Dec. 7, 1948. J. W. WEST 2,455,846

COAXIAL LEADIN FOR ELECTRON DISCHARGE DEVICES

Filed Oct. 18, 1946 2 Sheets-Sheet 1

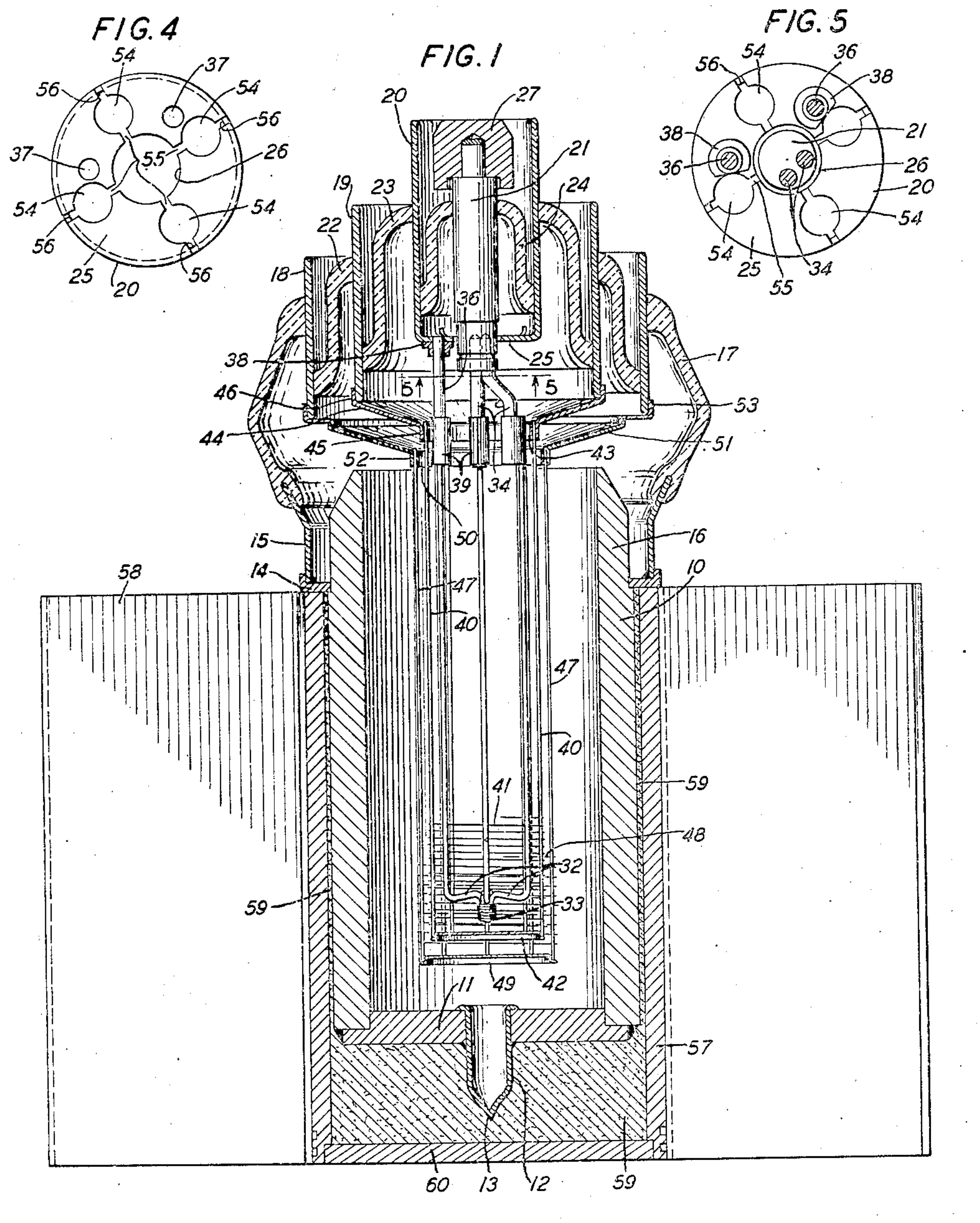

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FIG. 2

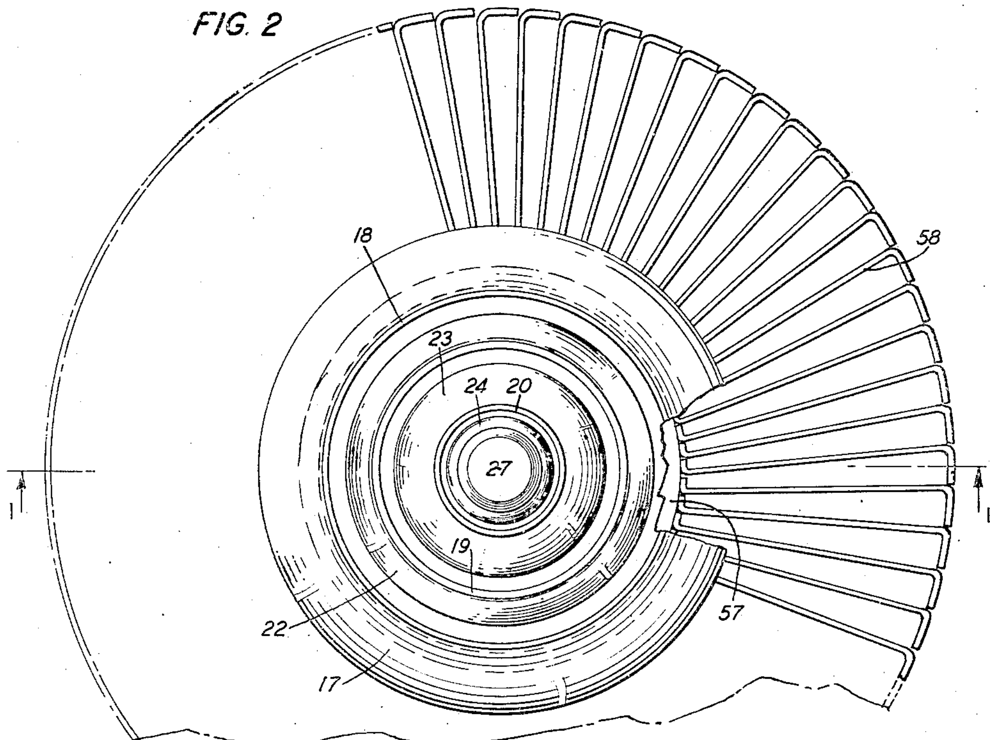


FIG. 3

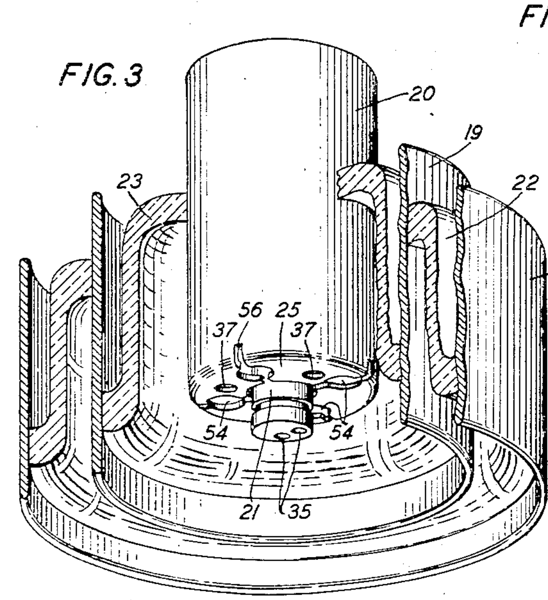
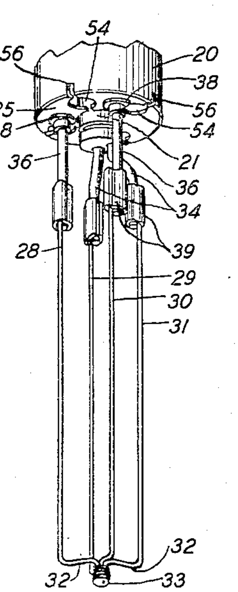


FIG. 6



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COAXIAL LEADIN FOR ELECTRON DISCHARGE DEVICES

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13 Claims. (Cl. 250—27.5)

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This invention relates to electron discharge devices and more particularly to such devices for generating high power energy in high frequency transmission systems.

