

Sept. 19, 1939.

J. E. CLARK ET AL

2,173,679

ELECTRON DISCHARGE DEVICE

Filed Aug. 11, 1938

2 Sheets-Sheet 1

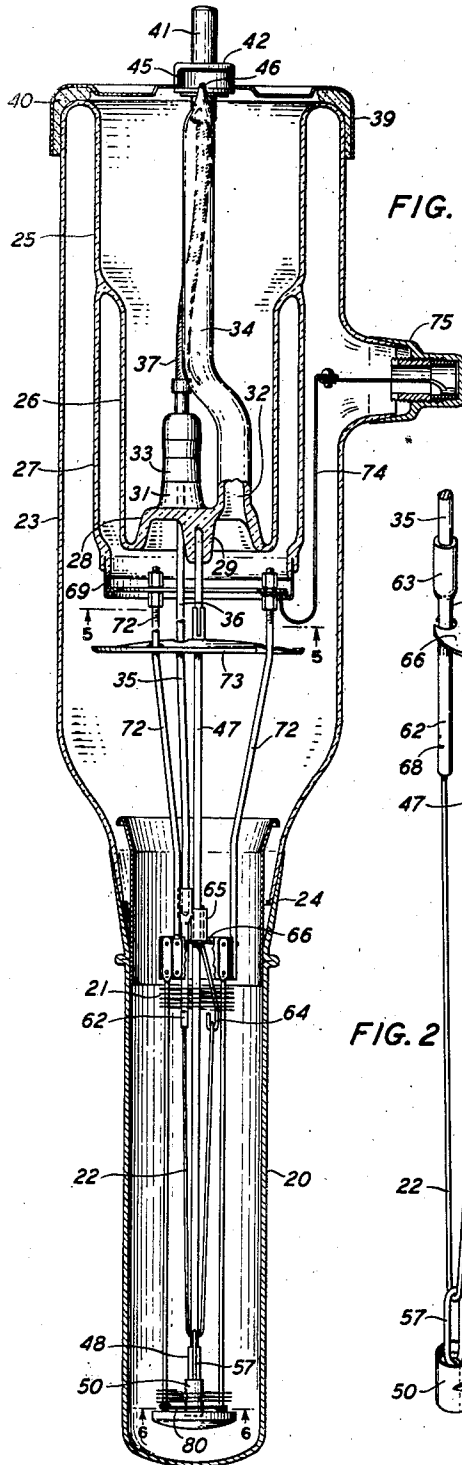


FIG. 1

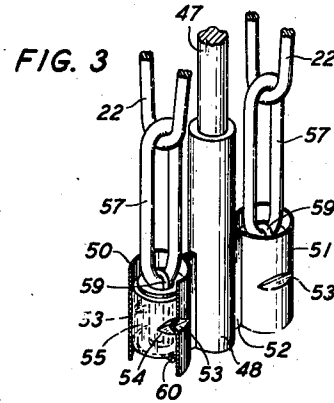


FIG. 3

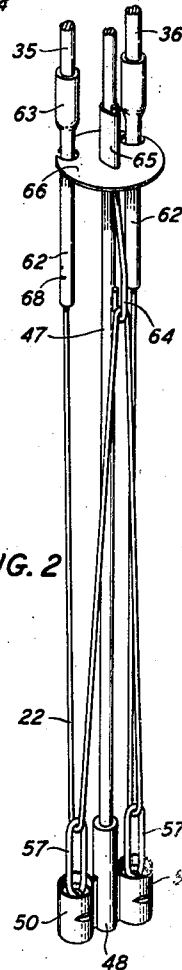


