

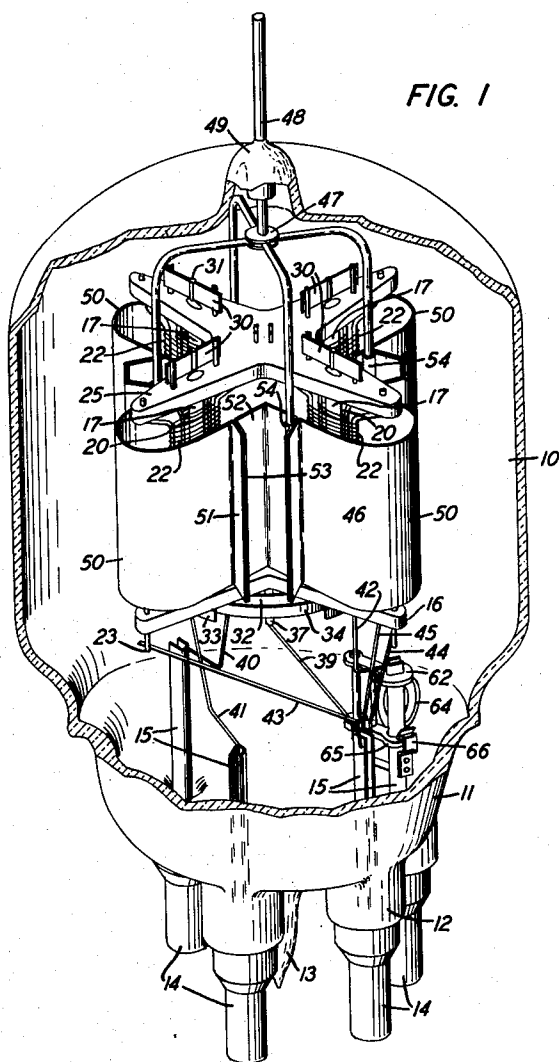
Aug. 15, 1944.

H. L. DOWNING ET AL
ELECTRON DISCHARGE DEVICE

2,356,035

Filed Nov. 22, 1941

4 Sheets-Sheet 1



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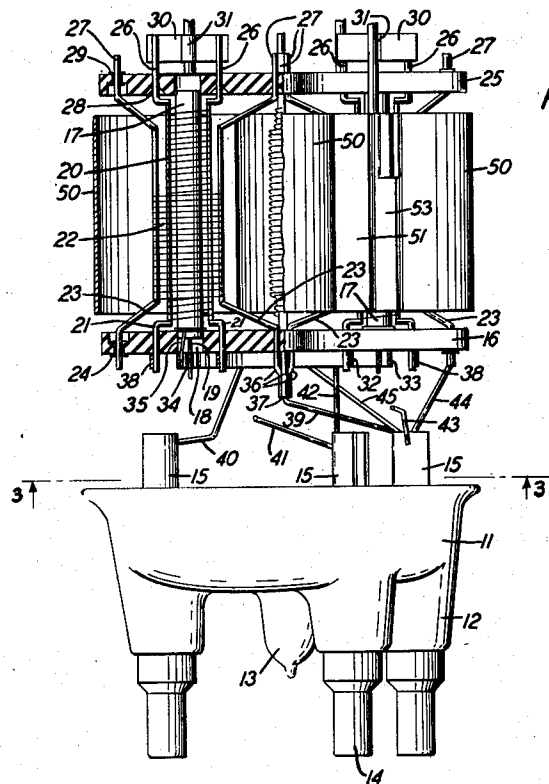