In certain applications of power generating electronic devices, the operating voltages for the electrodes are supplied through coaxial lines to obtain high efficiency and low loss in the cooperating circuits coupled to the devices. Since the conductors of the devices are mutually coupled to the coaxial lines to simulate connective continuations of the lines to the electrodes of the device, certain mechanical strain difficulties usually arise in the hermetic seals of the tubular conductors of the device connected to the internal electrodes. These difficulties occur particularly in the seals for high temperature electrodes, for example, the cathode, which is usually composed of a plurality of filamentary sections heated to emission temperature to supply copious electron flow in the operation of the device.

One object of this invention is to prevent deleterious temperature strains in the conductor seals of high power discharge devices.

Another object of the invention is to improve the coupling of the electrodes in the device to coaxial lines to reduce high frequency current losses in the propagation of the energy supplied to the device.

A further object of the invention is to rigidly mount the electrodes directly on coaxial conductors sealed in one end of the device for coupling to coaxial lines with low capacity interconnections.

Another object of the invention is to facilitate the mounting of the filamentary cathode in the device to provide coaxial terminals coextensive with the terminals of the other electrodes.

A further object relates to relieving temperature stresses in the joints between metal and glass portions of the evacuated vessel whereby a long operating life is assured.

These objects are realized in a typical embodiment of this invention in an external anode type discharge device including internal cooperating electrodes which are concentrically mounted within the anode. The internal electrodes are individually connected to external circuits by metallic sleeve terminal conductors of the coaxial type which are sealed in nested relation to telescopic insulating sections disposed intermediate the conductors, and the conductor assembly is joined to the anode by an insulated housing portion to segregate the low potential conductors from the high potential anode.

The feature of this construction is the reduction

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of the length of the device for a predetermined power output while maintaining the desired insulation resistance between adjacent conductors. This is accomplished by mounting the coaxial sleeve terminals in stepped relation about a central terminal and connecting adjacent terminals together by elongated insulating sections sealed adjacent opposite ends of the respective metallic walls of the sleeve terminals to provide the required insulation paths between the nested terminals.

Another feature of the invention relates to the mounting of the electrodes on the sleeve terminal conductors to provide a rigid assembly wherein the internal electrodes are held in proper concentric relation and substantially braced against misalignment by external shock or vibration. In a specific embodiment, a pair of cylindrical electrodes extending into the anode and uniformly spaced therefrom are individually joined to the outer pair of sleeve conductors by metallic conical shields which form barriers between the low potential conductors and the portion of the high potential anode extending within the housing of the device.

Important features of the invention relate to the mounting of the filamentary cathode in the device and the construction of the terminals therefor so that the high heating temperatures inherently encountered in the operation of the cathode do not adversely affect the composite hermetic seals at the junction of the metal terminals and insulating sections. In this construction the cathode terminals comprise a central plug member or standard surrounded by a metallic cup member having the closed end spaced concentrically from one end of the plug by an internal telescopic insulating wall section which is hermetically sealed to the inner end of the cup and the outer end of the plug member. The closed end of the cup member is provided with spaced radial slots to permit the closed portion of the cup to resiliently yield under expansion and contraction due to temperature changes so that torsional strains are relieved in the rigid glass seal adjacent the same end of the cup member and fractures or leaks in the glass or sealed joint are prevented. A multiple strand filamentary cathode is centrally mounted in relation to the other electrodes in the device and pairs of strands are rigidly affixed to the plug and cup members to supply heating current to the strands in parallel relation.

A further feature of the invention relates to the accurate space relation of the several electrodes in the device by reason of the coaxial position of the sleeve terminals on the end of the device. The coaxial sealing of the terminals in the insulating sections of the vessel insures coaxial symmetry of the individual electrodes supported thereon in relation to the surrounding electron receiving surface of the external anode.