FIG. 2

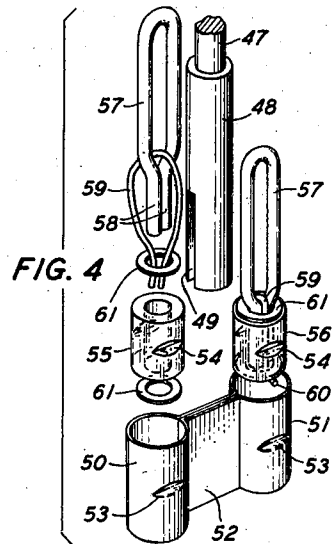


FIG. 4

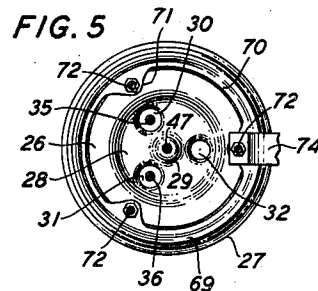


FIG. 5

INVENTORS: J. E. CLARK
V. L. RONCI
BY
Kalter C. Kiesel
ATTORNEY

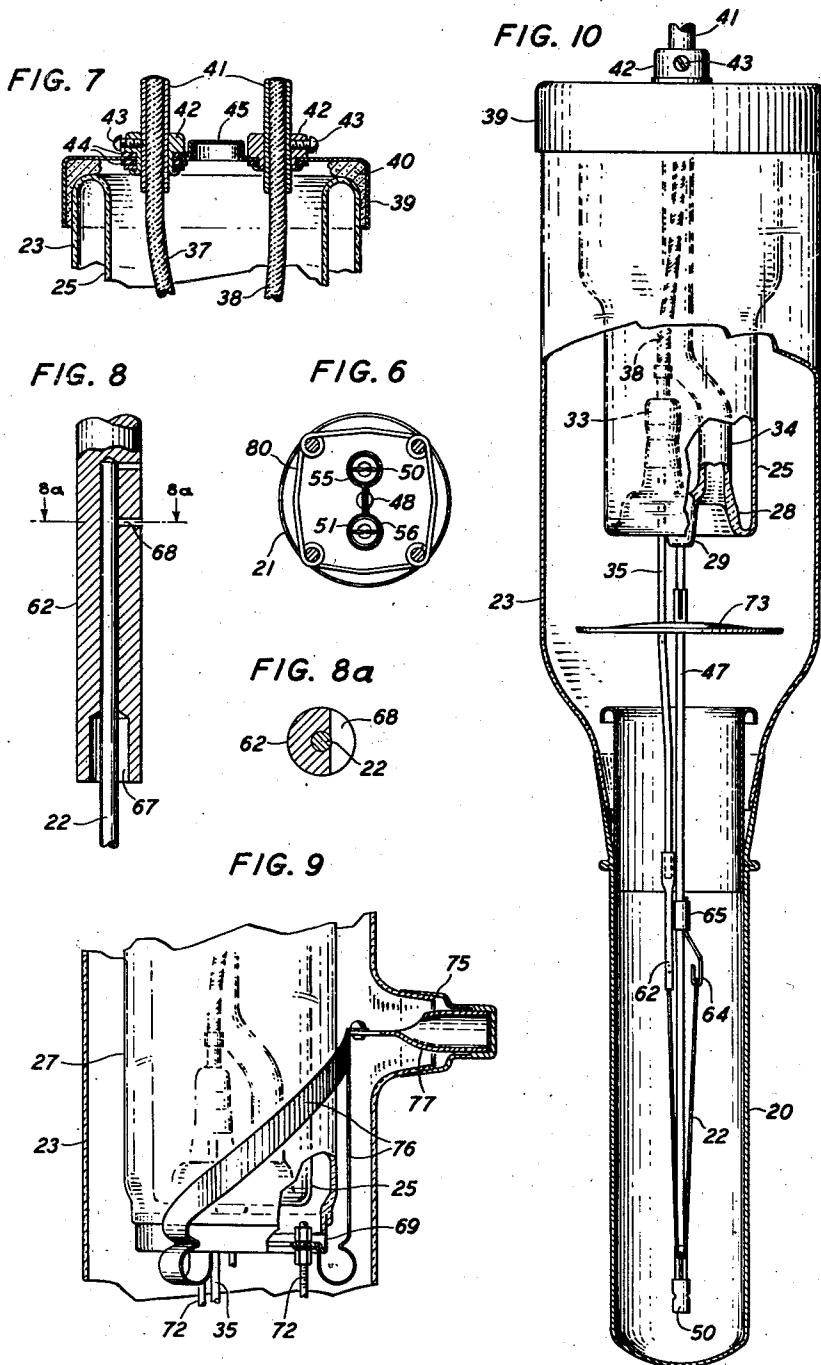
Sept. 19, 1939.

