

Jan. 18, 1938.

J. E. CLARK ET AL

2,105,472

HIGH POWER DISCHARGE DEVICE

Filed July 3, 1936

6 Sheets-Sheet 1

FIG. 1

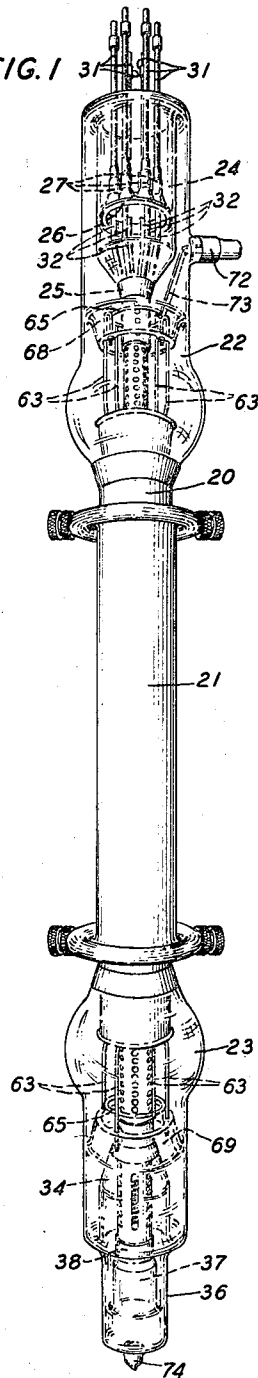
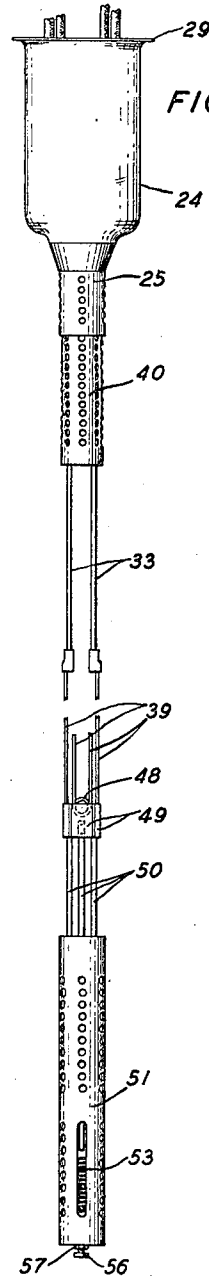


FIG. 2



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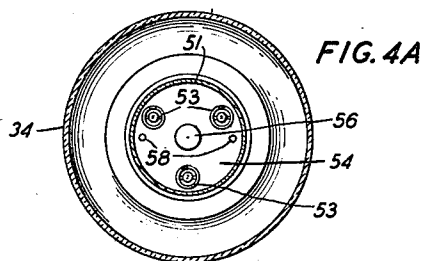
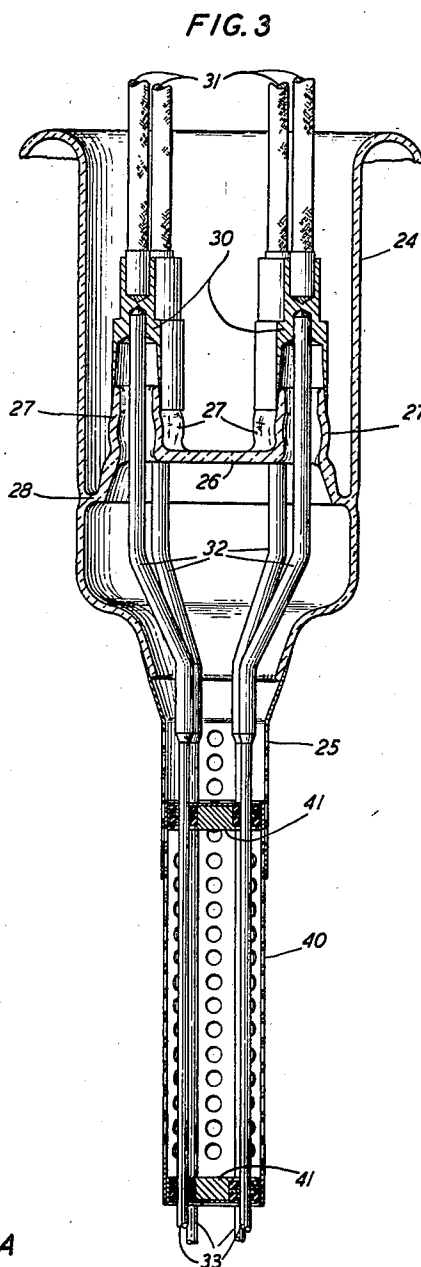
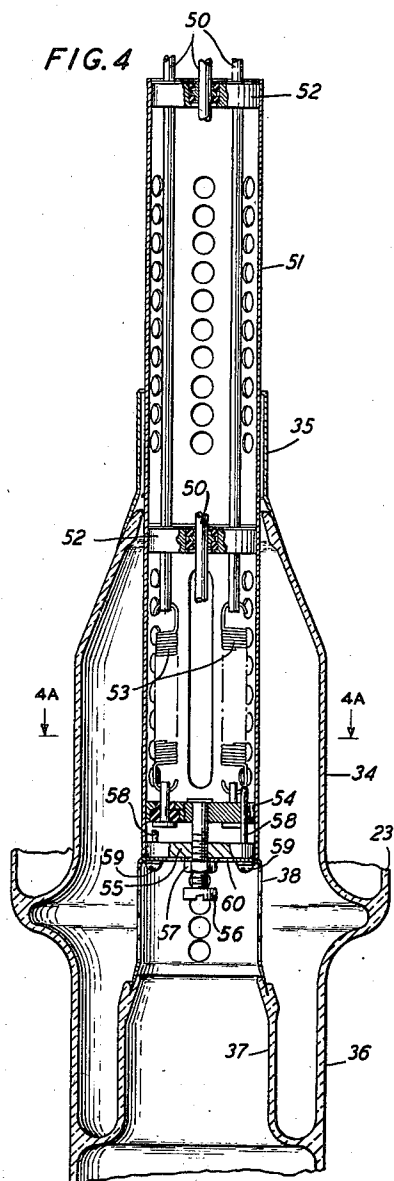
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FIG. 5

