

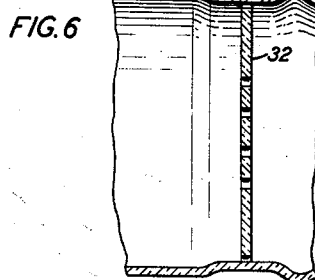
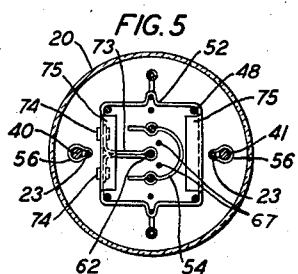
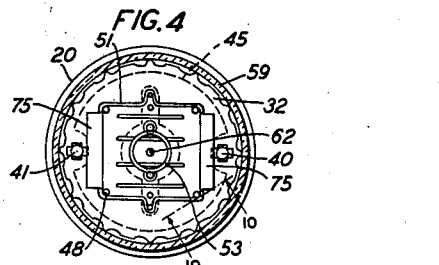
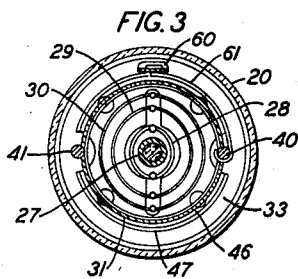
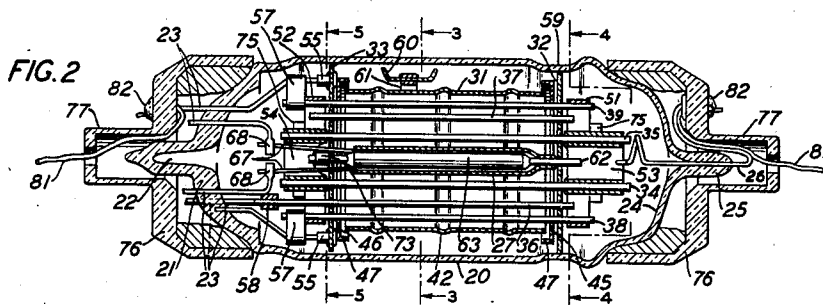
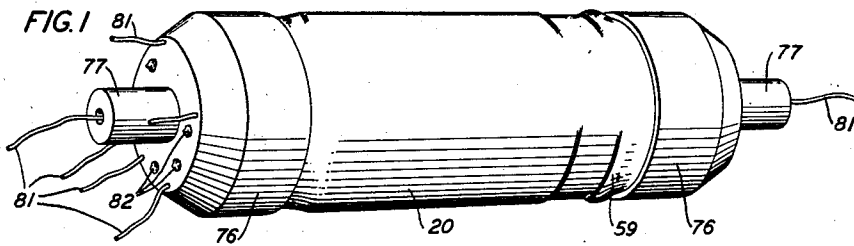
May 25, 1943.