J. E. CLARK ET AL
ELECTRON DISCHARGE DEVICE

2,173,679

Filed Aug. 11, 1938

2 Sheets-Sheet 2



INVENTORS: J. E. CLARK
V. L. RONCI
BY
Walter C. Kiesel
ATTORNEY

UNITED STATES PATENT OFFICE

2,173,679

ELECTRON DISCHARGE DEVICE

James E. Clark, Williston Park, and Victor L. Ronci, Brooklyn, N. Y., assignors to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application August 11, 1938, Serial No. 224,250

15 Claims. (Cl. 250—27.5)

This invention relates to electron discharge devices and more particularly to high power devices of the external anode type.

An object of the invention is to facilitate the assembly of the device whereby operating performance will be more stable.

Another object of the invention is to insure long operating life by the avoidance of faults which shorten the useful operation of the device.

A further object relates to manufacturing technique whereby reproducible units may be obtained which are superior in efficiency to prior devices.

In accordance with this invention as applied to a fluid cooled type device having an external anode, a vitreous portion is sealed thereto for insulating the internal electrodes from the anode. A pre-cast closure is provided within the vitreous portion for supporting the filament assembly and the conductors for supplying current to the filament. A rigid mounting is also provided to coaxially arrange a control electrode or grid with respect to the filament and the anode. This arrangement insures a stable structure which is free from flash-arcs and other disturbances which impair the efficiency and operating characteristics of the device. Furthermore, the correlation of the various elements of the assembly facilitates the manufacture of highly efficient devices on a mass production basis.

A feature of the invention relates to the simplicity of assembly to provide an efficient structure with a minimum number of components. In the filament assembly a standard is directly affixed to the center of the pre-cast closure member and rigidly supports the filament strands in relation to the other electrodes.

Another feature relates to the direct support of the grid structure by a metallic ring member sealed in the vitreous portion so that the grid is automatically centered with respect to the anode.

A further feature of the invention is the supporting assembly of the filament strands at the opposite end of the device to insure proper spacial relation of the strands with respect to the grid and the anode. This structure involves a metallic nest on the end of the standard for supporting insulating bushings which carry hooks engaging the filament strands. This arrangement insures proper displacement of the filament strands so that they do not tend to warp under operating conditions.

Another feature of the invention relates to the provision of a multi-arm conductor for the grid to facilitate the operation of the device in

ultra-high frequency systems. This conductor distributes the controlling current equally to the whole area of the control electrode to effect high power output in the device.

These and other features of the invention will be more clearly understood from the following detailed description in connection with the accompanying drawings:

Fig. 1 illustrates in cross-section a complete assembly of the discharge device in accordance with this invention;

Fig. 2 is a perspective view of a portion of the filament supporting assembly embodied in Fig. 1;

Fig. 3 shows an enlarged perspective view of the mounting for the filament with a portion broken away to visualize the details of construction;

Fig. 4 illustrates in exploded fashion the various elements of the mounting of Fig. 3;

Fig. 5 is a plan view of the grid mounting taken on the line 5—5 of Fig. 1;

Fig. 6 is a plan view of the grid and filament assemblies on the line 6—6 of Fig. 1;

Fig. 7 shows in cross-section details of the base and the method of securing the conductors to the base;

Fig. 8 is a greatly enlarged view in cross-section of the filament and current conductor showing the relationship of these elements;

Fig. 8a is a sectional view of the conductor of Fig. 8 taken on the line 8a—8a;

Fig. 9 is a partial view in cross-section of a modification of Fig. 1 to illustrate a different form of current conductor attached to the grid terminal of the device; and

Fig. 10 shows in cross-section the features of the invention applied to a power rectifier device.

The electron discharge device of this invention, as applied to one embodiment illustrated in Fig. 1, involves a three electrode device comprising an anode 20 which forms part of the enclosing vessel, a cylindrical wire wound control electrode or grid 21 within the anode and coaxial therewith, and a filamentary cathode 22 arranged within the grid. Since the anode is usually operated at a high potential while the grid and filament are operated at relatively low potentials, it is essential that the insulation paths between these electrodes are adequate to avoid breakdown at the high voltage of the anode. This is achieved by mounting the grid and filament structures from a vitreous portion 23 which provides a long insulating path between the grid and filament structures and the anode.

