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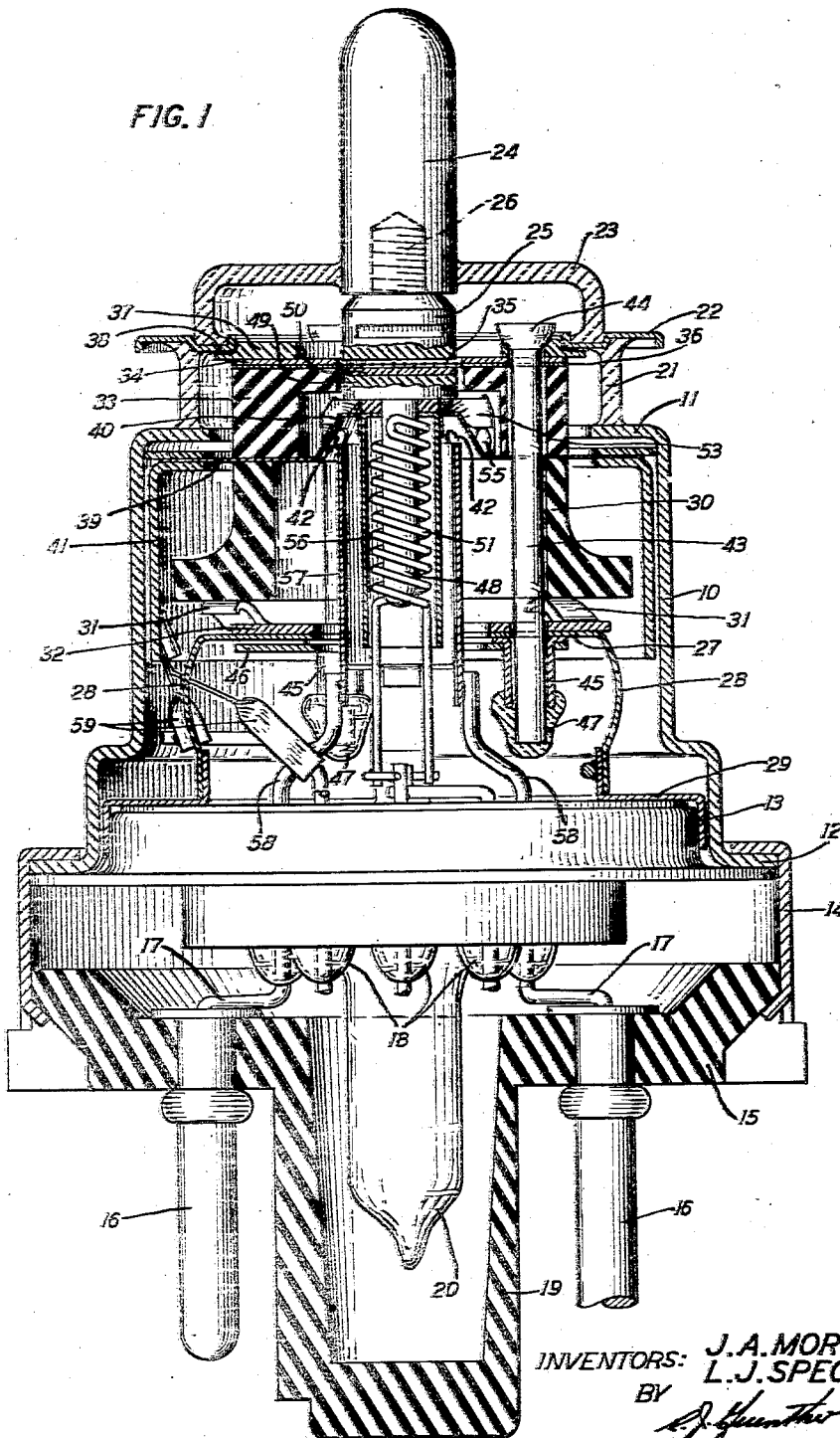
J. A. MORTON ET AL