C. DEPEW ET AL
ELECTRON DISCHARGE DEVICE

2,320,120

Filed April 21, 1942

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

FIG. 7

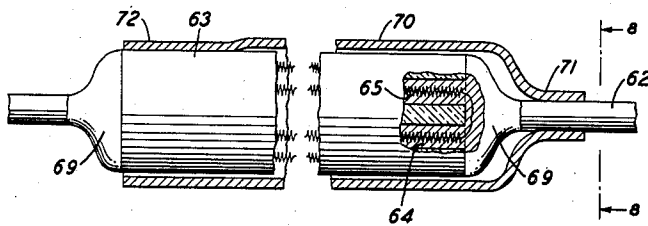


FIG. 8

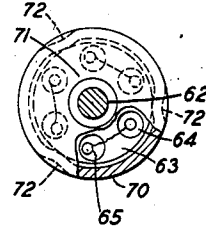


FIG. 9

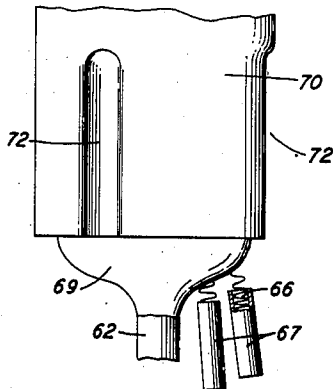


FIG. 10

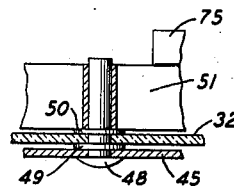


FIG. 12

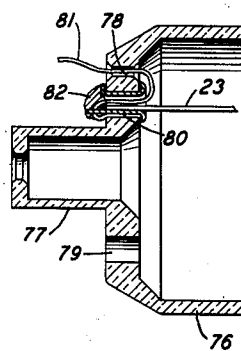
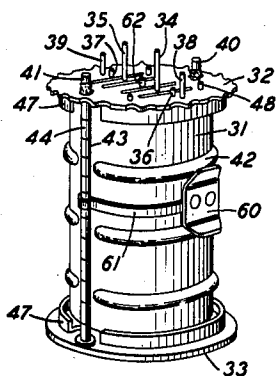


FIG. 11



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2,320,120

ELECTRON DISCHARGE DEVICE

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17 Claims. (Cl. 250—27.5)

This invention relates to electron discharge devices and more especially to such devices adapted to be hermetically sealed substantially permanently in an undersea cable.

An electron discharge device, particularly of the multielectrode type, such as a pentode, employed in radio and communicating systems generally, embodies an intricate assembly of fragile electrodes combined in a small unitary structure and encased in a vessel highly evacuated and having hermetically tight sealed portions for the leading-in conductors for the electrodes.

Such a device is susceptible to numerous mechanical and electrical difficulties, due to chemical deterioration, temperature changes, vibration, distortion and current leakage paths which may alter the stable electrical characteristics of the device or greatly accelerate the useful operating life of the device, so that it is rendered inefficient long prior to its intended or expected operating usefulness.

These physical difficulties, while readily overcome by replacement of the device in easily accessible surroundings, are practically fatal where the device is sealed in a submerged cable, such as in a submarine transmission system, where the raising of the cable is an extremely expensive undertaking.

An object of the invention is to fabricate the electrode assembly so that failures of the device due to mechanical and electrical faults are substantially eliminated over a relatively long period of years.

Another object of the invention is to improve the operating efficiency of the device to maintain uniform electrical characteristics throughout the operating life of the device.

A further object of the invention is to increase the useful life of the device by insuring that the internal structure is free from mechanical and electrical defects both during manufacture and use.

Still another object of the invention is to facilitate the connection of the elements of the device to external circuits or associate apparatus with less danger of a broken connection between these components in the system.

In accordance with this invention, the electron discharge device comprises an enclosing vessel containing a unitary assembly of electrodes including an indirectly heated cathode, three grids surrounding the cathode and an anode enclosing the cathode and grids. These electrodes are spaced in coaxial relation by

spacer assemblies at each end to insure constant linearity between the electrodes. The unitary assembly is rigidly mounted in the vessel at opposite ends and the leading-in wires are sealed therethrough and connected to rigid terminals carried by insulating bases affixed to both ends of the device. The bases also carry flexible conductors attached to the terminals and extending outwardly for connection to associated apparatus in the cable amplifier circuits. In this construction all physical connections between related elements of the electrodes are mechanically and electrically secure to insure against breakage and disconnection, which would impair the efficiency of the device in operation.

A feature of this invention relates to the detailed construction of the cathode unit to avoid difficulties due to chemical action or mechanical distortion. This is accomplished by mounting an insulating sleeve on a central conductor and threading a coated multisection helical heater element through the bores of the sleeve and forcing an insulating mass into the bores until filled, to rigidly position the heater coils in the insulator. The insulating mass also seals the ends of the insulating sleeve to completely embed the heater connections and form the sleeve and conductor as an integral element.

Another feature of this cathode construction is the stretching of a few turns of the end sections of the heater adjacent the sealing mass of insulation on one end of the cathode to provide expansion portions between the solid mass and the heater terminals.

Another feature relates to surrounding the end sections of the heater with reinforcing metallic sleeves to form rigid terminals of greater mass and stronger material than the fine heater wire coils.

A further feature relates to the connection of the cathode sleeve to the heater assembly so that the cathode can expand and contract without being subjected to strain by the insulator enclosed therein. This construction involves the placing of the cathode cylinder around the insulated heater assembly, spinning one end of the cathode into contact with the central standard and forming longitudinal flutes in spaced relation in the other end of the cathode to engage portions of the insulating mass. In this arrangement the cathode is out of contact with the major portion of the insulated heater assembly and therefore is free to expand and contract without danger of the large mass of in-

sulation exerting strain in the cathode cylinder.