FIG. 2

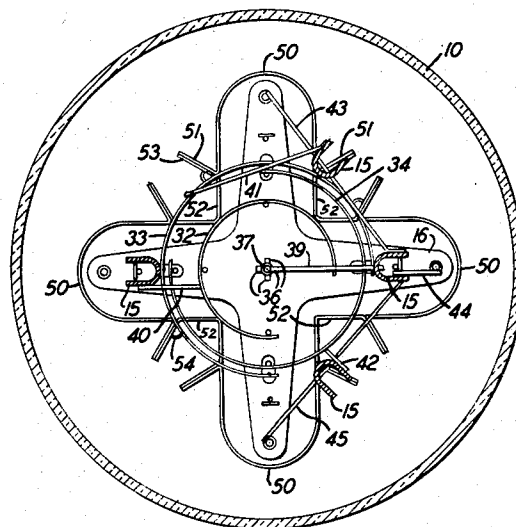


FIG. 3

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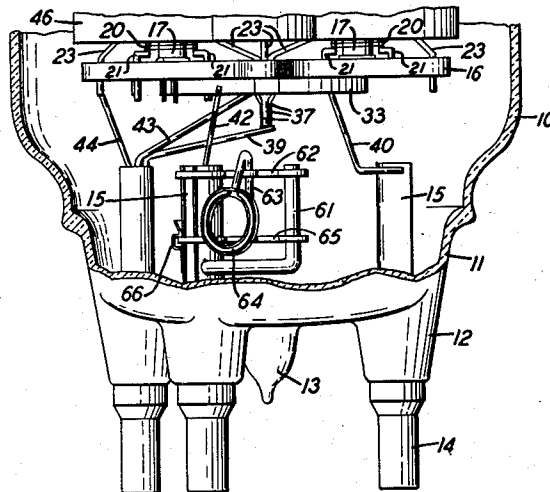


FIG. 4

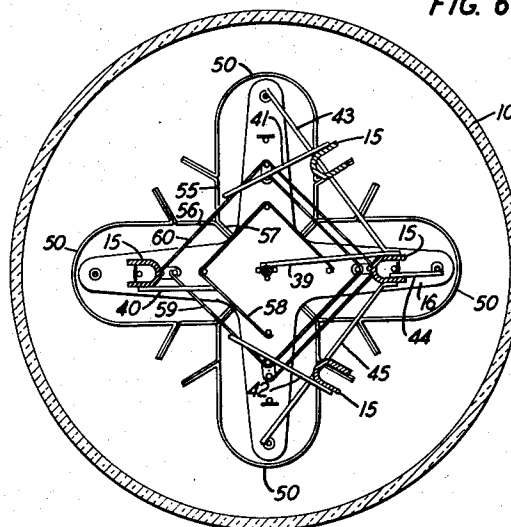


FIG. 6

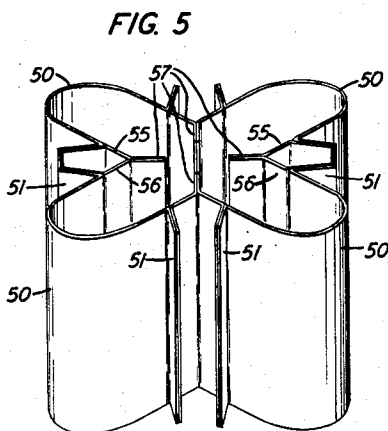


FIG. 5

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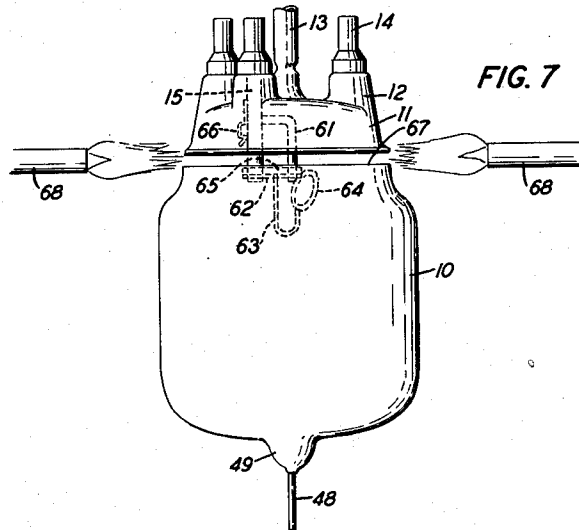