2,455,381

CATHODE ASSEMBLY FOR ELECTRON DISCHARGE DEVICES

Filed Oct. 1, 1947

2 Sheets-Sheet 1



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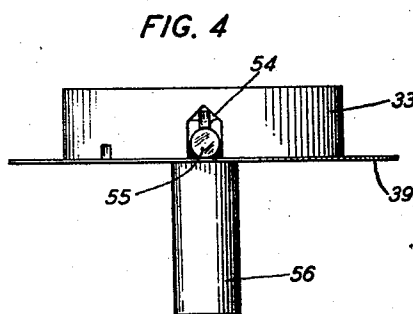
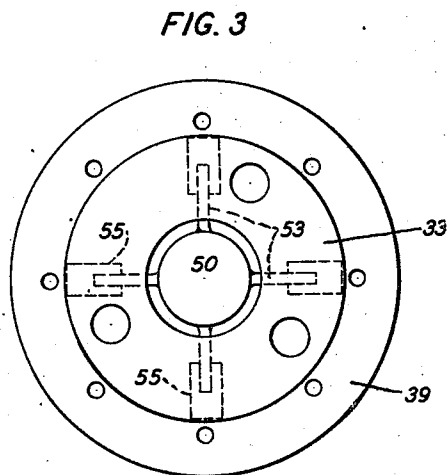
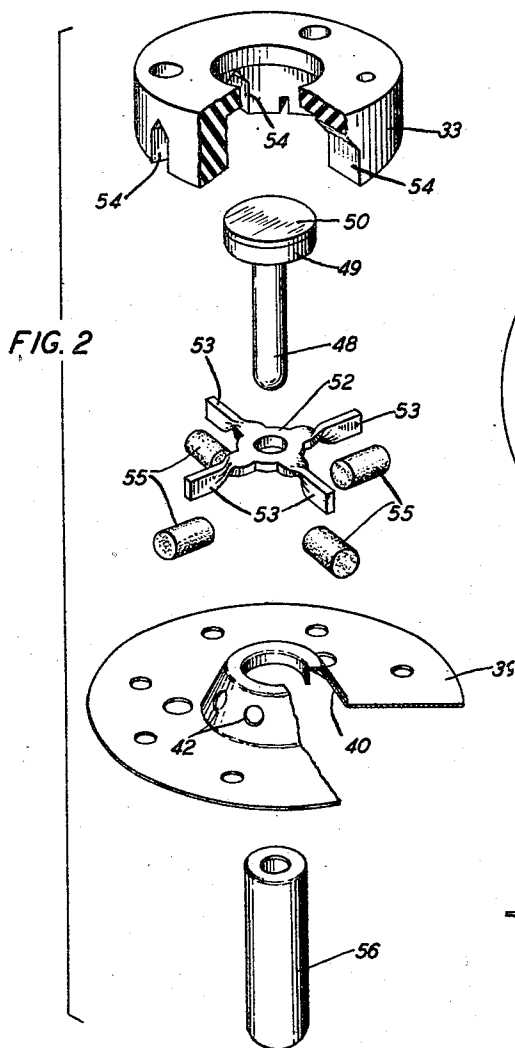
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CATHODE ASSEMBLY FOR ELECTRON DISCHARGE DEVICES

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2 Sheets-Sheet 2



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CATHODE ASSEMBLY FOR ELECTRON
DISCHARGE DEVICES

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8 Claims. (Cl. 250—27.5)

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This invention relates to electron discharge devices and more particularly to cathode assemblies for such devices especially suitable for operation at ultra-high frequencies and comprising one or more electrodes in very close proximity to the cathode.

One form of such electron discharge device, disclosed in the application Serial No. 572,596, filed January 13, 1945, of Jack A. Morton and Robert L. Vance, embodies a cathode, a control electrode or grid and an anode having substantially plane, parallel surfaces, the interelectrode spacings being extremely small, for example of the order of one-half mil between the cathode and the control electrode or grid. The cathode and the support therefor are constructed with accurately coplanar surfaces which serve as a reference plane for determining the cathode to grid spacing.

The operating characteristics, such as the transconductance and input impedance, at high frequencies of an electron discharge device involving close electrode spacings are dependent largely upon not only the accuracy with which the spacings are determined initially but also upon the constancy of the spacings during the operation of the device. During operation of the device, the electrodes, and particularly the cathode, are subject to large temperature changes. The inherent expansion and contraction effects of such changes tend to produce variations in the electrode spacings. Such variations, though they may be quite small on an absolute basis, are very material on a relative basis when the spacings are of the order of magnitude mentioned above, and result in substantial variations in the operating characteristics of the device. For example in a particular device having a cathode to grid spacing of the order of one-half mil, a change in the spacing of .15 mil results in a change of approximately 25 per cent in the transconductance and a change of approximately 25 per cent in the input impedance of the device.