The anode 20 is a metallic cylinder of cup form, preferably of copper, having a flared portion 24,

which may be hermetically sealed to an elongated tubular vitreous portion 23 of relatively hard boro-silicate glass, in accordance with a method disclosed in U. S. Patent 1,294,466 issued February 18, 1919, to W. G. Houskeeper, the anode and vitreous portion forming an enclosing vessel. The vitreous portion 23 is provided with a reentrant cylindrical stem 25 to which is joined two concentric extensions 26 and 27 which project longitudinally within the vessel.

A pre-cast or molded dish-type closure or stem 28 is fused to the end of the inner extension 26 and constitutes a supporting base for the filament assembly. This closure is provided with a solid central nodal portion 29 within the dished area and a plurality of equally spaced tubular extensions 30, 31 and 32, which project outwardly towards the termination of the stem 25 and the portion 23. The extensions 30 and 31 are provided with metallic cap seals 33, such as shown in Fig. 1, while the extension 32 is joined to an elongated tubulation 34, which curves towards the axis of the stem 25 and is employed during manufacture for evacuating the device of gases and other deleterious matter which might impair the high vacuum attained for efficient operation.

The cap seals carry rigid conductors 35 and 36, which extend into the anode portion 29 of the device. The cap seals are connected externally to flexible conductors 37 and 38 extending towards a metallic base 39 affixed to the end of the vitreous portion 23 with cement 40. Each of the flexible conductors, adjacent the end thereof, is surrounded by a rigid metallic jacket or sleeve 41 which projects through a metallic bushing 42 secured to the base 39 and the sleeve 41 is fastened to the bushing by a set screw 43. One of the bushings is insulated from the base by stacked washers 44, of mica, to segregate the conductors for supplying heating current to the filament 22 of the device. A central embossment 45 on the base is provided to protect the sealed tip 46 of the exhaust tubulation 34.

A rigid metallic standard 47 is sealed into the nodal portion 29 of the dish-type stem 23 and extends centrally within the anode 20. This standard carries an enlarged head 48 at the lower end, as shown clearly in Figs. 2 to 4, inclusive, and the extreme end of the head is provided with a longitudinal slot 49 as shown in Fig. 4. The head 48 forms a support for a sheet metal basket or nest having two symmetrical cylindrical sockets or sleeves 50 and 51 joined together by a three-ply folded connecting strip 52 which is seated in the slot 49 of the head, and the end of the head is welded. The nest is formed by shaping the cylindrical sleeves in spaced relation at the end of the center ply of the strip 52 and laying the terminating ends of the sleeves in parallel relation to the center ply. This construction provides an assembly having a certain amount of resiliency in the sheet metal so that the nest may be easily fabricated.

Each sleeve is provided with a notch or indentation 53 on opposite lateral sides transverse to the longitudinal axis of the sleeve as shown in Fig. 4. This notch forms a stop or locking joint for a cooperating niche or dent 54 in a pair of insulating bushings 55 and 56, preferably formed of quartz. These bushings are assembled in the sleeves 50 and 51 prior to the mounting of the nest in the slot 49 of the head simply by inserting the bushings in the expanded sleeves and after being seated therein the three-ply connect-

ing strip is pressed together. The fitted quartz bushings are prevented from being displaced from the sockets or turning therein by the cooperating niches and indentations on the bushings and sockets, respectively, and the confinement of the connecting strip 52 in the slot of the head insures a compact, rigid assembly which is made at low cost and easily fabricated with a minimum amount of labor and tools.

A closed loop member 57 having contacting end portions 58 extends through each bushing. A tie wire 59 engaging the loop is threaded through the bushing and the ends are bent outwardly as shown at 60 in Fig. 4. In order that the pressure exerted on the quartz bushing by the loop member and tie wire will not cause fracture of the bushing, a metallic washer 61 is applied to each end of the bushing prior to fastening the loop member therein. The tie wire not only secures the loop member in the bushing but prevents it from twisting or rotating in the bushing.