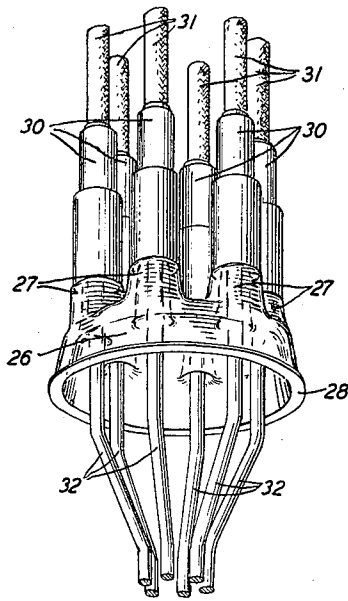


FIG. 7

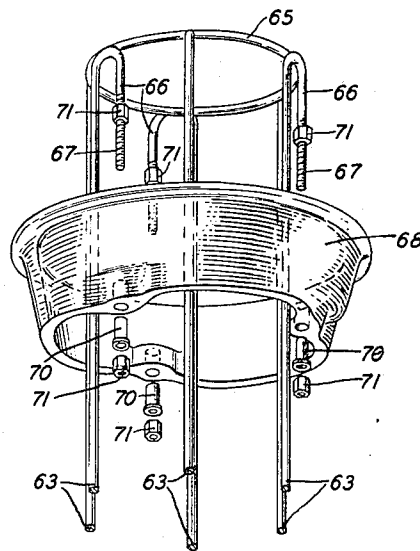


FIG. 6

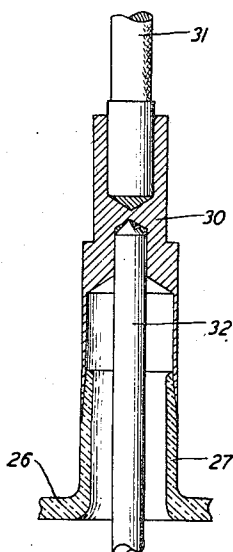
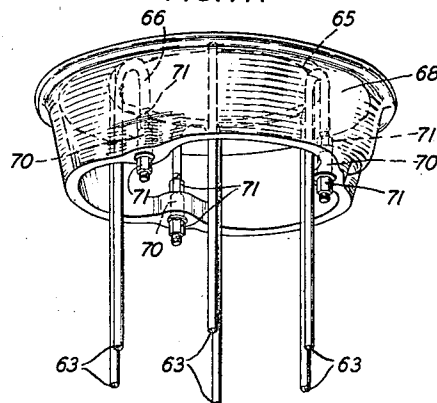