Still another feature of the assembly relates to the combination of the external anode with a large air-cooled heat radiator fixedly joined to the anode and forming a protective enclosure for the sealed exhaust tip on the end of the anode. This is accomplished by enclosing the anode in a metallic casing which provides a cavity or space for the sealing tip on one end of the anode and securing the anode in the radiator casing by fusible cadmium metal which also embeds the sealing tip in the metallic fusible mass in the cavity. The tip is, therefore, completely protected from injury and the metallic filling forms an intermediate mass of low resistance and high thermal conductivity which dissipates the heat energy expended in the anode and efficiently transmits it to the radiator.

These and other features of the invention will appear from a consideration of the following detailed description when taken in connection with the accompanying drawings which illustrate the construction of one embodiment of the invention. In the drawing:

Fig. 1 is an elevational view in cross-section of a typical construction of the device showing the assembly of the elemental parts;

Fig. 2 is a plan view of the device of Fig. 1, with a portion only of the air-cooled radiator shown in full lines, showing the concentric arrangement of the conductors;

Fig. 3 is an enlarged perspective view of the terminal portion of the assembly with sections of the seals broken away to illustrate the detailed construction;

Fig. 4 is a plan view of the cup terminal detail employed in the device of Fig. 1 illustrating the configuration of the closed end of the terminal cup;

Fig. 5 is a similar plan view of the cup terminal in combination with the central plug terminal taken on the line 5—5 of Fig. 1 to show the connection of the filamentary assembly to these terminals; and

Fig. 6 is a perspective view of the filamentary cathode and terminal assembly embodied in the device of this invention illustrated in Fig. 1.

Referring to the drawings and particularly to Fig. 1, the high power electronic discharge device of this invention is embodied in an external anode air-cooled type of device having a heavy copper sleeve or cylindrical portion 10 which forms the major section of the enclosing vessel and for convenience of assembly is provided with a separate closure plate 11, also of copper, which is brazed to the bottom of the cylinder by a high melting point solder. The closure plate 11 is provided with a central aperture to receive a metallic exhaust tubulation 12, the tubulation having a flared inner edge brazed to the inner surface of the closure and the outer surface of the closure being brazed to the tubulation, where it projects therefrom, by a solder seal to prevent leakage at the joints between these members. The tubulation permits the pumping and exhaust of the internal discharge space of the device after complete assembly to secure a high vacuum. The tubulation may be sealed off at 13 after the desired low pressure is secured in the device.

The opposite end of the anode is machined on the outer surface to slightly reduce the outer diameter to provide an internal tapered edge and a positioning seat adjacent the outer boundary of the anode for a metallic flanged ring 14 which is brazed to the copper anode at the outer surface of the anode. The ring 14 is preferably formed of steel having a copper plating applied thereto and the flanged ring supports a flared sleeve 15, preferably of a low expansion metallic alloy having the composition of approximately 28 per cent nickel, 18 per cent cobalt and the remainder principally iron. The sleeve 15 is mounted coaxially about the reentrant portion 16 of the anode and the flared portion extends divergently with respect to the tapered rim of the anode. In the assembly of these parts to the anode section, it is preferable to secure the sleeve 15 to the flanged ring 14 prior to mounting the ring on the anode. This is accomplished by inserting a copper wire ring within the sleeve at the junction of the sleeve to the ring and heating the copper wire to fusion temperature to flow copper into the joint between the sleeve and the flange of the ring. The ring and sleeve assembly may then be brazed to the anode body. The nickel-iron cobalt alloy is preferred for the sleeve since this metal has a coefficient of expansion similar to a glass or vitreous bulbous portion 17 of the enclosing vessel which is hermetically sealed to the flared rim of the sleeve 15. The bulbous section 17 is preferably formed of a low expansion glass, such as borosilicate glass, and constitutes an insulating housing forming part of the enclosing vessel of the device. It segregates the conductor terminals for the internal electrodes in the device from the high potential anode and provides a rigid mounting section for the terminal assembly at one end of the device.