One object of this invention is to minimize the effects of temperature upon the spacing of electrodes in an electron discharge device.

More specifically, one object of this invention is to maintain the spacing between a cathode and an electrode in immediate proximity thereto substantially constant and parallel despite large changes in the temperature of the cathode and the support therefor in the course of operation of the device.

In one illustrative embodiment of this invention, an electron discharge device of the general

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construction disclosed in the application above identified comprises a cathode having a substantially plane electron emissive face, a support for the cathode having a seating or reference surface accurately coplanar with the cathode face, a planar type grid in juxtaposition to the cathode face, and a spacer member between the support or reference surface and the grid structure and determining the initial spacing of the grid from the cathode.

In accordance with one feature of this invention, the cathode is so constructed and mounted from the support therefor that coplanarity of the cathode face and the reference surface is maintained despite large changes in the temperature of the cathode and the support.

More specifically, in accordance with one feature of this invention, the cathode is mounted from the support therefor by a mounting member which strongly resists relative motion, in the direction normal to the reference surface, of this surface and the emissive cathode face but permits relative or differential expansion and contraction of the cathode and the support in the direction parallel to the reference surface.

In accordance with another feature of this invention, the cathode is of composite construction such that the thermal expansion and contraction of the major portion thereof in the direction normal to the reference surface substantially matches that of the support.

The invention and the above-noted and other features thereof will be understood more clearly and fully from the following detailed description with reference to the accompanying drawing in which:

Fig. 1 is an elevational view, mainly in section, of an electron discharge device illustrative of one embodiment of this invention.

Fig. 2 is an exploded perspective view of the cathode assembly included in the device illustrated in Fig. 1;

Fig. 3 is a face view of the cathode assembly; and

Fig. 4 is a side view of a portion of this assembly.

Referring now to the drawing, the electron discharge device illustrated in Fig. 1 comprises an evacuated enclosing vessel including a cylindrical metallic portion 10 having flanges 11 and 12 at opposite ends thereof, and a metallic header or base 13 joined hermetically to the flange 12. Also joined to the flange 12 is a flanged metallic band 14 which supports an insulating disc or base 15 carrying terminal prongs 16 to which leading-

in conductors 17 sealed hermetically in apertures in the base 13 by glass beads 18 are connected. The disc or base 15 is provided with a hollow control stud 19 which encloses an exhaust tubulature 20 extending from the header 13. The enclosing vessel includes also a short, cylindrical vitreous section 21 sealed to the flange 11 and to a metallic disc 22, and a shallow, cup-shaped vitreous cap 23 sealed to the disc 22 and mounting the anode of the device.

The anode comprises a metallic stud 24 sealed centrally within the base of the cap 23 and a circular head or button 25 threaded to the stud 24 as indicated at 26.

Supported from the header 13 by a metallic member having an annular portion 27 and having also bowed arms 28 affixed to a stepped cylindrical mount 29 seated upon and secured to the header is a unitary cathode and control electrode or grid assembly, the cathode and grid being positioned coaxial with the anode and extending transversely parallel to the inner end of the anode button 25. This assembly comprises a cylindrical, insulating, e. g. ceramic, spacer 30 which is seated upon spring arms 31 integral with a metallic annulus 32 seated in turn upon the support or mount 27, and a second cup-shaped, insulating, e. g. ceramic, spacer 33 coaxial with the spacer 30 and having a central, circular aperture in its base.

An annular, metallic support or frame 34 mounts a planar grid 35 which is spaced a prescribed distance from the base of the spacer 33 by an annular, metallic shim 36, and is connected electrically to the disc 22 by a metallic retaining ring 37 joined to the disc, as by brazing material indicated at 38.

Disposed between the opposed ends of the spacers 30 and 33 is the annular portion 39 of a metallic cathode connector which includes also a central frusto-conical part 40. The connector mounts a metallic cylinder 41 coaxial with and in immediate proximity to the vessel portion 10 and defining a cathode to grid by-pass condenser therewith. The frusto-conical part 40 is provided with apertures 42 to facilitate evacuation of the space between it and the spacer 33.