FIG. 7

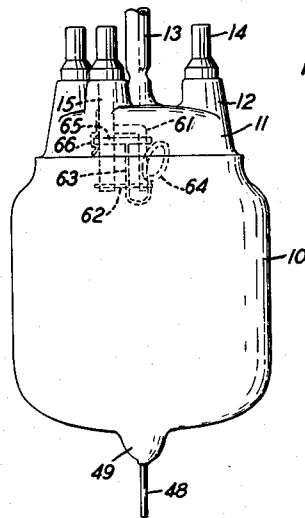


FIG. 8

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2,356,035

ELECTRON DISCHARGE DEVICE

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Application November 22, 1941, Serial No. 420,056

11 Claims. (Cl. 250—27.5)

This invention relates to electron discharge devices and more particularly to devices of high power output efficiency for use in short-wave systems.

In conventional discharge devices of the triode and multiple electrode types the power output is generally limited by size, the power factor increasing with larger capacity discharge devices. However, certain considerations, such as portability and compactness of associated equipment, confine the limit of size of the device, and it is necessary to attain the desired power output by increasing the magnitude of generating electron paths in the device to convey the higher power. This is accomplished, in one form by multiplying the initial electron source to the desired capacity to generate a larger volume of electrons which are projected toward a common anode so that a larger power output may be secured. This necessitates additional control and other influencing electrodes for each electron emitting element to obtain definite static and dynamic characteristics for the device operating within a given narrow range of the high frequency wave-length band.

The multiplicity of electrode elements involved in such a structure necessarily complicates the stability of the characteristics of the device and renders reproducibility a difficult undertaking, since each set of duplicate elements should present uniform conditions in the electron discharge path to the anode or output electrode in order to achieve the maximum efficiency from the discharge device. Furthermore, the space relation of all the elements should be maintained accurately uniform to obtain high mutual conductance and high insulation resistance commensurate with the increased power output possible with a given construction.

An object of this invention is to insure the stability of the electrical characteristics of multi-unit discharge devices of high power output.

Another object is to facilitate the assembly of multielement discharge devices to obtain high mutual conductance and low interelectrode capacity.

A further object of the invention is to efficiently dissipate heat energy generated in the output electrode of restricted area in a high frequency translating device.

Still another object is to improve the manufacturing technique whereby residual gases in the envelope of the device are efficiently removed and absorbed to insure stable performance and enduring operation.

In accordance with this invention the electron discharge device involves a plurality of units, each including a cathode, heater, control grid and screen electrode grouped uniformly between extending arms on spacing insulating members to constitute a compact assembly supported by conductors attached to the terminals of the discharge device. A common anode having enclosing sections commensurate with the plurality of units is supported in cooperating relation to the assembly and is provided with heat radiating portions to efficiently dissipate the heat generated in the limited size of the anode. This arrangement insures stable operation and reproducible devices since the electrode units are exact duplicates and are accurately spaced in relation to each other and to the cooperating sections of the anode to produce identical discharge path conditions in various directions so that the aggregate power is efficiently attained.

A feature of the invention relates to the coupling of the multielements of the assembly to the terminal conductors of the device to insure parallel and uniform circuit conditions for the operation of the device. This is accomplished by providing concentric conducting members adjacent one of the insulating spacers, each of which is connected to electrodes of like nature in all the units to join them in parallel relation so that the circuit conditions will be the same for all the units. These conducting members, furthermore, lend additional support to the electrodes by their clamping action against the spacing insulator so that the electrodes are rigidly held in their appropriate positions in relation to the other cooperating electrodes.

Another feature of the invention relates to the grouping of the units to facilitate the joinder of similar elements in a compact assembly. This is achieved by mounting the cathodes in the center of aligned arms of the spacing insulators and locating the several grid elements of each unit in cooperating relation in the arms so that their supporting terminations are distributed in definite boundaries encompassed by the concentric conducting members and all of the screen grids are coupled together at the axis of the assembly. This facilitates the fabrication of the assembly and materially aids the support of the multiunit mount in the device.

Another feature relates to the provision of tapered guides in the top and bottom insulating spacers to readily assemble the mount so that the multielements may be combined in a compact assembly with a minimum of delay.