Another feature of the unit assembly relates to the fabrication of the end spacer elements to form rigidly secured assemblies readily mounted in relation to the ends of the electrodes to provide a compact unitary structure. In this arrangement an insulating spacer disc and a metallic shield disc, having aligned apertures for the electrodes, are secured together by spaced pins which project beyond the spacer disc and support a rectangular electrostatic shield which is ultimately connected to one of the grid electrodes of the device.

Another feature of this construction is the connection of the cathode to the shield and the grid by an embracing strap which engages the central standard supporting the cathode assembly.

A further feature is the dissipation of heat from the grid adjacent the cathode and anode to reduce secondary emission which is liable to alter the electronic control of the device. In this arrangement the control grid and the suppressor grid adjacent the cathode and anode respectively are provided with heat radiating shields at opposite ends to maintain these grids cool so that secondary emission is avoided.

Another feature of the invention is concerned with the support of the unitary electrode structure in the enclosing vessel. This embodies a structure in which the electrodes of the unit are mechanically and electrically secured to conductors at one end of the device which are sealed in a dished stem fused to one end of the vessel, the other end of the unit being supported by contact of the insulating spacer with the interior wall portion of the vessel. The wall portion is preshrunk on a cylindrical boundary of the spacer disc to insure that the internal diameter is exact to accommodate the spacer disc.

Still another feature of this invention relates to the coupling of the electrodes to associated external apparatus and to facilitate the mounting of the device in a suitable housing. This arrangement involves the application to each end of the vessel of a molded insulating base which encloses an end portion of the vessel adjacent the lead-in wires of the electrodes, the base having a cup-shaped portion cemented to the vessel and provided with a central hollow projection which protects the seals of the vessel.

Another feature of this construction is the coupling of the electrode lead-in wires to terminals carried by the base and distributed around the central projection, and the connection of flexible conductors to the terminals, each connection being mechanically and electrically secure, the flexible conductors being free from strain and substantially unbreakable by frictional movement between the base and the associated apparatus.

These and other features, advantages and superior consequences may be attained in accordance with this invention and will be more particularly enumerated in the following detailed description which, together with the accompanying drawings presents the construction of an improved and long life discharge device.

Fig. 1 is an external perspective view of the complete device showing the configuration of the device and the terminal bases at opposite ends;

Fig. 2 is a view in cross section of the device of Fig. 1 illustrating the detailed structure of the internal assembly and the coupling of the elec-

trodes to the terminals on the respective bases of the device;

Figs. 3, 4 and 5 are cross-sectional views of the electrode unit taken on the lines 3—3, 4—4 and 5—5, respectively, of Fig. 2;

Fig. 6 is an enlarged detail view in cross section of portions of the enclosing vessel and the electrode unit spacer disc to clearly illustrate the preshrunk area of the vessel and the relation of the spacer thereto;

Fig. 7 is an enlarged side view, partly in section and partly broken away, of the cathode assembly to illustrate the details of construction embodied therein;

Fig. 8 is an end view of the cathode taken on the line 8—8 of Fig. 7;

Fig. 9 is an enlarged view of the lower end of the cathode assembly of Fig. 7 to show the details of the heater terminations adjacent the exposed insulating mass;

Fig. 10 is a fragmentary view in cross section on an enlarged scale of the details of the spacer assembly taken on the line 10—10 of Fig. 4;

Fig. 11 illustrates in perspective the unitary electrode assembly of Fig. 2 with parts on opposite ends removed to clarify the exposition of the unit structure; and

Fig. 12 is a view in cross section of the insulating base on each end of the device and showing in detail the terminal construction and related parts attached thereto.

