrode encompassing said first electrode and of shorter length than said first electrode, and a pair of crossed insulator mounting members, each of said members having an aperture therein having stepped end portions, said electrodes being mounted in said apertures and separated by the distance between two stepped end portions in each aperture.

4. An electron discharge device comprising a plurality of electrodes, the outer electrodes encompassing the inner electrodes and being of shorter length than said inner electrodes, a pair of crossed insulator mounting members, each of said mounting members having an aperture therein, said apertures having stepped portions at each end, said electrodes fitting into said apertures and bearing against said stepped end portions, and means locking said members in position preventing motion of said electrodes or support members.

5. An electrode assembly for an electron discharge device comprising a cathode, an anode encompassing said cathode and of shorter length than said cathode, and a pair of crossed insulator mounting members, said members having each an aperture therein having stepped end portions, said cathode and anode being mounted in said apertures and separated by the dimension be-

tween two stepped end portions in each aperture.

6. An electrode assembly for an electron discharge device comprising a hollow cathode, a heater element within said cathode, an anode encompassing said cathode and of shorter length than said cathode, a pair of crossed insulator support members having apertures therein, said apertures having stepped end portions positioning said anode and said cathode, and means locking said crossed support members.

7. An electrode assembly for an electron discharge device in accordance with claim 6 wherein said locking means comprises insulator end spacer members having crossed slits therein and fitting onto said crossed support members.

8. An electrode assembly for an electron discharge device in accordance with claim 6 wherein said locking means comprises a plurality of metallic spacer members having slits therein and fitting onto said crossed support members.

9. An electron discharge device comprising a cathode, an encompassing anode of shorter length than said cathode, a first support member having an aperture therein, said aperture being stepped at each end and including a slit extending from each end, a second support member having an aperture therein, said aperture being stepped at each end, said second member fitting into the aperture and slit in said first member and being positioned normal thereto, said anode and cathode being positioned in said both apertures by said plurality of stepped ends, said cathode and anode being separated by the dimension between two stepped end portions in each aperture, and means locking said members in position preventing motion of said anode, cathode, or support members.

10. An electron discharge device comprising a vessel, a plurality of leads extending in said vessel, a hollow cathode, a heater element within said cathode, an anode of shorter length than said cathode encompassing said cathode, a pair of crossed mounting members each having an aperture therein, said apertures having stepped end portions engaging said anode and cathode, said mounting members being substantially normal to each other, insulating spacer members having slits therein fitting over said crossed mounting members and locking said mounting members, anode, and cathode in a compact electrode assembly, and a plurality of tabs positioned on said spacers electrically connected to said anode, cathode, and heater elements and secured to said leads.

11. An electron discharge device in accordance with claim 10 wherein said tabs are substantially L-shaped and have an aperture in the base of the L and a connecting surface adjacent said aperture and substantially normal to the plane of the tab, said tabs being mounted in pairs, one on each side of said insulating spacer members, and said leads extending through said apertures in said tabs and being secured to said connecting surfaces.

12. An electron discharge device comprising a vessel, a plurality of leads extending in said vessel, a hollow cathode, a heater element in said cathode, an anode encompassing said cathode and of shorter length than said cathode, a pair of crossed support members each having apertures therein, said apertures having stepped end portions mounting said anode and cathode, said anode and cathode being separated by the dimension between two stepped end portions in each aperture, a plurality of metallic spacer members having slits fitting onto said crossed support members and locking said cathode, anode, and support members in position, means electrically connecting said anode, cathode, and each end of said heater element individually to one of said metallic spacer members, and means securing said metallic spacer members to said leads.

13. An electron discharge device in accordance with claim 12 wherein said last mentioned means comprises a tab integral with each of said metallic spacer members and including an end surface normal to said spacer member and secured to one of said leads, the tabs on said spacer members being angularly removed from each other.

14. An electrode assembly for an electron discharge device comprising a pair of cathodes, an anode encompassing each cathode and of shorter length than said encompassed cathode, a first base mounting member having a pair of apertures therein, said apertures being stepped at each end and each having a slit extending from each end, a pair of second mounting members having apertures therein, said apertures being stepped at each end, said second mounting members fitting into said slits in said first member, said anodes and cathodes being positioned by said stepped apertures, and means locking said mounting members in position substantially normal to each other preventing motion of said anodes, cathodes or mounting members.

15. An electron discharge device comprising a vessel, a plurality of leads extending in said vessel, a pair of hollow cathodes, a heater element in each cathode, an anode encompassing each cathode and of shorter length than said encompassed cathode, a first base mounting member having a pair of apertures therein, said apertures having stepped end portions and each having a slit extending from each end, a pair of second mounting members extending into said slits in said apertures and being substantially normal to said first base mounting member, said second mounting members each having an aperture therein, said apertures having stepped end portions, said anodes and cathodes being positioned by said stepped end portions and being separated by the dimension between two stepped end portions in each aperture, insulator end spacers having slits therein, said spacers fitting over said first and second mounting members and locking said members, and a plurality of tabs positioned on said spacers electrically connected to said anodes, cathodes, and heater elements and secured to said leads.

16. An electron discharge device comprising a vessel, a plurality of leads extending in said vessel, a pair of hollow cathodes, a heater element in each of said cathodes, an anode encompassing each of said cathodes and of shorter length than said encompassed cathode, a first base mounting member having a pair of apertures therein and a slit positioned between said apertures, said apertures having stepped end portions and each having a slit extending from said end, a pair of second mounting members extending into said second mentioned slits and said apertures and being substantially normal to said first base mounting member, said second mounting members each having an aperture therein, said apertures having stepped end portions, said anodes and cathodes being mounted by said stepped end portions and being separated by the dimension between two stepped end portions in each aperture, a shielding member extending into said first

mentioned slit between the two electrode assemblies, a pair of insulator end spacers having slits therein, one of said end spacers fitting onto each end of said crossed mounting members, means connecting said heater elements in parallel, and a plurality of tabs positioned on each of said spacers electrically connected to said cathodes, anodes, and parallel ends of said heater elements, said tabs being substantially L-shaped and each having an aperture in the base of the L and a connecting surface adjacent said aperture and substantially normal to the plate of the tab, said

leads extending through said apertures in said tabs and being secured to said connecting surfaces.

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