Since the device of this invention is primarily intended to be utilized in combination with ultra-high frequency operating systems in which coaxial transmission lines form the propagation circuits for the efficient generation of the transmitting energy supplied by the device, it is essential that the coupling of the device to these lines have a minimum energy loss component and avoid the introduction of extraneous capacity and impedance components so that the characteristics of the coordinated lines and device may be maintained at prescribed values. This is accomplished by forming the electrode terminals of the device as separate sections of the coaxial lines and mounting these sections in cooperative relation to the internal electrodes of the device and the insulating portions of the vessel so that these terminal sections intermesh with the lines and, in effect, form direct continuations of the lines to the electrodes. However, in order to achieve this result, it is essential that the interrelation of the terminals with the device produce the required insulation resistance between the several electrodes to derive efficient coupling and avoid the introduction of temperature and mechanical strains or stresses in the terminal seals between the conductive and insulative parts of the device.

The realization of these factors constitutes one feature of this invention. The terminal conductors of the device of this invention are grouped in coaxial relation on the insulating section 17 of the vessel so that the coaxial lines may be readily combined with the device to couple the cooperating electrodes with the external circuits of the system. In a particular arrangement, the terminals or conductors for the electrodes in the device are a group of multiple, nested, sleeves or cylinders 18, 19 and 20 mounted in stepped and coaxial relation about a central terminal or standard 21. The several conductors are insulatingly spaced in proper position by insulating walls which are mounted in telescopic relation between the sleeve terminals, to form a completely enclosed containing vessel for the internal electrodes. The sleeve terminal conductors are concentrically mounted both with respect to each other, with the axial standard 21 and the glass vessel section 17 by "hard" glass bell-shaped sections 22, 23 and 24 which are interposed in telescopic relation between adjacent sleeve conductors 18 and 19 and 20 and between the interior of conductor 20 and the central standard 21.

The glass bell-shaped sections and the sleeve conductors are arranged in nested relation to reduce the over-all length of the device, to provide internal coaxial supports for the electrodes within the device and external contact portions for coupling to coaxial lines for supplying the operating voltages to the internal electrodes. In this construction, the sleeves progressively extend from the terminal end of the device in stepped relation so that the sleeve conductor 18 projects a short distance beyond the end of the glass vessel section 17, the sleeve 20 extends the furthest from the end of the vessel and the sleeve 19 extends in a position intermediate the respective terminals on opposite sides thereof. The central standard 21 and the respective sleeve terminals 18 to 20 inclusive, are preferably formed of the nickel-iron-cobalt alloy similar to the sleeve 15 so that these terminals can readily be sealed to the borosilicate glass sections interposed therebetween and will have temperature coefficients matching the coefficients of the glass sections. The outer end of the glass section 24 is hermetically sealed to the cylindrical surface of the central column or standard 21 adjacent the outer end while the inner end of the section 24 is sealed to the inner wall of the sleeve 20. The latter is provided with a platform closure portion 25 having a central opening or aperture 26 through which the central standard 21 projects, the flared end of the glass section 24 being sealed to the inner wall of the sleeve 20 adjacent the platform 25. The bell section 23 is sealed to an intermediate portion of the outer wall of the sleeve 20 and the flared end is sealed to the inner wall of the sleeve 19 adjacent the inner end thereof. The bell section 22 is sealed to the outer wall of the sleeve 19 adjacent the outer end and the flared rim of the section is sealed to the inner wall of the sleeve 18 adjacent the inner end. The combined terminal assembly is sealed to the glass section 17 by joining this glass section to an outer intermediate wall portion of sleeve 18. The inner flared seals of the bell-shaped glass sections to the respective sleeve terminals may be performed in accordance with the method disclosed in the application Serial No. 434,520 filed March 13, 1942 of J. E. Clark and V. L. Ronci. The central standard 21 may be provided with a copper terminal head 27 which is brazed to the outer end of the standard by a high melting point solder, such as 20 per cent silver and 80 per cent copper which has a melting point of 910° C. the head being flush with the end of the sleeve terminal 20. It will be noted, in the nested combination of the insulated spacer sections and the sleeve terminals that the conductive sleeves form shielding members between successive insulating spacer sections, not only to protect the insulating sections from conducting charges within the discharge space but also to protect the sections against mechanical injury from external causes.