Referring to the drawings and particularly to Fig. 2, the electron discharge device of this invention includes a sealed enclosing vessel having a cylindrical-body portion 20 and a molded dished stem 21 fused to one end thereof and having a central exhaust tubulation 22, the stem having a plurality of leading-in wires 23 sealed in a circular boundary around the tubulation 22. The vessel is also provided with a dome-shaped portion 24 at the opposite end which terminates in a seal 25 for a leading-in conductor 26. The vessel encloses a unitary electrode assembly of the pentode type involving a central cathode 27, a control grid 28, a screen grid 29, a suppressor grid 30 and a cylindrical anode 31. These electrodes are spaced in coaxial relation by end spacer discs 32 and 33, of insulating material, such as mica. The grid 28 is supported by a pair of parallel rods 34 and 35 which extend a considerable distance beyond the end mica spacers 32 and 33. The screen grid 29 is supported by support rods 36 and 37, the rod 36 being longer than the cooperating support and extending beyond the mica spacer disc 33. The suppressor grid 30 is carried by a pair of support rods 38 and 39 which extend beyond opposite ends of the mica spacers 32 and 33, and the anode is attached to heavy support rods 40 and 41 rigidly fixed in metallic eyelets carried by the end spacer discs 32 and 33. The anode 31 is formed of semi-cylindrical sections having spaced corrugations 42 distributed about the sections to increase the strength thereof and the two sections are affixed to the support rods 40 and 41 by spaced ears 43 and 44 along the length thereof which are interlocked around the supports in alternate manner similar to a pintle-type hinge. This construction is provided to insure a good mechanical connection between the support rods of the anode and the sections thereof. The spaced ears are welded to the rods to provide both a mechanical and electrically secure joint. As shown in Fig. 11 the supports for the grids are arranged along a single diameter of the spacer member 32 while

the supports of the anode 31 are in a transverse plane of the spacer member.

In order to increase the electrostatic control of the discharge path from the cathode to the anode in the unit, a pair of electrostatic disc shields 45 and 46 are mounted between the electrodes and the spacer members 32 and 33, respectively. These discs have central cut-out portions, as shown in Figs. 3 and 4, to clear the support rods of the various electrodes extending through the spacer members and are also provided with side cut-out portions, as shown in Figs. 3 and 4, to clear the support rods of the anode. These shields are provided with a cylindrical rim or flange 47 which extends beyond the boundary of the anode 31 to provide a shield surface adjacent the edges of the anode. These shields are rigidly affixed to the mica spacer disc by spaced pins 48, as shown in Figs. 4 and 10, which project through the spacer disc and are separated therefrom by a washer 49 while a second washer 50 engages the opposite side of the disc 32, the pins or rivets 48 extending beyond the disc 32 to support a rectangular shield 51 which is mechanically secured and welded to the rivets 48. The same construction is carried out with the spacer 33 and disc shield 46 at the lower end of the assembly in which a rectangular shield 52 is rigidly affixed to the pins 48 extending through the disc and mica spacer. The rectangular shields 51 and 52 are provided with loop portions on opposite sides to engage the support rods 38 and 39 of the suppressor grid on opposite ends of the unit to electrically shield the control grid from the anode and to facilitate cooling of the grid by radiating the heat generated in the grid due to its proximity to the anode 31. Likewise the grid adjacent the cathode is provided with heat radiating shields at opposite ends in which the long support rods 34 and 35 support a cylindrical heat shield 53 while the opposite ends of these rods have a U-shaped heat shield 54 attached thereto. These heat shields are provided with a black coating in order to efficiently dissipate heat energy absorbed from the grid supports so that the grids are relatively cool during operation and therefore are not subject to distortion or capable of emitting secondary electrons. It should be noted that the coupling of related elements to any of the support rods of the electrodes is both mechanical and electrical, as by welding, to insure a tight joint which is not liable to be broken during handling or in service and in the event that a welded joint should be separated the mechanical joint will be unimpaired to provide a secure connection between the associated parts of the elements.

The electrode assembly is rigidly supported in one end of the vessel adjacent the stem 21 by the leading-in wires 23, a pair of which is anchored to the spacer disc 33 by eyelets 55 while another pair is mechanically secured to the anode support rods 40 and 41 by metallic clips 56 which surround them to provide a mechanical connection, the clips being welded to the rods to provide an electrical connection. The pair of conductors anchored in the eyelets 55 are secured to the screen grid support rods by metallic straps 57 which are clamped around the rods and wire respectively and welded thereto. The long support rod 36 of the screen grid carries a clamping strap 58 welded thereto and also to another leading-in conductor 23 in the stem 21. The conductor 26 on the other end of the vessel extends down to the cylindrical shield 53 of the control

grid and is mechanically secured thereto and welded in place.