FIG. 7A



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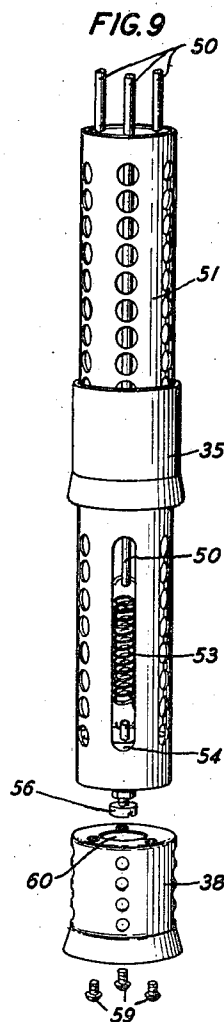
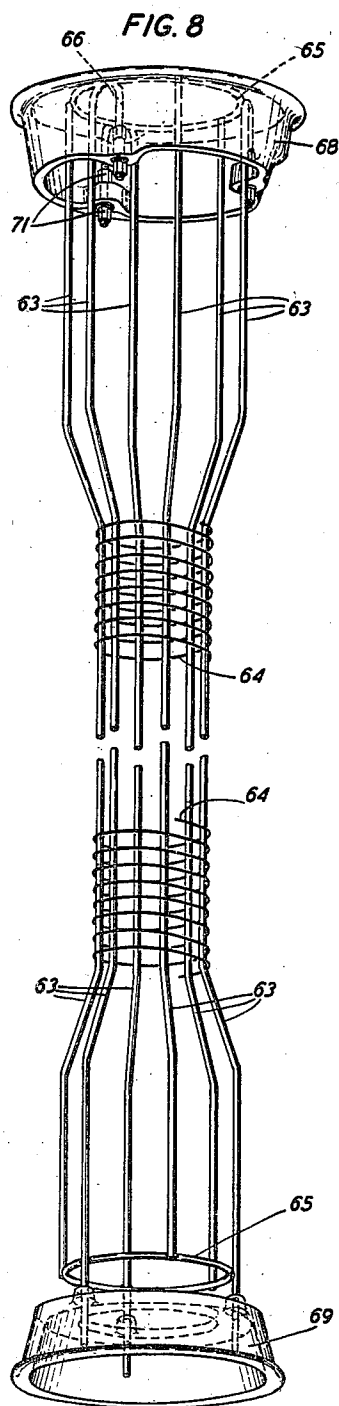
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FIG. 10

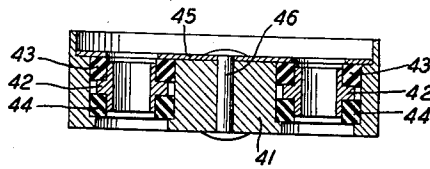


FIG. 11

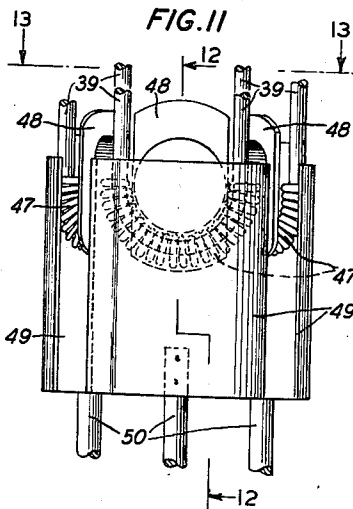


FIG. 12

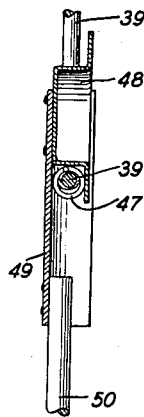


FIG. 13

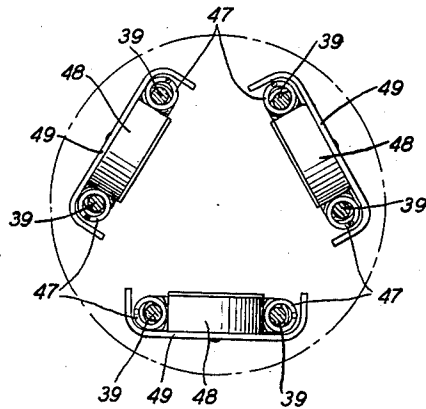


FIG. 14

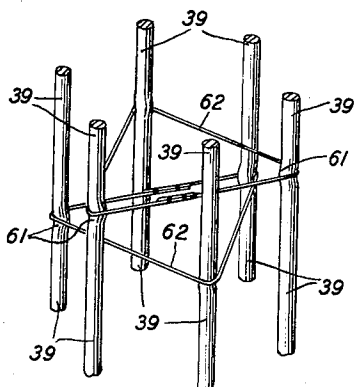
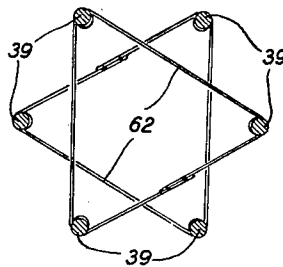