The current conductors 35 and 36 are provided with an extension rod 62 having an enlarged hollow end portion 63 into which the conductor extends and is rigidly secured thereto by welding. The standard 47 carries a hook 64 which is fastened by a strap 65 to the standard and the strap also supports a heat shield or deflector 66 which is provided with cut-out portions clearing the extension rods 63 of the conductors. The opposite end of the extension rod 62 is drilled, as shown in Fig. 8, and counterbored at 67 and also provided with saw slots 68 at spaced intervals near the bottom of the drilled hole. A preformed tungsten filament 22 having the end legs threaded through the loop members 57 and the midpoint engaging the hook 64 is connected to the extension rods of the conductors by inserting the legs into the drilled holes of the rods 62. An arc weld is made through the slots 68 to rigidly affix the filament end in the rod. This form of connection avoids any rough weld spots on the rod 62 which might serve to form an arc during the operation of the device and the long socket embracing the filament adjacent the weld insures a rigid mechanical support for the filament. The counterbored end of the rod operates as a heat conserving shield for the portion of the filament entering the rod so that end-cooling effect is diminished.

The advantage of this construction may be summarized by considering the simplicity of the mounting in which the conductor seals are displaced from the high temperature zone of the device and the filament supporting structure is rigid enough to perform its function in retaining the filament in proper relation to the other electrodes without introducing auxiliary supporting elements which tend to reduce the leakage resistance between electrodes by the occurrence of flashing arcs from the anode.

The device shown in Fig. 1, being of the amplifier type, also includes the control electrode or grid 21 which surrounds the filament and is placed coaxial within the anode 20. In conformity with the simplicity of the filament structure the grid assembly is also simplified to avoid flash-over or arcs from the anode.

The outer vitreous extension 27 which projects slightly beyond the filament stem 26 has a metallic ring or collar 69 sealed into the rim. This ring is provided with an inwardly depressed flange portion 70 having three equally spaced bearing portions 71 which are in radial alignment with the dished stem extensions 30, 31 and

32 as shown in Fig. 5. The grid 21 which is of a conventional design is supported by bent rods 72 which extend to the ring 69 and are secured thereto by locking nuts which engage the threaded rods on opposite sides of the bearing portions 71 of the ring.

at a maximum commensurate with the required rigidity of the filament mounting.

While this description enumerates certain specific details relating to the various features of the invention it is, of course, understood that many modifications may be made in the elements depicted without departing from the spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. An electron discharge device comprising an enclosing vessel having a metallic portion serving as an anode and a vitreous portion sealed thereto, a reentrant tubular stem joined to said vitreous portion, a vitreous dished closure of greater cross-section than said stem fused to said tubular stem and having a nodal portion of a mass of vitreous material, a metallic standard carried by said nodal portion, conductors sealed in said vitreous closure, and a filamentary cathode supported by said standard and said conductors.

2. An electron discharge device comprising an enclosing vessel having a metallic portion serving as an anode and a vitreous portion sealed thereto, a reentrant tubular stem joined to said vitreous portion, a pre-cast vitreous dished closure fused to said tubular stem and having a nodal portion in the form of a solid mass, a metallic standard sealed in said nodal portion, conductors sealed in said vitreous closure, and a filamentary cathode supported by said standard and said conductors.

3. An electron discharge device comprising an enclosing vessel having a metallic portion serving as an anode and a vitreous portion sealed thereto, a reentrant tubular stem joined to said vitreous portion, a pre-cast relatively thick vitreous closure fused to the edge of said tubular stem and having a central solid nodal portion, a metallic standard rigidly fixed to said nodal portion, conductors sealed in said closure, and a filamentary cathode supported by said standard and said conductors.

4. An electron discharge device comprising an enclosing vessel having a metallic portion serving as an anode and a vitreous portion sealed thereto, a reentrant tubular stem joined to said vitreous portion, a pre-cast dished vitreous closure fused to said tubular stem and having protrusion portions extending from either side thereof, terminal members attached to a plurality of said protrusion portions and being co-extensive with said tubular stem, a standard having one end embedded in a protrusion portion on the opposite side of said closure, and a filamentary cathode supported in relation to said anode by said standard and said terminal members.