The piled up elements, above described, in the cathode-grid assembly are securely held together by insulating rivets 43 having heads 44 bearing against the retaining ring 37 and being sealed to eyelets 45 on a second retaining ring 46 by vitreous masses 47.

The cathode includes a metallic stud or stem 48 having a circular head or flange 49 to which a metallic disc 50 is secured, the circular face of the disc 50 being coated with an efficient thermionic electron emissive material. The cathode is heated to effect copious electron emission from the coating thereon by a bifilar, insulated filament 51 which encompasses the stem 48 and has its ends connected to two of the leading-in conductors 17.

As has been pointed out heretofore, in devices intended for operation at ultra-high frequencies extremely small electrode spacings are required and the performance of the devices is dependent upon maintenance of the prescribed spacings and parallelism within very close limits. The magnitude of the problem involved will be readily appreciated from consideration of the fact that in a typical device a cathode to grid spacing of substantially one-half mil is required and the temperature to which the cathode emissive sur-

face is heated during activation and operation is of the order of 700-850 degrees C. In accordance with one feature of this invention, the cathode is so constructed and mounted that relative displacement between the emissive face of the cathode and the surface of the spacer 33 upon which the shim 36 rests is substantially minimized whereby, inasmuch as the cathode to grid spacing is determined by the thickness of the shim, the spacing is maintained substantially constant during operation of the device and despite the temperature variations to which the cathode and adjacent elements are subjected during such operation.

Specifically, the cathode is supported from the spacer 33 by a spider member which, as shown clearly in Fig. 2, comprises a centrally apertured portion 52 and a plurality of arms 53 of rectangular section, the arms being relatively thin and having their major transverse dimension normal to the plane of the central portion 52. The latter is fitted upon the stem 48 and, as shown in Fig. 1, abuts and is joined to the head 49. The arms 53 are seated edgewise in the apices of generally V-shaped grooves 54 in the spacer 33 and are fixed therein by short, cylindrical members 55 force fitted or glazed in the grooves and advantageously of the same material as the spacer 33.

Particularly advantageous, the cathode member 48, 49 and spider 52, 53 are fabricated of the same material and this material and that of the spacer 33 are correlated so that the thermal expansion and contraction of the cathode and spacer are substantially equal, consideration being taken of the fact that during operation of the device the spaced is at a somewhat lower temperature than the cathode. In a specific and illustrative construction, a cathode member and spider of molybdenum, the temperature coefficient of which is

$$5 \text{ to } 6 \times 10^{-6} \frac{\text{inches}}{\text{inch degrees C.}}$$

and a spacer of steatite having a temperature coefficient of

$$6 \text{ to } 7 \times 10^{-6} \frac{\text{inches}}{\text{inch degrees C.}}$$

have been found to be satisfactory. The disc 50 advantageously is of nickel to provide a satisfactory base for an alkaline earth oxide emissive coating.

In the fabrication of the cathode-spacer assembly, after the cathode member 48, 49, 50 is mounted in the spacer, the outer face of the disc 50 and the outer base face of the spacer 33 are lapped or grounded so that they are accurately coplanar. The disc face then is coated with emissive material, the coating thickness being accurately controlled. The base face of the spacer 33 thus constitutes a reference surface for fixing the cathode to grid spacing by the shim 36.

Because of the relation of the temperature coefficients of the cathode stem and spacer materials and the fact that the spacer is at a somewhat lower temperature than the cathode during the operation of the device, differential expansion of the stem and spacer in the direction tending to effect departure of the cathode face and reference surface from coplanar relation is minimized. The arms 53, because of their construction, are rigid in the direction parallel to the axis of the stem 48 and normal to the reference surface and, thus, tend strongly to maintain the desired coplanarity of the cathode face

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and reference surface. However, because of their thinness, these arms are somewhat flexible normal to the direction noted and this, together with the fact that under the conditions under which the cathode is operated some sliding motion between the arms 53 and the rods 55 can occur, allows sufficient elongation or contraction of the arms with temperature variations to prevent buckling thereof, and, hence, to prevent departure of the cathode face and reference surface from the desired coplanar relation. Thus, the cathode and spacer assembly illustrated and described assures maintenance of the extremely small cathode to grid spacing and constancy of operating characteristics during the operation of the device. In the specific construction mentioned heretofore, wherein the cathode is operated at a temperature of the order of 750 degrees C. ± 50 degrees C., the cathode to grid spacing is maintained constant within ± 0.02 mil.