FIG. 15



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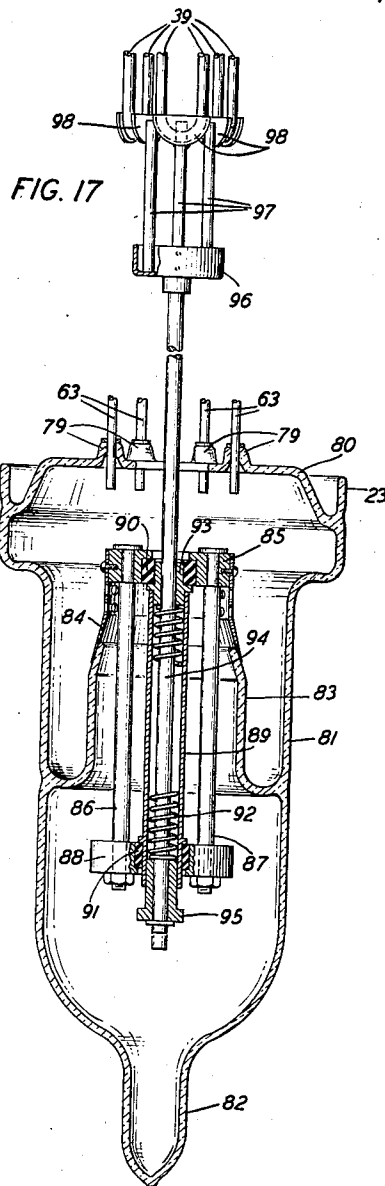
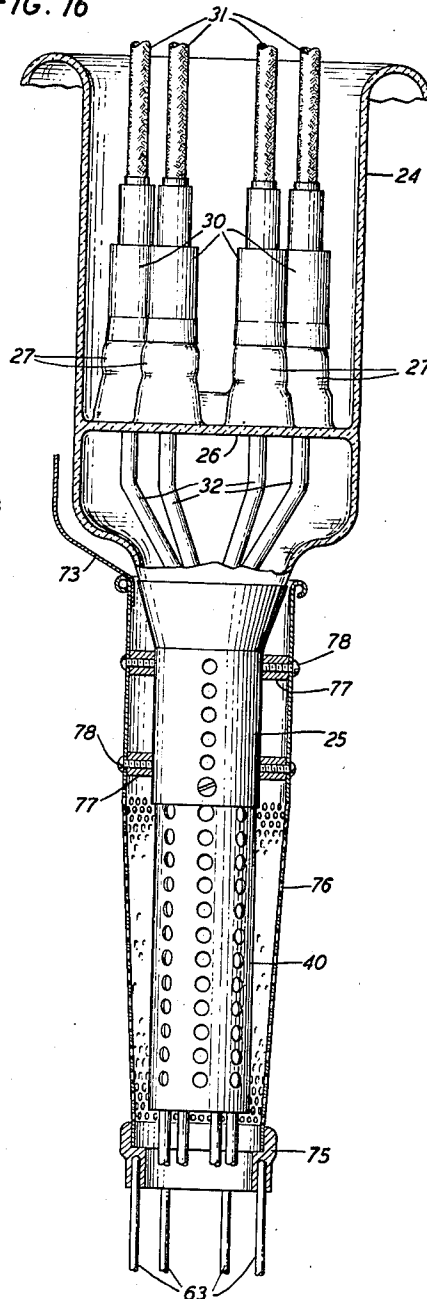


FIG. 16



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UNITED STATES PATENT OFFICE

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HIGH POWER DISCHARGE DEVICE

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Application July 3, 1936, Serial No. 88,756

20 Claims. (Cl. 250—27.5)

This invention relates to high power discharge devices of the water-cooled anode type.

In such devices, especially where the device is of considerable size and capacity, for instance, a device having a rating of 250 kilowatts, it is essential that the internal electrodes are adequately insulated from the anode; that these electrodes are mounted in a manner to compensate for expansion due to the internal heat generated in the device, and that the assembly or fabrication is efficiently consummated to reduce the cost and insure stable and interchangeable units.

One of the objects of this invention is to provide a rugged assembly capable of withstanding the severe conditions of continuous operation for long periods.

Another object of the invention is to preserve the inter-spacial relationship between the several electrodes regardless of the effect of the internal heating produced in the device.

A further object of the invention is to organize the fabrication of the device in such a manner that the various elements may be assembled with the aid of machinery to obviate the use of skilled labor and to insure concentric disposition of the electrodes in the device.

In accordance with one aspect of this invention the device embodies a double-ended structure in which an external cylindrical anode forms an intermediate portion and is terminated by a glass portion at each end, the anode being provided with an integral surrounding jacket in which a cooling fluid is circulated to dissipate the heat generated in the device. A filamentary cathode assembly is mounted within the anode and is supported at both ends by the glass terminating portions. A control electrode or grid element is interposed between the cathode and anode and is also supported at both ends by the glass terminating portions. This arrangement insures positive interspace relationship between the cooperating active elements of the device and permits large amounts of power to be generated and controlled at high efficiency. Furthermore, the operating life of the device is considerably lengthened by the provision of long leakage paths along the walls of the glass terminating portions between the electrodes.

A feature of the invention relates to the mounting of the control electrode or grid to provide for expansion and contraction thereof during operation of the device. This arrangement comprises the fusing of annular glass members to the walls of the glass terminating portions, the

members having their small diameter ends projecting toward the adjacent anode end and aligned with respect to each other so that the upright support members of the grid extend through guides provided in the annular faces of the glass members. This construction provides an independent support for the grid electrode which compensates for the elongation of the grid and maintains the grid in uniform space relation with respect to the anode.

A further feature of this assembly is the provision of fused-in metallic bearing guides in the glass members to eliminate sticking of the grid supports in the annular members.

Another feature of the invention relates to a cathode assembly mounted coaxially within the grid structure and supported under tension to maintain uniform interspace relation with respect to the grid and anode of the device. This assembly involves the rigid support of the cathode strands individually at one end of the vessel by the leading-in conductors and the resilient support of the strands at the other end of the vessel. The resilient support comprises a plurality of tension rods which carry supporting members engaging the loops of the multi-strand cathode. These rods are embodied in a unit casing or shield which insures proper spacial relation of the cathode strands and compensates for inequalities due to differences in stress of the individual strands of the cathode. This arrangement facilitates the mounting of the cathode assembly in the device, permits the establishment of a uniform initial tension to all the strands of the cathode, prevents deformation of any of the strands due to differences in elongation of one or more of the strands and prolongs the operative action of the tension supports by protecting them from the intense heat generated during the operation of the device.