The end of the unit remote from the stem 21 is rigidly supported by contact of the spacer disc 32 with the wall of the vessel of the body portion 20. However, since the inner wall diameter of the vessel is variable due to manufacturing conditions, it is extremely difficult to match the diameter of the disc 32 with the inner wall of the vessel. This is overcome in accordance with this invention by preshrinking a cylindrical boundary 59 of the vessel, as shown in Fig. 6, to insure that the internal diameter will exactly match the diameter of the disc 32 to provide a tight fit yet permit the expansion of the unit due to temperature changes. A getter support 60 is attached to the anode by a strap 61 secured to one of the anode support rods, the getter, shown as pellets, on the support being vaporized during the final evacuation period of the device. The electrodes and the various elements constituting part of the unitary structure are thoroughly outgassed by high temperature treatment during the pumping procedure to remove any chemical impurities which might impair the electrodes or form leakage paths along the insulating supports for the electrodes thereby increasing the efficiency of the device during operation. Such chemical action is more apt to occur in the heater assembly of the cathode and in the active coating on the cathode surface.

These difficulties are overcome in accordance with this invention by a cathode construction, as shown in Figs. 7 to 9, inclusive, in which the cathode is supported on a central standard or core rod 62 which is surrounded by an insulating sleeve 63 preshrunk on the core rod by firing prior to the fabrication of the cathode assembly. The sleeve 63, formed of a refractory insulating material, such as aluminum oxide, is provided with a plurality of longitudinal bores 64 distributed around the core rod 62. A heater element 65 having a plurality of coiled heater sections, coated by spraying with an insulating material, such as aluminum oxide, is inserted in the bores of the sleeve in serpentine fashion with the terminating end sections 66 projecting from the bottom of the sleeve 63. The latter sections are reinforced by nickel sleeves 67 to provide rigid connections which are engaged by flat end portions 68 of a pair of leading-in conductors 23 in the stem 21. The close coiled turns of the heater sections of the wire 65, due to the heating temperature extant within the sleeve 63, normally diffuse a metallic substance therefrom which deposits on the inner surface of the bores as a metallic film and is liable to short-circuit portions of the heater. This is avoided in accordance with this invention by forcing a plastic mixture of aluminum oxide through the bores of the sleeve 63 to completely fill the spaces and hermetically seal the ends of the sleeve to the core rod by a mass of the insulating material 69. The heater element is therefore solidly embedded in the sleeve by the mass of insulation completely surrounding it so that film formation is avoided.

The extending heater sections 66 are slightly stretched intermediate the reinforcing sleeves 67 and the mass 69 to provide expansion sections between the cathode assembly and the rigidly attached leading-in conductors. The sleeve 63 is surrounded by a cathode cylinder 70 which is provided with the usual alkaline oxide coating to form the active emission surface and the cathode sleeve is supported in relation to the insulator

to avoid distortion strains being imposed on the cathode cylinder by the expansion of the sleeve material. This is accomplished by spinning one end of the cathode cylinder 71 into contact with the core rod 62 thereby providing a mechanical and electrical connection through the core rod. The opposite end of the cathode sleeve is provided with short longitudinal flutes 72 equally distributed around the base of the cathode sleeve to engage the insulating sleeve 63 at distributed points while maintaining the major portion of the cathode sleeve out of contact with the insulated heater assembly. The multisection heater assembly is operated at 20 volts with a low current flow of .25 ampere, thus having an energy dissipation of about 5 watts, to uniformly heat the cathode sleeve 70 by conduction to a temperature of about 670° C. to provide a uniform emission temperature for the active coating on the cathode surface.