A further feature of the invention relates to the support of a getter mounting in the device to prevent oxidation of the getter material during the sealing of the enclosing receptacle. The support for the getter material is slidably movable adjacent one of the terminal conductors in the stem so that it is projected away from the sealing area during the fusing of the enclosing bulb to the rim of the stem. This prevents the intense heat generated during the sealing operation from oxidizing the getter material or prematurely flashing the material. When the fusion of the vessel is completed the getter support is retracted into the stem and locked in a stationary position to be flashed during the final evacuation process of the device.

These and other features of the invention will be described in the following detailed description which, together with the accompanying drawings, represent a complete exposition of the invention.

Fig. 1 is a perspective view of a complete embodiment of the structural features of the invention with parts of the enclosing vessel broken away to illustrate the internal multiple unit assembly of the electrodes;

Fig. 2 shows the device of Fig. 1 in elevation with the enclosing bulb removed and portions of the mount in cross section to illustrate various details of construction;

Fig. 3 is a plan view of Fig. 2 showing the relation of the mount and the anode with respect to the conductors in the stem;

Fig. 4 is a partial view in elevation of the structure of Fig. 2 from a different angle to clearly show the getter support mounting in accordance with this invention;

Fig. 5 shows a modified form of the anode assembly in perspective with heat radiating fins on opposite sides of the anode;

Fig. 6 is a plan view of a modified form of the mount illustrating the anode of Fig. 5 in combination with a multiunit structure having a different form of the concentric conducting members for the electrodes;

Fig. 7 is an outline view of the device of this invention in inverted position to illustrate the method of sealing the enclosing vessel in which the getter mounting is displaced from the sealing area; and

Fig. 8 shows the same structure with the seal completed and the getter mounting retracted toward the stem during the evacuation process of the device.

Referring to the drawings and particularly to Figs. 1, 2 and 3, the electron discharge device of this invention comprises a bulbous enclosing vessel 10, of low expansion vitreous material, such as borosilicate glass, which has its open end sealed to the rim of a molded or precast dish stem 11 of similar material, the stem being provided with a plurality of outwardly extending tubular projections 12 distributed in spaced relation in the base of the stem and a central tubulation 13 for evacuating the enclosing vessel in the final processing of the device, the tubulation being sealed off to maintain a high degree of vacuum in the device. The projections 12 have hollow metallic thimble terminals 14 hermetically sealed thereto for applying suitable potentials to the electrodes within the device. Each thimble supports a rigid channel-shaped metallic conductor 15 which fits snugly within the thimble portion of the terminal and is soldered

or welded to the interior surface at the bottom thereof.

A multiple unit electrode assembly or mount is supported within the vessel and comprises a lower cross-shaped spacer member 16, of ceramic material or similar insulation, provided with spaced apertures in the separate arms to support four electrode units which are disposed in radial directions from the center of the spacer. In the center of each arm of the insulating spacer 16 an oval-shaped tubular cathode sleeve 17 is positioned with its lower end seated in an oval aperture 18, the sleeve being coated with the usual electron emitting layer, such as barium and strontium oxides. Each cathode is provided with an internal heater element, of the hairpin or double spiral type, which is coated with an insulating material, such as aluminum oxide, to prevent electrical contact of the heater element with the cathode sleeve, the heater element being provided with a pair of terminations 19 extending through the aperture 18 in the spacer member 16. A helically wound grid or control electrode 20 surrounds each cathode sleeve and the uprights thereof are provided with outwardly bent angular extensions 21 projecting through a pair of apertures on opposite sides of the cathode aperture 18 in a radial direction along the arm of the spacer member 16. A similar grid 22 of larger dimensions, which functions as a screen electrode, surrounds the cathode and grid 20 and has its uprights provided with spreading bent extensions 23 on opposite sides, one of the extensions being seated in an aperture close to the center of the spacer member 16 while the other extension is secured to an eyelet 24 clamped in a recessed aperture near the outer extremity of the arm of the spacer member 16.