Another feature of the invention relates to the alignment of the cathode tension assembly in the device by providing a guiding sleeve which engages the casing unit to insure accurate centering of the unit and permit the unit to elongate due to changes in temperature. This arrangement also increases the protection of the active tension springs of the cathode assembly by providing a separate chamber in which the springs are shielded from the heat diffused throughout the main portion of the device.

A further feature of the invention relates to the correction of an inherent effect of the heating of the cathode strands during operation due to their length and small diameter. This ar-

rangement consists in strapping the strands in groups at their centers to overcome the effect of bowing outwardly toward the grid. This is accomplished by tying the strands in triangular formation by light connecting wires, the wires being held in position by notching or crimping the cathode strands.

Another feature of the assembly of the complete device is the provision of long insulating paths between the respective electrodes so that leakage between the electrodes at greatly unequal potentials is avoided. This is accomplished by terminating the cathode assembly at opposite ends of the vessel through reentrant coaxial stems while the anode which is the high potential electrode is separated from these terminations by the glass end portions of the vessel and the grid supporting structure is terminated at opposite ends at points intermediate the cathode and anode terminations.

A further feature of the invention relates to the method of fabricating the complete assembly principally with the aid of glass working machinery and thereby standardizing the component parts of the structure to facilitate production, increase efficiency and reduce the manufacturing cost of the device. The procedure consists in fabricating the anode and glass end portions in one unit, winding the grid structure as another unit and building up the cathode unit on a stem supporting the leading-in conductors. The anode unit is placed in a glass sealing machine and the grid supporting stems are successively sealed in the glass terminating portions in symmetrical alignment with respect to the anode. The grid structure is introduced into one end of the anode unit and adjusted in supporting relation in the grid stems and finally locked in position in one of these stems. The grid terminal which has previously been sealed to one of the glass end portions is provided with a flexible conductor which is welded to the grid structure. The cathode assembly is then threaded through one end of the vessel while in a vertical position until the tension casing is adjusted in position with respect to the guide sleeve and a rigid supporting collar on the opposite supporting stem. The tension casing is affixed to the rigid collar and the stem end of the cathode assembly is temporarily fixed in position while the tension on the cathode strands is regulated at the opposite end. When the proper tension is secured the stem is sealed to the vessel and the opposite end is drawn down to an exhaust tubulation to be affixed to the pumping station. After complete exhaust of the device the tubulation is sealed off. This method insures a proficient technique of assembly which saves considerable time and expense and materially enhances the manufacturing facilities for handling immense and complicated assemblies. Furthermore, the operations are mainly performed with preformed elements which may be handled efficiently by machine so that highly skilled labor is reduced to a minimum.

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 is a general perspective view of the complete device embodying the features of this invention;

Fig. 2 shows in suspension a unitary mount of the cathode assembly of this invention with a center portion of the cathode strands broken out to reduce the over-all length of the structure;

Fig. 3 is an enlarged view in cross-section of the upper stem construction of the cathode mount shown in Fig. 2;

Fig. 4 is an enlarged view in cross-section of the lower stem construction of the cathode mount shown in Fig. 2;

Fig. 4A is a cross-sectional view of the lower stem of Fig. 4 taken on the line 4A—4A;

Fig. 5 is a perspective view of the terminal stem of the cathode assembly;

Fig. 6 shows an enlarged cross-section of the terminal construction of Fig. 5;

Figs. 7 and 7A are exploded and assembly views in perspective of one of the grid stems in accordance with this invention;

Fig. 8 is a perspective view of the complete grid structure with the mid-portion broken away;

Fig. 9 shows in perspective the cooperating elements of the lower portion of the cathode mount and their relative positions without the glass stem, as shown in Fig. 4;

Fig. 10 is an enlarged cross-sectional view of the spacer disc involved in the stem structures shown in Figs. 3 and 4;

Fig. 11 shows an enlarged view of a portion of the cathode mount pertaining to the juncture of the tensioning devices and the cathode strands;

Fig. 12 shows in cross-section the details of one of the tension devices taken on the line 12—12 of Fig. 11;

Fig. 13 is a plan view of the portion of the tension devices shown in Fig. 11 to illustrate the arrangement of the elements;

Fig. 14 shows, in perspective, a longitudinal section of the cathode strands and the manner of strapping the strands in groups;

Fig. 15 is a plan view of the cathode strands shown in Fig. 14;

Fig. 16 shows in cross-section a modified arrangement of the upper portion of the device in accordance with this invention in which the cathode mount and the grid are coupled to a unitary stem; and

Fig. 17 illustrates in cross-section the lower portion of the device in accordance with the modification of this invention and therefore forms the termination of the structure shown in Fig. 16.