In the device as shown in the embodiment of the invention, a pair of coaxial grid electrodes are mounted within the anode in coaxial spaced relation thereto and also to an enclosed electron emitting source in the form of a multi-strand filament assembly. The composite sleeve terminal assembly not only intermeshes with the coaxial lines of the system but also on the inner end rigidly mounts the internal electrodes in coaxial relation to the anode surface. The cathode assembly includes four strands 28, 29, 30 and 31, as shown in Fig. 6, which are formed of thoriated tungsten of sufficient diameter to form a self-supporting structure and capable of consuming the current supplied thereto to raise the strands to high temperature for the emission of electrons across the discharge space to the anode. These strands are provided with gooseneck end portions 32 which are joined together at the center by a tungsten helix 33 which welds the four sections into a box-like frame to maintain the strands in uniform lateral relation.

The strands are interconnected in parallel relation to the central standard 21 and the platform 25 of the cup-shaped sleeve 20 by a pair of molybdenum studs 34 which are welded in sockets 35 in off-center relation in the top surface of the standard 21. Another pair of molybdenum studs 36 are mounted in off-center relation on the platform 25 in apertures 37 of the platform and are reenforced at the junction with the platform by nickel eyelets 38, to improve the welded joint at the thin wall of the platform 25. The filament strands are joined to the stud rock by embracing molybdenum collars 39, to rigidly support the frame filament assembly from the platform and central standard.

A cylindrical control grid surrounds the filament assembly and is formed of upright spaced molybdenum wires 40 having a uniformly pitched helix 41 of small diameter molybdenum wire wound around the support wires and welded thereto to form a cylindrical grid structure. The lower end of the grid structure is reenforced by a heat shield or disc 42, for example, of tantalum, and the opposite ends of the support wires 40 are welded to a nickel collar 43 which is attached to the inner surfaces of the support wires and forms a base ring support for the grid structure. The control grid assembly is mounted in coaxial relation to the cathode assembly by a truncated conical shield 44 of nickel-iron-cobalt alloy having a turned ring portion 45 at the smaller diameter end which embraces the terminal end of the grid assembly and in conjunction with the ring 43 welds the grid frame to a rigid mounting assembly. The shield 44 is also provided with a turned rim 46 at the large diameter end which extends around the inner rim of the sleeve terminal 19 and is welded thereto.

A screen grid or accelerating electrode coaxially surrounds the control grid and is formed of a plurality of upright support wires 47, preferably of molybdenum, supporting a uniformly spaced grid helix 48, also of molybdenum wire having the same diameter as the helix 41 on the control grid. The inner end of this grid is closed by a tantalum disc shield 49 and the supporting end carries a nickel sleeve or rim 50 on the inner surfaces of the support wires 47 to assure the cylindrical alignment of the grid supports. The accelerator grid is coaxially spaced around the control grid and uniformly spaced from the inner surface of the anode 10 by a truncated conical shield 51 of nickel-iron-cobalt alloy, having a ring extension 52 at the smaller diameter and embracing the grid support rods 47 and the associated nickel ring 50 to which it is welded. The larger diameter end of the shield is provided with a flanged lip 53 which embraces the inner end of the sleeve conductor 18 and is welded thereto. This arrangement provides coaxial symmetry for the mounting of the internal electrodes in the anode and rigidly maintains the electrodes in their prescribed relation regardless of temperature variations in the device. The coaxially spaced conical shields also form successive barriers between the tapered edge of the anode extending within the vessel of the device and the low potential conductors of the cathode assembly so that arcing is prevented across this path within the device. Furthermore, the concentric supporting assembly of the grids from the conical shields prevents shocks and vibrations, incident to the handling of the device, from affecting the spacial relation of the internal electrodes with respect to the anode surface and thereby materially prolongs the operating life of the device due to the absence of shorts between the closely spaced electrodes within the enclosing vessel.