The cathode 17 and grids 20 and 22 of each unit are held in their desired spaced relation at the top of the mount by a cross-shaped ceramic insulating member or spacer 25 which is provided with complementary apertures therein to accommodate the cathodes and angular extensions 26 of grids 20 and spreading extensions 27 of grids 22 to accurately align the electrodes of the various units and maintain them in rigid position. In order to facilitate the assembly of the upper insulating spacer to the various projecting portions of the multiple electrode unit the apertures facing the electrodes are chamfered or flared, as shown at 28, Fig. 2, to readily guide the electrode extensions through their appropriate apertures to line up the unit and the spacer is held in position by outwardly bent extensions 27 of the grids 22 being welded to eyelets 29 seated in the recessed ends of the arms. Each grid 20 of the multiple unit is provided with a heat radiator 30 which is formed of a pair of juxtaposed flat strips having a central sleeve portion 31, the strip being welded to the extensions 26 of the grid beyond the insulating spacer 25 so that the sleeve portion 31 is concentric with the oval aperture of the cathode 17. The heat radiator 30 may be blackened or carbonized to provide better heat radiation.

The various elements or electrodes of like character of the multiple unit are connected in parallel by concentric rings or connectors mounted edgewise with respect to the lower surface of the insulating spacer 16 wherein the inner arcuate ring 32 is connected to the extensions 21 of the grids 20 nearest to the center of the spacer member 16, the ring 32 abutting against the lower surface of the spacer 16 to

rigidly position the grids in their relative positions. The arcuate ring 32 is surrounded by a pair of similar concentric rings 33 and 34, the ring 33 having its ends terminating at the same arms as the inner ring 32 while the ends of the ring 34 terminate at the opposite arms of the insulating spacer 16. The arcuate ring 34 or intermediate ring is connected to the terminations of one side of the heater elements in the four units and the outer ring 33 is connected to the other terminations of the four heater elements, this ring also providing the multiple connection to the cathodes 17 through a connecting strip 35 welded to the lower end of each cathode sleeve and the ring 33. The reverse disposition of the rings 33 and 34 permits suitable contact to be made to the rings notwithstanding their close relation over a greater part of their lengths. The multiple rings prevent longitudinal shifting of the cathodes, heaters and inner grids and the electrode elements rigidly secure the rings to the spacer member 16.

All of the grids 22 which have their spreading extensions 23 converging toward the center of the spacer member 16 are tied together by downwardly extending flat strips which are connected to a central core rod 37 to form an axial terminal. The outer ends of the extensions 21 of the grids 20 may be anchored to the insulating spacer 16 by short tabs 38 welded to the extensions and abutting against the lower surface of the arms of the insulator 16. The multiple unit assembly or mount is supported in the vessel by the conductors 15 in the stem which are provided with connector wires coupled to the various elements in the mount. This is shown more clearly in Fig. 3 in which an angular connector wire 39 is welded at opposite ends to the axial core rod 37 and the middle right-hand conductor 15, respectively. The inner arcuate ring 32 is connected to the remote terminal 15 oppositely disposed with respect to the middle terminal, above described, by a wire connector 40. The outer arcuate ring 33 is connected to another conductor 15 by a connector wire 41 and the intermediate ring 34 is connected to the remaining conductor 15 by a connector wire 42. A plurality of bracing connector wires 43, 44 and 45 extend from the middle conductor 15 to the extremities of the arms of the insulator 16 to be connected to the extensions 23 of the grids 22 to lend additional support to the mount in the vessel. This arrangement unites the various electrode assemblies in a compact unitary mount to provide adequate insulation between the numerous elements incorporated therein, and to facilitate the multiple connections of like elements in the units to a minimum of terminal connections in the stem, so that the highest insulation resistance may be obtained between the closely compacted electrodes in each unit, whereby the aggregate electron emission may be obtained and controlled with high efficiency and a high power output obtained in the high frequency range.