Referring now to the drawings, and particularly to Fig. 1, showing the complete assembly and Figs. 2 and 8 showing the cathode mount and the grid mount of the device, respectively, according to this invention, the complete structure, which has an over-all length of approximately seven feet and a capacity of 250 kilowatts power output, involves a highly evacuated enclosing vessel of the general form shown in United States Patent 1,976,521, issued October 9, 1934, to V. L. Ronci and J. E. Clark. This vessel includes a cylindrical metallic anode portion 20 surrounded by an integral metallic cooling jacket 21, and two vitreous bulbous extension portions 22 and 23, of relatively hard glass, which are hermetically sealed to opposite ends of the anode portion 20 in accordance with the method disclosed in United States Patent 1,294,466 issued February 18, 1919 to W. G. Houskeeper.

The bulbous extension 22 is provided with a reentrant glass stem 24 which tapers to a metallic collar 25 fused to the stem and forming an integral part thereof. A pre-cast or molded dish-type stem 26, shown more clearly in Fig. 5, is provided with six tubular sleeves 27 arranged in circular formation and projecting outwardly toward the joined end of the stem 24 and the bulb-

ous extension 22. A flange rim 26 of the dish-type stem 26 is fused to the inner wall of the stem 24 intermediate the collar 25 and the flared portion 29 of the reentrant stem. Each of the sleeves 27 is provided with a metallic terminal, shown clearly in Fig. 6, which consists of a cup seal 30 having a flexible braided copper terminal extension 31 projecting beyond the upper end of the device, as shown in Fig. 1, and a rigid metallic conductor 32, all of the conductors being bent inwardly to bring the conductors together in spaced parallel relation within the compass of the collar 25, as shown in Fig. 3. A rigid metallic rod or leading-in wire 33 is welded to each conductor and extends into the area of the anode 20.

The bulbous extension 23 on the opposite end of the anode is provided with a reentrant stem 34 terminating in a metallic guiding sleeve or collar 35 and an outwardly extending end portion 36 which is also provided with a reentrant stem 37 terminating in an apertured metallic cap 38 coaxially arranged with respect to the guiding sleeve 35. The dish stem 26 and the apertured cap 38 are the rigid terminating supporting points of a cathode assembly or mount in accordance with this invention in which a plurality of strands of hairpin sections 39 of filament wire, such as tungsten, are arranged in a cylindrical boundary within the cylindrical anode 20. The ends of the filament strands are secured to the rigid wires 33 and the intermediate portions of the wire 33 are held in spaced relation by a shield casing 40, shown in Fig. 3.

This casing is secured to the collar 25 and is provided with a spacer disc 41 at each end which has apertures corresponding to the number of rigid wires 33 passing therethrough. A flanged metallic sleeve or bearing 42 is supported between a pair of insulating bushings 43 and 44 in each aperture of the disc and a retaining plate 45 secures these units in the disc by a rivet 46, as shown more clearly in Fig. 10. The metallic sleeve 42 permits sliding movement of the rigid wires 33 in a longitudinal direction and thereby relieves stress in the terminals 30 and the glass stem forming the rigid terminus of the cathode assembly.

The loop end or bight of each filamentary strand 39 of the cathode is provided with a loose helical spring spacer 47 which engages a rigid sheave 48 attached to the inner surface of a shielding plate 49. The spacers 47 tend to reduce the contact temperature between the tungsten strands and the sheave 48 which is formed of a different metal, such as molybdenum. Each of these plates is attached to a rigid rod 50 slidably supported in spaced relation in a tubular metallic casing or shield 51. This casing or shield is also provided with spacer discs 52 which engage the rods 50 and the discs including the guiding sleeves and bushing supports, as shown in Fig. 10. The rods 50 are attached to tension springs 53 also enclosed in the casing 51 and the springs are insulatively connected to a common metallic slidable disc 54. A closure disc 55 is secured to the lower end of the shield 51 and the slidable disc 54 is adjustably secured to the closure disc by a tension regulating screw member 56 which is provided with a locking nut 57. The metallic disc 54 is prevented from twisting by the slidable engagement with a pair of guide rods 58 extending from the closure disc 55. The tension assembly is secured to the apertured cap 38 by screws 59 and the regulating member 56 extends through the central aperture 60 of the cap. This mount-

ing arrangement rigidly supports opposite ends of the cathode assembly at the ends of the device to insure stable relation of the cathode with the cooperating electrodes of the device, but permits expansion and contraction of the filamentary strands of the cathode and the conductors and protects the tension springs from the excessive heat generated in the device. The long tension casing 51 is also aligned in relation to the cap member 38 by the guiding sleeve 35 on the stem 24.

Since the cathode strands are relatively long, it is one of the features of this invention to overcome the bowing effect of heating the long strands to prevent contact of the filament with other cooperating electrodes of the device. The strands of the cathode are crimped or notched at related points, as shown at 61 in Fig. 14. In the arrangement of the six strands of the cathode, as shown, heating current may be supplied so that the strands may be grouped in two sections with a triangular shaped tie wire or brace 62 strapping three strands together at the notched points of the strands. The separate groups form a star in cross-section, as shown in Fig. 15, with the braces in superimposed and opposite relation.