The cathode, as shown in Fig. 2, is mounted in the axis of the unit with the core rod 62 extending beyond the ends of the mica spacers 32 and 33 in the center of the plane of the grid wires extending through the spacers. The reinforced heater extensions 67 pass through small openings in the lower spacer member 33 in slightly offset position, as shown in Fig. 5. Since the cathode cylinder 70 is mechanically and electrically connected to the core rod 62 at the top of the assembly, it is possible to utilize the core rod as the conductive connection to the cathode. This is accomplished by tying the lower end of the core rod to the rectangular shield 52 so that the cathode is interconnected with the suppressor grid 30 in the utilization of the device in the cable amplifier system. In order to mechanically and electrically connect the cathode with the suppressor grid a T-shaped folded strap 73, Fig. 5, has one leg of the T formed into a loop which surrounds the core rod 62 and is clamped and welded thereto. The cross arms of the T-shaped strap lie parallel to one side of the rectangular shield 52, the ends thereof being interlocked to the shield by clip portions 74 which extend through the side wall of the shield and are mechanically attached thereto. These clips are also welded to insure a tight electrical joint. This arrangement permits the cathode to be maintained at a uniform temperature since thermal dissipation is eliminated by the strap 73 being connected to the cathode core rod which is at a higher temperature than the cathode. The rectangular heat shields 51 and 52 on opposite ends of the suppressor grid are provided with vane extensions 75 which are bent at an angle with respect to the rectangular wall of the shield, to form electrostatic shields as well as heat shields between the internal grid structures and the anode conductors. At the top of the unit the shield extensions 75 are bent outwardly, as shown in Fig. 4, to form a barrier between the grids and the anode supports 40 and 41 while the extensions 75 on the lower heat shield 52 are bent inwardly, as shown in Fig. 5, to avoid contact with the anode supports 40 and 41.

The discharge device of this invention is primarily adapted for mounting in a cable housing of elongated construction so that it is preferable to affix mounting bases on opposite ends of the device. These bases are formed of chemically inert insulating material, such as a composition of aluminum oxide, silicon dioxide and magnesium oxide, to constitute a ceramic having high dielectric properties and easily molded or cast

into any desired shape. The base is formed into a cup-shaped member 76 having a central tubular extension 77 and a portion of the cup body being tapered between the cylindrical wall and the flat surface surrounding the central extension to provide a streamlined body adapted to fit in a cushion mounting in the housing, the exterior of the base being glazed. The flat portion of the base is provided with a plurality of pairs of small and large apertures 78 and 79, respectively, around the central projection 77, and a metallic eyelet 80, is secured in the larger aperture to form a terminal for the leading-in conductors 23 of the device. The terminal 80 also forms an anchor for a long flexible beryllium, copper cobalt alloy conductor or wire 81 extending outwardly from the base, as shown in Fig. 1, to facilitate the connection of the device to associated apparatus in the cable structure. These flexible wires, which are braided, are protected from oxidation by a gold plating and are attached to the terminal 80 in a particular manner to provide a mechanical and electrical joint and at the same time prevent breakage of the wire due to frictional contact or bending stress.

As shown in Fig. 12, the flexible wire 81 is secured to the terminal 80 by positioning the wire on the exterior of the eyelet and enclosing one turn of the wire under the eyelet flange on the inner surface of the base to provide a good mechanical connection. The wire is then threaded through the eyelet from the outside and finally threaded through the smaller aperture 78 to extend outwardly from the base. When the leading-in conductor 23 is inserted in the eyelet or terminal 80, a plug of solder 82 simultaneously connects the leading-in conductor, terminal wire 81 and eyelet 80 electrically together and seals the opening of the eyelet. Therefore, only the portion of the conductor 81 within the eyelet is coated with solder material, and since this portion is not subject to bending or friction, there is no danger of the flexible conductor being stiffened by the solder coating beyond the eyelet. The extension 77 forms a protective covering for the glass seals at opposite ends of the device and also provides a central outlet for certain electrodes of the device, such as the control grid as shown in Fig. 2. In this construction of the flexible conductor 81 the wire is mechanically secured to the eyelet, then threaded through the eyelet to project into the base so that it can be led out through the central extension 77, the conductor and the grid leading-in wire 26 being simultaneously affixed to the terminal by the solder plug 82. The anode connection may be brought out through the opposite central extension 77 in a similar manner.

While the invention has been disclosed with respect to a specific embodiment of the various features of the invention, it is, of course, understood that various modifications may be made in the detailed assembly of the parts and the relation thereof in the device without departing from the scope of the invention as defined in the appended claims.

What is claimed is:

1. An electron discharge device comprising an enclosing vessel, a unitary electrode assembly therein including a plurality of electrodes, spacer members on opposite ends of said electrodes, heat radiating shields exterior to said spacer members connected to opposite ends of one of said electrodes, and second shields encompassing the first

shields connected to opposite ends of another of said electrodes.