The multiple units of the mount are surrounded by a common anode or plate electrode 46 which is provided with four sections closely parallel to the respective electrode units and is supported by a four-armed suspension hanger 47 secured at the top to an anchor plate carried by a heavy conductor 48 hermetically sealed in an axial protuberance 49 projecting from the top of the enclosing vessel 10. The anode may be coated on the exterior with a heat dissipating

layer, such as carbon or zirconium. The anode is formed of four U-shaped sections 50 having the longitudinal ends or fins 51 bent at a tangential angle of 60 degrees from the plane surface thereof. Adjacent anode sections are connected together by an intermediate angle-shaped member 52 having longitudinal flanges 53 abutting against and welded to the flanges 51 of the anode sections to provide a completely enclosed anode of cross-shaped configuration with the heat radiating fins directed in converging relation adjacent the central portion of the unit, where the greatest amount of heat energy is generated. One of the fins 53 on the intermediate member 52 of the anode is formed to provide a socket 54 to receive the downwardly extending arm of the suspension supporting hanger 47 of the anode, whereby the anode is rigidly supported from the top of the vessel and accurately spaced with respect to the individual units of the multiple mount enclosed thereby.

Fig. 5 shows a modified form of the anode in which the U-shaped sections are joined together in a unit by multiple intermediate members 55 and 56 having their inner ends along the longitudinal length joined together in abutting relation to form an internal fin 57, the intermediate adjacent section being bent outwardly to form diverging arms in line with the parallel extensions of the U-shaped sections 50 and the terminating ends being bent inwardly to cooperate with the fin extensions 51 of the anode sections. This arrangement, as shown in Fig. 6, increases the heat dissipation of the energy absorbed in the anode and at the same time localizes the heat energy in each unit to its respective area to more efficiently dissipate the heat energy generated during the operation of the device. This figure also shows a different arrangement of the concentric multiple connectors for the electrode elements in the form of rectangular-shaped conducting strips mounted in the same manner as the concentric rings 32, 33 and 34 previously described. In this construction, however, the inner connector 58 is connected to the extensions 21 of the four grids in the arms at the terminations and the angles of the rectangular configuration, the terminations of the connector being located on two of the adjacent arms of the insulator 16. The intermediate connector 59 is secured to the terminations of one side of all the heater elements with the ends thereof disposed adjacent the opposite arms of the insulator 16. The outer rectangular connector 60 is connected to the remaining terminations of the heater elements and also all of the cathodes with its ends located on adjacent arms of the spacer member in line with the terminations of the parallel lengths of the other connectors. That is, one termination is on the same arm as one of the terminations of the connector 58, while the other termination is on the same arm as the termination of the connector 59. This permits adequate spacing for attaching the required connector wires between the multiple connectors and the conductors in the stem so that the insulation paths between electrodes of different potential value are not diminished.

Another feature of the invention is concerned with the mounting of a getter assembly in the device so that in the final evacuation of the vessel the occluded gases may be absorbed in a metallic film deposited in the region of the stem 11. This arrangement is shown more clearly in Fig. 4, in which one of the channel-shaped rigid

conductors 15 extending through the stem is provided with a frame mounting formed of an angle rod 61 projecting from the conductor with an upright arm extending parallel to the conductor. The conductor and angle rod are connected at the top to form a frame by a rigid guide plate 62, which embraces the extremities of the conductor and rod to provide guidance for the getter mounting detail. The mounting comprises a crook-shaped support rod 63 extending through an aperture in the guide plate 62, the bent end of the rod 63 carrying a grooved annular ring 64 containing a short section of getter wire deposited in the ring, the material of the wire being any suitable gas absorber, such as magnesium or nickelated barium. The getter support rod 63 is anchored to the center of a slidable arm 65 having portions surrounding the conductor 15 and the angle rod 61, the arm 65 being normally locked in its lowermost position by a spring clip 66 attached to the side of the conductor 15 remote from the getter mounting.