The assembled elements of the control electrode or grid are shown clearly in Fig. 8 in which the grid consists of a plurality of longitudinal rods 63 which are bent at the mid-portion to reduce the diameter of the structure and a wire helix 64 is welded to the rods to provide a rigid electrode which is arranged coaxially between the cathode mount and the cylindrical anode 20. The grid upright rods 63 are joined at opposite ends to a closed ring 65 and alternate rods are extended on one end beyond the ring and form guide wires for the grid structure. The same wires at the opposite end of the grid are folded back, as shown at 66, in U-shaped formation and provided with threaded extensions 67. The grid structure is supported in the discharge device at points intermediate the ends of the device and the ends of the anode 20 by pre-cast or molded, truncated, conical annular glass members 68 and 69 which have their large diameter flared ends fused to the inner wall of the bulbous extensions 22 and 23, respectively. These conical members are provided with metallic tubular bearings 70, preferably formed of molybdenum, fused into apertures provided in the thickened wall of the smaller diameter rim of the conical members. These bearings provide a metal-to-metal contact in the conical members for the grid supports and prevent gripping of the grid supports particularly in the conical member 69 which forms an expansion guide for the grid. The conical members are fused to the walls of the bulbous extension in such a relation that upon insertion of the grid structure through the upper end of the device, the U-shaped extensions of the rod 63 enter the bearings in the conical member 68 simultaneously with the entrance of the guide extensions of the rod 63 in the bearings of the conical member 69. This arrangement prevents any twisting or distortion of the grid assembly during the mounting of the element and also provides a simple method for fabricating the unit of the device.

The threaded extensions 67 of the grid support rods 63 extending through the metallic bearings 70 are rigidly fastened to the conical member 68 by nuts 71 on opposite sides of the metallic bearings in the conical member 68. The grid structure is connected to an external terminal 72 on the bulbous extension 22 by a flexible connec-

tion 73 for applying suitable operating potentials to the grid electrode, to control the emission of electrons from the cathode to the anode of the device. The segregation of the grid supports at points intermediate the anode terminations and the cathode terminations insures adequate insulating paths between the various electrodes operating with potentials of unequal power and increases the leakage paths between the various electrodes so that greater efficiency may be obtained in the operation of the device. After the complete assembly of all the elements in the structure, as shown in Fig. 1, the device may be evacuated through a tubulation 74 provided on the lower end of the stem 36 which is finally sealed when a desired degree of vacuum is obtained in the device.

Figs. 16 and 17 show a modification of the internal assembly of the device shown in Fig. 1 in which the grid and cathode mounts are assembled at opposite ends of the device on compound stems sealed to the bulbous extensions 22 and 23, respectively. The upper end stem is substantially the same as described in connection with Fig. 1 except that the grid support rods 63 are secured to a metallic collar 75 which is supported on a conical metallic shield or sleeve 76 attached to the collar 25 by spacers 77 and screws 78. The lower ends of the grid support rods extend through guiding sleeves 79 in a dish-type stem 80 which is fused to the wall of the bulbous portion 23. A hollow extension 81 is formed on the bulbous portion 23 and terminates in a tubulation 82 for evacuating the device while an internal stem 83 is provided in the extension and a metallic collar 84 is formed on this stem to support a metallic disc platform 85. A pair of parallel support rods 86 and 87 extend from the platform and carry a similar platform 88 which serves as a frame for the compression spring assembly of the cathode. This assembly consists of a tubular member or sleeve 89 insulated from the frame by washers 90 and 91 and a compression spring 92 is enclosed in the sleeve and held therein by a metallic bearing 93. The spring 92 surrounds a rigid standard 94 which is held under tension by the spring and a metallic bushing or stop member 95. The tension rod is secured to a cup 96 to which is attached three short rods 97 which are provided with semi-sheaves 98 for engaging the bights of the filament strands 39.

While the invention has been disclosed with respect to particular embodiments of the structures and their relation with respect to each other it is, of course, understood that various modifications may be made in the details of the assembly 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 elongated enclosing vessel having a cylindrical metallic portion serving as an anode, vitreous portions sealed to opposite ends of said metallic portion, each of said vitreous portions having a reentrant stem, a cathode assembly extending throughout the length of said vitreous portions and said metallic portion and supported on each end by a stem, and a cylindrical grid coaxially arranged between said anode and said cathode assembly, said grid being supported at each end by said vitreous portions intermediate each end of the anode and the adjacent stem of each vitreous portion.

2. A high power discharge device having a metallic water jacket surrounding a tubular me-

tallic anode portion terminating with opposite insulating portions, a reentrant stem in each of said insulating portions, a cathode assembly coaxially supported within said anode by said stems, an internal flange member supported by each of said insulating portions, and a control electrode concentric with said cathode assembly and said anode carried by said flange members.