5. In an electron discharge device having an enclosing vessel, a pre-cast vitreous dished stem sealed in one end of said vessel, said stem having a central solid nodal portion and tubular portions extending therefrom in a direction opposite to said nodal portion, metallic seals carrying conductors secured to a plurality of said tubular portions, a metallic standard sealed in said nodal portion, and a filament supported by said conductors and said standard.

6. An electron discharge device comprising an enclosing vessel having a metallic portion serving as an anode and a vitreous portion sealed thereto, the reentrant tubular stem being joined to said vitreous portion, a pre-cast vitreous closure fused to said tubular stem, conductors

The skeleton supporting structure of the grid prevents the establishment of stray fields from the high potential anode and reduces arcing between the anode and the grid supporting structure. Furthermore, the supporting base of the grid, namely, the collar or ring 69, is sufficiently removed from the anode to insure a high insulation path between these electrodes. A further precaution taken to protect the filament seals and the ends of the grid supports, is the provision of a heat deflecting and electrostatic shield 73 which is supported on the standard 47 adjacent the ring 69 and serves as a baffle between the anode field and the metallic elements shielded by it. This shield is provided with oversized apertures for the free passage of the grid supports 72 and the filament conductors 35 and 36. The grid 21 is connected to an external circuit by a flexible strap 74 which is secured to the ring 69 by a nut associated with one of the rods 72 of the grid and at the other end is coupled to a terminal 75 sealed to the side wall of the vitreous portion 23 in accordance with the disclosure of Patent 2,114,439, issued April 19, 1938, to J. E. Clark and V. L. Ronci.

A modified arrangement of the grid terminal and current conductor, especially for high frequency current operation, is shown in Fig. 9, in which a bifurcated conductor 76 having a flexible arm attached to each grid support 72 on the collar 69 is coupled to a metallic insert 77 welded in the terminal cap 75.

In order to protect the contour of the fine wire winding 21 of the grid against distortion resulting from abnormal shocks in transit, which might cause the filament support nest to strike the winding, a strong wire guard ring 80 shown in Fig. 6, absorbs any shock directed toward the grid and thereby preserves the shape and characteristics of the grid.

Since flash-over or arcing may occur between the anode and any sharp point which forms a receptive area on the low potential electrodes which are unshielded or otherwise exposed to the electric field of the anode, it has been found that burrs and other sharp points on the supporting elements of the internal electrodes may be completely removed by a chemical buffing treatment of the metallic parts of the electrode structures prior to their assembly in the enclosing vessel so that the metals are smooth and polished. This treatment also materially reduces the evacuation period of the device, since the surface of the metallic parts is chemically free from spurious impurities. The tungsten filament and other tungsten parts are chemically cleaned and then buffed chemically by anodic treatment in an etching bath of dilute caustic soda, the molybdenum parts are similarly treated in dilute chromic acid, and the nickel parts are buffed in dilute acetic acid. The copper elements are also thoroughly cleaned in an ammonia bath.

Fig. 10 illustrates the construction of a rectifier type discharge device embodying the stem and filament supporting structure according to this invention. It is readily seen that the insulation path between the anode and the terminal portion of the filament structure is maintained

sealed in said vitreous closure, a central standard carried by said closure, a sheet metal nest having indentations supported by said standard, cooperating insulators seated in said nest and engaging said indentations, a folded filament attached to said conductors, and means carried by said insulators engaging said filament.

7. An electron discharge device comprising an enclosing vessel having a metallic portion serving as an anode and a vitreous portion sealed thereto, a reentrant tubular stem joined to said vitreous portion, a pre-cast vitreous closure fused to said tubular stem, conductors sealed in said vitreous closure, a central metallic standard carried by said closure, a sheet metal nest affixed to said standard including parallel cylindrical portions joined by a connecting strip, said cylindrical portions having transverse indentations, vitreous bushings located in said cylindrical portions and having depressions corresponding to said indentations, loop members carried by said bushings, and a filament attached to said conductors and said loop members.