To obtain a high thermal efficiency for the cathode, the heater filament is encompassed by a pair of coaxial metallic cylindrical baffles or shields 56 and 57, the baffle 56 being supported from the frusto-conical part 40 of the cathode connector and the baffle 57 being supported from the header 13 by extensions 58 of two of the conductors 17.

Electrical connection to the cathode is established between two of the terminal prongs 16 and the condenser cylinder 41 by way of metallic strips 59 joined to the cylinder 41 and two of the conductors 17.

Although a specific embodiment of the invention has been shown and described, it will be understood that it is but illustrative and that various modifications may be made therein without departing from the scope and spirit of this invention as defined in the appended claims.

What is claimed is:

1. An electrode assembly for electron discharge devices, comprising a support member having an aperture therein and having also a plurality of grooves in one face thereof and extending outwardly from said aperture, a cathode extending through said aperture and having an electron emissive face parallel to said one face, and means supporting said cathode from said member, said means comprising arms affixed to said cathode and seated in said grooves.

2. An electrode assembly for electron discharge devices, comprising an insulating disc having an aperture therein and having also a plurality of grooves in one face thereof and extending radially outward from said aperture, a cathode extending into said aperture and spaced from the bounding wall thereof, said cathode having an emissive face substantially coplanar with the other face of said disc, a plurality of strip supports each seated edgewise in a respective one of said grooves, said supports being affixed to said cathode, and means holding said supports in said grooves.

3. An electrode assembly for electron discharge devices, comprising a support of insulating material and having an aperture therein, a cathode member extending into said aperture and spaced from the bounding wall thereof, said cathode including a body portion of metal having a thermal expansion coefficient slightly lower than that of said insulating material, said cathode including also a thin nickel disc affixed to said body portion and having an alkaline earth oxide emissive coating thereon, and means mounting said cathode from said support.

4. An electrode assembly for electron discharge

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devices, comprising a support of insulating material and having therein an aperture and a plurality of grooves of V-section extending outwardly from said aperture, an electrode extending into said aperture and spaced from the bounding wall thereof, a plurality of strip members mounting said electrode from said support, each of said strip members being connected to said electrode and seated edgewise in the apical portion of a respective one of said grooves.

5. An electrode assembly for electron discharge devices, comprising a disc of insulating material having an aperture therein and having also a plurality of grooves of V-section extending outwardly from said aperture, a spider member having a central portion within said aperture and having also a plurality of arms of rectangular section extending from said central portion, each of said arms being seated edgewise in the apical portion of a respective one of said grooves, locking means fitted in each of said grooves and bearing against the arm therein to hold it in place, and a cathode affixed to said central portion and supported by said spider.

6. An electrode assembly for electron discharge devices, comprising an insulating disc having a planar face, an aperture extending therethrough from said face and a plurality of grooves extending outwardly from said aperture, a cathode extending through said aperture and having an end face coplanar with said planar face, thin strip support members joined to said cathode and each seated edgewise in a respective one of said grooves, and insulating rods each affixed in a respective one of said grooves and bearing against the support member thereon.

7. An electrode assembly for electron discharge devices comprising a cathode having a body portion of molybdenum and having also a planar electron emissive face, a disc encompassing said body portion, spaced therefrom and having a plurality of grooves therein extending laterally away from said body portion, said disc having also a planar face parallel to said emissive face and said disc being of a ceramic having a thermal expansion coefficient slightly higher than that of molybdenum, and a plurality of thin molybdenum strip supports fixed to said body portion and each seated edgewise in a respective one of said grooves.

8. An electrode assembly for electron discharge devices, comprising a disc of ceramic material having an aperture extending therethrough, a plane face and a plurality of V-section grooves extending radially outward from said aperture, a cathode extending through said aperture and spaced from the bounding wall thereof, said cathode including a molybdenum stem portion and a thin metal disc affixed to one end of said stem portion and having its outer face coplanar with said plane face, an electron emissive coating upon said outer face, said ceramic material having a thermal expansion coefficient slightly higher than that of molybdenum, a molybdenum spider supporting said cathode from the ceramic disc, said spider having a central part secured to said stem portion and having also thin strip arms each seated edgewise in the apical part of a respective one of said grooves, and ceramic rods each fixed in a respective groove and bearing against the arm therein.

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No references cited.