Since the multiple electrode mount contains so many closely spaced electrode elements, it is undesirable to affix the getter mounting thereto because of the danger of vaporized metal being precipitated on the mount to form leakage paths and thereby endanger the insulation resistance between the closely spaced electrodes in the mount. It is, therefore, necessary to position the greater mounting as far as possible from the electrode mount, and since the conductors in the stem are widely spaced to preserve the high insulation necessary in the device the stem forms an appropriate location for the getter mounting. However, another difficulty is presented in fixedly positioning the getter mounting in the stem due to the necessity of heating the rim of the stem to a plastic state in order to seal the bulb 10 to the stem. The intense heating flame necessary for producing the annular seal between the stem and the bulb would ordinarily oxidize the getter material in the mounting and therefore impair the efficiency of the getter and necessarily increase the energy required for flashing the getter material during the final evacuation of the device.

The slidable getter mounting of this invention overcomes this difficulty as shown in Figs. 7 and 8. The getter support is displaced from the zone of the heating flame for fusing the bulb to the stem and then the getter mounting is retracted into the stem and locked in normal position during the pumping and final evacuation process of the device. After the electrode mount is supported on the conductors in the stem as shown in Fig. 2, the stem with the mount is inverted and the enclosing bulb 10 with the anode sealed therein is positioned about the unit so that the open end 67 of the bulb is placed close to the rim of the stem 11 as shown in Fig. 7. In this position the getter ring 64 on the crook-shaped support 63 drops downwardly on the frame so that it is displaced from the region or zone of the open end of the bulb and the rim of the stem. A pair of oppositely disposed burner flames 68 are directed toward the edges of the bulb and the stem to heat the glass to the fusion point to hermetically seal the bulb to the stem. Since the getter material in the ring 64 is displaced from the zone of the heating flame oxidation of the getter material is prevented and after the seal is completed and cooled the getter support is retracted into the stem and locked in normal position by the spring clip 66 as shown in Fig. 8.

The locking of the getter support in the stem is required since the device is normally in an inverted position during the pumping of the tube since the central tubulation extends downwardly and is sealed to an exhaust manifold to evacuate the device and heat the electrode assembly to remove gases from the electrode elements. The locking spring therefore maintains the getter mount within the stem or directed toward it while the device is in a suspended position during the evacuation process. The getter material is then flashed by a suitable means, such as an external high frequency coil, just prior to the final sealing off of the tubulation from the manifold so that the flashed getter material is directed toward the dished stem away from the multiple electrode unit. In the normal operation of the device the getter mounting is securely locked in the stem by the spring clip 66.

While the invention in its various features and aspects has been disclosed with respect to specific constructional arrangements it is, of course, understood that various modifications may be made in the detailed structure shown without departing from the scope of the invention as defined in the appended claims.

What is claimed is:

1. In an electron discharge device, a multiunit mount including separate groups of a sleeve cathode, a heater therein, and a control element surrounding said cathode, insulating spacer members supporting said groups therebetween, a common anode surrounding said groups, and a plurality of concentric conducting members adjacent one of said spacer members rigidly securing the cathode, heater and control element of each group in position in said spacer members.

2. In an electron discharge device, a multi-unit mount including separate groups of a sleeve cathode, a heater therein, and a control element surrounding said cathode, insulating spacer members supporting said groups therebetween, a common anode surrounding said groups, and a plurality of concentric conducting strips mounted edgewise on the side of one of said spacer members opposite said groups to rigidly fasten said groups therein.

3. In an electron discharge device, a multiunit mount including separate groups of a sleeve cathode, a heater therein, and a control element surrounding said cathode, insulating spacer member supporting said groups therebetween, a common anode surrounding said groups, a plurality of flat arcuate conducting members mounted in concentric relation on one of said spacer members to secure said group elements in position, and connections from like elements to said arcuate members in parallel relation.

4. In an electron discharge device, a multi-unit mount including separate groups of a sleeve cathode, a heater therein and a control element surrounding said cathode, multiarmed insulating spacers supporting said groups therebetween, each group being mounted between aligned arms of said spacers, and a plurality of flat arcuate metallic strips in edgewise contact with one of said spacers and in circular alignment with the terminations of the heater and control element in each group.