8. An electron discharge device comprising an enclosing vessel having a metallic portion serving as an anode and a vitreous portion sealed thereto, a reentrant tubular stem joined to said vitreous portion, a pre-cast vitreous closure fused to said tubular stem, conductors sealed in said vitreous closure, a metallic standard attached to said vitreous closure, a sheet metal nest carried by said standard including parallel cylindrical portions joined by a connecting strip, said cylindrical portions having transverse indentations, vitreous bushings located in said cylindrical portions and having depressions corresponding to said indentations, loop members having a portion extending through said bushings, tie wires securing said loop members rigidly in said bushings, and a folded tungsten filament threaded through said loop members and connected to said conductors.

9. In an electron discharge device, a filament support comprising a standard, a metallic member attached thereto having twin sleeve portions, an insulating member located within each sleeve portion, means for preventing twisting and longitudinal movement of said insulating member in each of said sleeve portions, an elongated loop extending from each insulating member, and a folded filamentary element strung through the loops.

10. An electron discharge device comprising an enclosing vessel having a metallic portion serving as an anode and a vitreous portion sealed thereto, a reentrant tubular stem joined to said vitreous portion, a pre-cast vitreous closure fused to said tubular stem, conductors sealed in said vitreous closure, a central metallic standard engaging said closure and extending into said anode portion, a sheet metal nest including parallel cylindrical positions, insulating bushings contained in said cylindrical portions, and a three-ly connecting strip on said nest secured to said standard, and a filamentary cathode supported between said conductors and said bushing.

11. An electron discharge device comprising an enclosing vessel having a metallic portion serving as an anode and a vitreous portion sealed thereto, a reentrant tubular stem joined to said vitreous portion, a metallic ring sealed into the rim of said reentrant stem, said ring having an in-

wardly formed flange, a closure on said stem, a filament supported by said closure, a grid surrounding said filament, and extensions on said grid secured to said ring flange.

12. An electron discharge device comprising an enclosing vessel having a metallic portion serving as an anode and a vitreous portion sealed thereto, a reentrant tubular stem joined to said vitreous portion, a metallic ring sealed into the rim of said reentrant stem, said ring having an inwardly formed flange, a closure on said stem, a filament supported by said closure, a grid surrounding said filament, extensions on said grid secured to said ring flange, a terminal sealed to said vitreous portion, and a bifurcated flexible conductor attached to said terminal and all of the extensions of said grid.

13. An electron discharge device comprising an enclosing vessel having a metallic portion serving as an anode and a vitreous portion sealed thereto, a pair of concentric reentrant portions fused to said vitreous portion, a cast vitreous closure at the inner end of one of said reentrant portions, an annular metallic member at the inner end of said other reentrant portion and in superimposed relation to said closure, a filamentary electrode supported by said closure, a control electrode surrounding said filamentary electrode and supported by said annular metallic member, and a guard ring on said control electrode adjacent the end of said filamentary electrode.

14. An electron discharge device comprising an enclosing vessel having a metallic portion serving as an anode and a vitreous portion sealed thereto, a reentrant stem joined to said vitreous portion, inner and outer concentric tubular extensions superimposed on said stem, a vitreous closure fused to said inner extension, a metallic ring sealed into the rim of said outer extension, a central standard projecting from said closure, a filament supported by said standard, a grid supported by said ring, and a disc shield mounted on said standard coextensive with said tubular extensions and serving as a baffle between said ring and closure and said anode.

15. An electron discharge device comprising an enclosing vessel having a metallic portion serving as an anode and a vitreous portion sealed thereto, a reentrant stem joined to said vitreous portion, inner and outer concentric tubular extensions superimposed on said stem, a vitreous closure fused to said inner extension, a metallic ring sealed into the rim of said outer extension, conductors sealed in said closure, a central standard projecting from said closure, a metallic nest at the free end of said standard having twin sleeve portions, quartz bushings in said sleeve portions, said sleeves and bushings having cooperating indentations for locking said bushings in said sleeves, loops carried by said bushings, a folded filament engaging said loops and said conductors in said closure, a cylindrical wire wound grid surrounding said filament, support rods extending from said grid to said metallic ring, and a metallic shield attached to said standard adjacent said closure and ring and having apertures for the passage of said conductors and said grid support rods.

JAMES E. CLARK.
VICTOR L. RONCI.