2. An electron discharge device comprising an enclosing vessel, a unitary electrode assembly therein including a plurality of electrodes, spacer members on opposite ends of said electrodes, disc shields interposed between said electrodes and said spacer members, heat radiating shields exterior to said spacer members connected to opposite ends of one of said electrodes, and a second set of shields encompassing the first heat shields connected to opposite ends of another of said electrodes, said disc shields and second shields being electrically interconnected.

3. An electron discharge device comprising an enclosing vessel, a unitary electrode assembly therein including a cathode and a plurality of cooperating electrodes, spacer members on opposite ends of said electrodes, heat radiating shields exterior to said spacer members connected to opposite ends of one of said cooperating electrodes, a second set of shields encompassing the first shields and being connected to opposite ends of another of said cooperating electrodes, and a metallic connection extending between one of the encompassing shields and said cathode.

4. An electron discharge device comprising an enclosing vessel, a unitary electrode assembly therein including a cathode and a plurality of cooperating electrodes, spacer members on opposite ends of said electrodes, radiating shields exterior to said spacer members connected to opposite ends of one of said cooperating electrodes, a second set of shields encompassing the first heat shields and connected to opposite ends of another of said cooperating electrodes, and a metallic connection extending between one of the encompassing shields and said cathode, a portion of said connection extending parallel to and within the boundary of the first and encompassing shields on one end of said unit assembly.

5. An electron discharge device according to claim 3 in which one of the encompassing shields is rectangular, the inner shield is semicircular and the cathode is attached to a folded strap having the ends interlocked to one side of an encompassing shield.

6. A cathode assembly comprising a central support, an insulating sleeve surrounding and rigidly secured to said support, a heater element extending through said sleeve, said element having terminal extensions projecting from said sleeve, a filling of insulating material completely embedding said heater element in said sleeve except for said terminal extensions, and reinforcing metallic members surrounding said extensions.

7. A cathode assembly comprising a central support, an insulating sleeve surrounding and rigidly secured to said support, a heater element extending through said sleeve, said heater element having terminal extensions projecting from said sleeve, a filling of insulating material completely embedding said heater element in said sleeve except for said terminal extensions, and reinforcing metallic members surrounding said extensions, said terminal extensions having a yieldable portion intermediate each of said reinforcing members and the mass sealing said heater element.

8. A cathode assembly comprising a central support, an insulating sleeve surrounding and rigidly secured to said support, a heater element extending through said sleeve, and a cathode sleeve surrounding and spaced from said insu-

lating sleeve having a portion engaging one end of said support and another portion longitudinally fluted and engaging said sleeve.

9. An electron discharge device comprising an enclosing vessel, a unitary electrode assembly therein including a heater type cathode, supports for said electrodes, insulating disc spacers at opposite ends of said electrodes engaging said supports, heat shields embracing certain of said supports at opposite ends exterior to said spacers, conductors sealed in one end of said vessel and attached to a plurality of said electrodes, a conductor sealed in the other end of said vessel and connected to one of said electrodes, a pair of similar cup-shaped bases attached to the opposite ends of said vessel, each base having a central hollow extension in alignment with the axis of said vessel, and terminals carried by said bases connected to said conductors.

10. An electron discharge device comprising a plurality of electrodes enclosed in an elongated vessel and leading-in wires for said electrodes sealed in said vessel, a molded insulating base secured to each end of said vessel, said base having a cup-shaped portion and a central tubular extension projecting outwardly therefrom, said base having a plurality of large and small apertures formed therein in pairs distributed about said extension, a metallic hollow terminal secured in the larger aperture for the reception of one of said leading-in wires, and a flexible wire extension mechanically locked between said base and terminal, said wire extending downwardly through said terminal and finally being threaded through said smaller aperture, said terminal leading-in wire and flexible wire being simultaneously secured together by a fusible metal seal covering the exterior of said terminal.

11. An electron discharge device comprising a plurality of electrodes enclosed in an elongated vessel and leading-in wires for said electrodes sealed in said vessel, a molded insulating base secured to each end of said vessel, said base having a cup-shaped portion and a central tubular extension projecting outwardly therefrom, said base having a plurality of large apertures formed therein and distributed about said extension, a metallic hollow terminal secured in said aperture for the reception of one of said leading-in wires, a flexible wire extension mechanically locked between said base and terminal, said flexible wire extending through said terminal and finally extending outwardly through said central tubular extension, and a solder plug covering said terminal and simultaneously securing said terminal leading-in wire and flexible wire together.