5. An electron discharge device comprising an enclosing vessel having a dish stem, rigid conductors sealed in said stem, a multiunit mount within said vessel including separate electrode groups of a sleeve type cathode, a heater element enclosed thereby, and a control grid surround-

ing said cathode, cross-shaped insulating spacers on opposite ends of said mount, said groups being radially disposed in the arms of said spacers, a plurality of arcuate metallic strips supported on the side of one of said spacers directed toward said stem and attached to like elements in each group to connect them in parallel relation, supporting connections between said strips and said conductors, and a surrounding anode having sections enclosing the separate electrode groups and being supported in cooperative relation from the top of said vessel.

6. An electron discharge device comprising an enclosing vessel having a dish stem, rigid conductors sealed in said stem, a multiunit mount within said vessel including separate electrode groups of a sleeve type cathode, a heater element enclosed thereby, and a control grid surrounding said cathode, cross-shaped insulating spacers on opposite ends of said mount, said electrode groups having extensions projecting through one of said spacers toward said stem, a plurality of concentric metallic strips in edgewise contact with said spacer and engaging the extensions of like electrodes in said groups to rigidly secure them in position, supporting connections extending between said strips and said conductors, and a common anode surrounding said mount and supported from said vessel.

7. An electron discharge device comprising an enclosing vessel having a dish stem, rigid conductors sealed in said stem, a multiunit mount within said vessel including separate electrode groups of a sleeve type cathode, a heater element enclosed thereby, and a control grid surrounding said cathode, cross-shaped insulating spacers on opposite ends of said mount, a plurality of metallic incomplete rings concentrically mounted in edgewise relation adjacent one of said spacers, the outer ring being connected to all the control grids in said groups, other rings being connected to said heater elements, said cathodes being coupled to one of the rings connected to said heater elements, an anode surrounding said mount and separately supported in said vessel with respect to said mount, and supporting connections extending between said rings and said conductors.

8. An electron discharge device comprising an enclosing vessel having a dish stem, conductors sealed in said stem, a multiunit mount within said vessel including a pair of cross-shaped insulating spacers in aligned spaced relation, a sleeve cathode mounted in the center of each pair of aligned arms of said spacers, a control grid surrounding each cathode and having spread extensions in said arms on opposite sides of said cathode, an insulated heater element within each cathode having terminal extensions projecting through one of said spacers, a screen grid sur-

rounding each cathode and control grid and having spread extensions fitted into said spacers, said screen grid extensions being located at the extremities of said spacers and at the center thereof, an edgewise mounted metallic strip engaging the spread extensions of said control grids on the side of said spacer opposite said electrodes, a pair of parallel strips concentric with said first strip engaging the terminations of said heaters and said cathodes, an anode having U-shaped sections corresponding to the number of electrode units in said mount surrounding said mount, supporting connections extending between said strips and certain of said conductors, and a separate connection extending between the remaining conductor and the common center of said screen grid extensions.

9. An electron discharge device comprising an enclosing vessel having a dish stem, a multiunit mount within said vessel including a pair of spaced insulators having a plurality of aligned arms extending in different directions, a tubular cathode and an internal heater element supported between each pair of aligned arms, a helical grid surrounding each cathode, a common anode having hollow sections spaced substantially parallel to said cathodes, and grids, the sections extending in the same directions as said arms, a conductor supporting said anode and sealed to the top of said vessel, a plurality of terminals sealed in said stem, and three concentric metallic bands between said terminals and said mount, two of said bands being connected to opposite ends of said heater elements and the remaining band being connected to all of said grids, said bands being coupled to individual terminals for supporting said mount.

10. In a high frequency electron discharge device containing an electrode mount having groups of cooperating electrodes arranged in different radial directions, an anode surrounding said mount having U-shaped portions individual to each of said groups, said portions being provided with outwardly extending fins and the fins on adjacent portions converging toward each other.

11. In a high frequency electron discharge device containing an electrode mount having groups of cooperating electrodes arranged in different radial directions, an anode surrounding said mount having U-shaped portions individual to each of said groups, adjacent portions being joined together near the center of said mount to form sharp angle connections, inwardly projecting extensions on said angle connections forming tangential radiating fins, and outwardly extending tangential fins on said portions intermediate said angle connections and the curvature of said portions.

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