Another important feature of the invention relates to the relief of tension and torsional strains in the glass-to-metal seals at the junction of the glass section 24 and the cup-shaped terminal member 20 in view of the high temperature imposed on these joints, particularly at the inner joint close to the conducting studs of the filamentary assembly. The stresses and strains attendant upon varying temperature conditions at the sealed joint are overcome, in accordance with a feature of this invention, by making the platform 25 substantially yieldable so that temperature changes are dissipated in the metal rather than being transmitted to the hermetic seal at the inner end of the bell-shaped section 24. The top of the platform 25 is provided with spaced circular openings 54, as shown in Figs. 4 and 5 connected with the large diameter central opening 26 by short slots 55 which extend radially between the larger diameter openings in the platform. In addition to these slots, the outer boundaries of the apertures 54 are slotted, as shown at 56, and these slots, as shown in Fig. 3, extend beyond the edge of the platform and partially along the cylindrical surface of the sleeve portion 20 of the terminal. The radial slots and spaced apertures across the transverse dimension of the platform 25 provide yieldable segments in the cup-shaped terminal of the cathode assembly which expand and contract with temperature changes in the high temperature structure of the cathode and thereby prevent such changes, or the effects of such changes, reaching the hermetic seal adjacent the inner end of the cup terminal. Hence, leaks or fractures of the glass are eliminated and the vacuum type seal of the glass joint is preserved to insure maximum operating life for the combined structure.

The heat energy generated in the anode due to the high operating potentialities of the device is efficiently dissipated by air-cooling and this involves a large surface radiator assembly which completely encloses the outer anode section of the device. This radiator includes a copper sleeve casing 57 of slightly larger diameter than the external diameter of the anode. The sleeve portion of the casing abuts against the flanged ring 14 on the anode, the sleeve being of sufficient length to form a protecting wall around the sealing tip 12 of the anode. The casing is surrounded by a cylindrical assembly of spaced copper radiating fins 58 which may be secured to the casing 57, in accordance with the methods disclosed in my prior Patent 2,341,752, issued February 15, 1944. The radiator assembly is secured to the anode by a fusible filling of low thermal resistance and high thermal conductivity metal 59, such as cadmium, having a melting point of approximately 320° C., which flows between the walls of the casing and anode to rigidly affix the radiator to the anode and forms a solid mass of metal around the sealing tip 12 which is embedded in the mass and protected from injury from external causes. The bottom of the casing may be closed by a cover 60, also of copper, to provide a finished appearance for the assembly.

While the invention has been disclosed with respect to a specific embodiment of related electrodes in the device, it is of course, understood that various modifications may be made in the number of electrodes combined in the assembly or in the combination of the detailed parts of the construction without departing from the scope of the invention as defined in the appended claims.

What is claimed is:

1. An electron discharge device comprising a vessel enclosing a plurality of electrodes, concentric tubular conductors insulatingly sealed to said vessel, said electrodes being connected to said conductors, and yieldable means extending across one of said conductors to relieve temperature strains in the sealed insulating joint adjacent the junction with said one conductor.

2. An electron discharge device comprising a vessel enclosing a plurality of electrodes, concentric tubular conductors insulatingly sealed to said vessel, said electrodes being connected to said conductors, and the inner tubular conductor having an integral transverse portion extending across one end, said transverse portion having a plurality of yieldable segments to relieve temperature strains in the sealed insulating joint adjacent the junction with said inner conductor.

3. An electron discharge device comprising a vessel enclosing a plurality of electrodes, a cup-shaped conductor and a plurality of concentric conductors insulatingly sealed to said vessel, said electrodes being supported by said conductors, and the closed end of said cup-shaped conductor having spaced planar segments to relieve temperature stresses in the seal joining said cup-shaped conductor to the adjacent conductor.

4. An electron discharge device comprising a vessel enclosing a plurality of electrodes, a cup-shaped conductor and a plurality of concentric tubular conductors insulatingly sealed to said vessel, said electrodes being supported by said tubular conductors, said cup-shaped conductors having a central opening in the closed end and a plurality of slots extending beyond the edge of said closed end, a metallic standard extending through said central opening, another electrode supported by said cup-shaped conductor and standard, and an insulating closure bridging the interior of said cup-shaped member to said standard.