12. An electron discharge device comprising a unitary electrode assembly including a central support, a tubular cathode secured to said support, an insulated heater element surrounding said support and enclosed in said cathode, a plurality of pairs of parallel supports extending on opposite sides of said central support, helical grids and an anode attached successively to pairs of said parallel supports and surrounding said cathode, insulating spacer discs on opposite ends of said electrodes and engaging said supports, alternate pairs of said grid supports extending beyond said spacer discs, and embracing heat shield members attached to said alternate pairs of supports on opposite ends of said grids.

13. An electron discharge device comprising a unitary electrode assembly having a central support, a tubular cathode secured to said sup-

port, an insulated heater element surrounding said support and enclosed in said cathode, a plurality of pairs of parallel supports extending on opposite sides of said central support, helical grids and an anode attached successively to pairs of said parallel supports and surrounding said cathode, insulating spacer discs on opposite ends of said electrodes and engaging said supports, alternate pairs of said grid supports extending beyond said spacer discs, a cylindrical shield and a U-shaped shield attached to opposite ends of the inner parallel pairs of supports, and a pair of rectangular shield members attached to said outer parallel pair of grid supports.

14. An electron discharge device comprising a unitary electrode assembly having a central support, a tubular cathode secured to said support, an insulated heater element carried by said support and enclosed in said cathode, a plurality of pairs of parallel supports extending on opposite sides of said central support, helical grids and an anode attached successively to pairs of said parallel supports and surrounding said cathode, insulating spacer discs on opposite ends of said electrodes and engaging said supports, alternate pairs of said grid supports extending beyond said spacer discs, heat shield members attached to said alternate pairs of supports on opposite ends of said grids, and a T-shaped folded strap embracing said central cathode support and being interlocked with one of said shield members.

15. An electron discharge device comprising a unitary electrode assembly having a central support, a tubular cathode secured to said support, an insulated heater element surrounding said support and enclosed in said cathode, a plurality of pairs of parallel supports extending on opposite sides of said central support, helical grids and an anode attached successively to pairs of said parallel supports and surrounding said cathode, insulating spacer discs on opposite ends of said electrodes and engaging said supports, alternate pairs of said grid supports extending beyond said spacer discs, a cylindrical shield and a U-shaped shield attached to opposite ends of the inner parallel supports of one grid, a pair of rectangular shield members attached to the outer parallel pair of grid supports, and a folded strap extending between portions of said U-shaped shield and embracing said central cathode sup-

port, said strap having bent extensions parallel to one section of an outer rectangular shield member and the ends clamped thereto.

16. An electron discharge device comprising a unitary electrode assembly having a central support, a tubular cathode secured to said support, an insulated heater element surrounding said support and enclosed in said cathode, a plurality of pairs of parallel supports extending on opposite sides of said central support, helical grids and a cylindrical anode attached successively to pairs of said parallel supports and surrounding said cathode, insulating spacer discs on opposite ends of said electrodes and engaging said supports, alternate pairs of said grid supports extending beyond said spacer discs, embracing heat shield members attached to said alternate pairs of supports on opposite ends of said grids, and a metallic disc shield interposed between said electrodes and said spacer discs at each end of the unit, the metallic discs being secured to said spacer discs and the respective outer heat shield members on the opposite side of said spacer discs.

17. An electron discharge device comprising a unitary electrode assembly having a central support, a tubular cathode secured to said support, an insulated heater element surrounding said support and enclosed in said cathode, a plurality of pairs of parallel supports extending on opposite sides of said central support, helical grids and a cylindrical anode attached successively to pairs of said parallel supports and surrounding said cathode, insulating spacer discs on opposite ends of said electrodes and engaging said supports, alternate pairs of said grid supports extending beyond said spacer discs, embracing heat shield members attached to said alternate pairs of supports on opposite ends of said grids, and a metallic disc shield interposed between said electrodes and said spacer discs at each end of the unit, the metallic discs being secured to said spacer discs and the respective heat shield members on the opposite side of said spacer discs, said metallic discs having a cylindrical rim portion formed in the direction of the electrodes, the opposed rim portions surrounding opposite ends of said cylindrical anode.

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