5. An electron discharge device comprising a hollow metallic anode portion, a tubular terminal, an insulating enclosing vessel portion join-

ing said terminal to said anode portion, an electrode within said anode portion and supported by said terminal, a cathode axially mounted in relation to said electrode, a cup-shaped terminal coaxially within said tubular terminal, a central solid metallic terminal extending through said cup-shaped terminal, said cathode being connected to said cup-shaped and central terminals, and interconnecting insulating sections sealed between said central, cup-shaped and tubular terminals and surrounded thereby.

6. An electron discharge device comprising a hollow metallic anode portion, a tubular conductor, an insulating enclosing vessel portion joining said conductor to said anode portion, an electrode within said anode portion and supported by said conductor, a cathode axially mounted in relation to said electrode, a cup-shaped terminal coaxially within said tubular conductor, a central solid metallic terminal extending through said cup-shaped terminal, said cathode being connected to said cup-shaped and central terminals, and interconnecting glass cup sections having opposite ends hermetically sealed to the respective adjacent walls of said conductor and terminals within and between which they are situated.

7. An electron discharge device comprising a vessel enclosing a plurality of electrodes including a multi-section filamentary assembly, concentric conductors insulatingly sealed to said vessel and supporting said electrodes, one of said conductors being an inverted cup-shaped member having a central aperture, alternate sections of said filamentary assembly being attached thereto, a central plug member extending through said cup-shaped member and supporting the remaining sections of said filamentary assembly, and a vitreous seal portion extending between said cup-shaped member and central plug, said cup having peripheral slots therein to relieve stresses in the vitreous seal adjacent thereto.

8. An electron discharge service comprising an enclosing vessel, a plurality of electrodes therein, concentric cylindrical conductors at one end of said vessel, said electrodes being individually supported by said conductors, and bell-shaped glass sections interposed between said conductors, the inner ends of said sections being sealed to the interior inner walls of said conductors and the outer ends being sealed to the exterior outer walls of adjacent conductors.

9. An electron discharge device comprising an enclosing vessel, an anode, a filamentary cathode within said anode, a terminal support for said cathode including a metallic cup-shaped member having a central aperture, a metallic conductor extending through said aperture, connectors joining said cathode to said member and conductor, and insulating sections forming part of said vessel sealed between said conductor and cup-shaped member and between said cup-shaped member and vessel, said cup-shaped member having spaced openings adjacent said central aperture and radial slots extending from said aperture and beyond the closed edge of said member.

10. An electron discharge device comprising an enclosing vessel, an anode, a multi-strand filamentary cathode within said anode, a terminal support for said cathode including a metallic cup-shaped member having a central aperture, a metallic standard extending through said aperture, insulating sections forming part of said vessel sealed between said standard and cup-shaped member and between said cup-shaped member and said vessel, and a pair of rigid supports extending from each said standard and cup-shaped member and joined to said multi-strand cathode.

11. An electron discharge device comprising an enclosing vessel having a hollow anode portion, a metallic sealing tip extending from said anode portion, cooperating electrodes within said anode portion, conductors sealed on one end of said vessel supporting said cooperating electrodes therein, a protective casing surrounding said anode and tip, a plurality of radiator fins mounted externally on said casing, and a solder filling joining said casing to said anode and embedding said tip within said casing.

12. An electron discharge device comprising an enclosing vessel having a hollow anode portion, an annular flange member affixed to said anode adjacent one end, a metallic sealing tip extending from the opposite end of said anode portion, cooperating electrodes within said anode portion, conductors supporting said cooperating electrodes therein, an insulating portion of said vessel sealing said conductors to said flange member, a metallic casing surrounding said anode and having a cavity enclosing said tip, said casing being in contact with said flange member, a filling of cadmium metal joining said casing to said anode and embedding said tip in said cavity, and a closure for said casing adjacent the filling mass of metal.

13. A connector for electron discharge devices comprising a plurality of coaxial cylindrical conductors disposed one within another and in laterally spaced relation, and a plurality of insulating spacers each disposed between two adjacent conductors, each of said spacers including an elongated cylindrical portion spaced from the respective adjacent conductors and end portions sealed hermetically to the respective adjacent conductors.

JOHN W. WEST.

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