3. A high power discharge device having a metallic water jacket surrounding a tubular metallic anode portion terminating with opposite insulating portions, a reentrant stem in each of said insulating portions, a cathode assembly coaxially supported within said anode by said stems, a truncated conical vitreous member extending toward the end of the anode and fused to the wall of one insulating portion, a corresponding vitreous member fused to the wall of the opposite insulating portion and arranged in opposed relation to the other member, a helical wire grid, and a plurality of longitudinal rods carrying said grid, the ends of said rods being supported in both conical members.

4. A high power discharge device having a metallic water jacket surrounding a tubular metallic anode portion, vitreous portions sealed to opposite ends of said metallic portion, each of said vitreous portions having a reentrant stem, a cathode assembly extending throughout the length of said vitreous portions and said metallic portion and supported at each end by a stem, a truncated conical vitreous member extending toward one end of the anode and fused to the wall of said vitreous portion, a corresponding vitreous member fused to the wall of the opposite vitreous portion and arranged in opposed relation to the other member, a helical wire grid, a plurality of longitudinal rods carrying said grid, the ends of said rods projecting through both conical members, and metallic bearings held in said conical vitreous members for engaging said rods.

5. An electron discharge device comprising an enclosing vessel having a cylindrical metallic portion serving as an anode, vitreous portions sealed to opposite ends of said metallic portion, each of said vitreous portions having a reentrant stem, a cathode assembly extending throughout the length of said vitreous portions and metallic portion and supported at each end by said stems, a pair of truncated conical vitreous members extending toward opposite ends of said anode and fused to the walls of said vitreous portions, a helical wire grid, said vitreous members having metallic bearings fused therein, the bearings in one of said vitreous members being offset with respect to the bearings in the corresponding member whereby the ends of said grid supporting rods are simultaneously inserted in all the bearings during the mounting of the grid structure.

6. An electron discharge device comprising an enclosing vessel having a cylindrical metallic portion serving as an anode, vitreous portions sealed to opposite ends of said metallic portion, each of said vitreous portions having a reentrant stem, a cathode assembly extending throughout the length of said vessel and supported at each end by a stem, a truncated conical vitreous member extending toward the end of the anode and fused to the wall of said vitreous portion, a corresponding vitreous member fused to the wall of the opposite vitreous portion and arranged in opposed relation to the other member, a helical wire grid, and a plurality of longitudinal rods carrying said grid, the rods at one end being slidably in engage-

ment with one of said conical vitreous member and the rods at the other end being rigidly fastened to said corresponding vitreous member.

7. A water-cooled discharge device comprising
 5 an anode portion and a glass portion, said glass portion having a reentrant stem, an outwardly extending dish member sealed within said stem, a cathode supported from said stem, leading-in conductors for said cathode extending through said
 10 stem and sealed in said dish member, and a grid interposed between said anode and cathode and supported by said glass portion independent of said stem.

8. An electron discharge device comprising a
 15 cylindrical anode portion having a vitreous bulbous portion sealed to each end, a hollow stem projecting into each bulbous portion, a metallic collar sealed to the inner end of each of said stems, a molded vitreous dish member having its edge
 20 sealed to the inner wall of one of said stems, said dish member having a plurality of sleeve portions arranged in a circular boundary, conductors extending through said sleeve portions and sealed thereto and extending in a group through the
 25 collar on the respective stem, a tubular shield supported by said collar, spacing discs mounted in said shield and provided with guiding sleeves through which said conductors extend, looped cathode strands attached to pairs of said con-
 30 ductors, tension members engaging said looped cathode strands at the free end, a tubular shield enclosing said tension members, said shield having guiding discs for spacing said tension members, means securing the latter tubular shield to said
 35 metallic collar at the opposite end of said device, and means for regulating the tension applied to said cathode strands.

9. A high power discharge device having a metallic water jacket surrounding a tubular
 40 metallic anode portion terminating with opposite insulating portions, a reentrant stem in each of said insulating portions, a cathode assembly coaxially supported within said anode by said stems, said assembly including a sleeve shield at each
 45 end extending beyond the adjacent end of said anode, and a guiding collar supported by one of said insulating portions engaging a sleeve shield of said assembly, a suspension cathode unit comprising a plurality of looped cathode strands ar-
 50 ranged in a cylindrical boundary, a plurality of tension rods engaging the looped ends of said cathode strands, a plurality of conductors secured to the ends of said strands, regulating means positioned on one end of one of said
 55 sleeve shields for said cathode, and a dish type stem insulatingly supporting said conductors.

10. In an electron discharge device, a tension support for a cathode comprising a tubular shield
 60 having a disc closure at each end, one of the discs having apertures, insulated guides mounted in said apertures, slidable rods extending through said guides, a cathode consisting of a plurality of looped strands, means on said rods engaging
 65 said looped strands, resilient springs attached to said rods within said shield, an adjustable disc supporting said springs, and tension regulating means extending from said other disc and supporting said adjustable disc.

11. In an electron discharge device, a tension
 70 support for a cathode comprising a tubular shield having a disc closure at each end, one of the discs having apertures, insulated guides mounted in said apertures, slidable rods extending through
 75 said guides, a cathode consisting of a plurality of looped strands, curved plates longitudinally at-

tached to said rods and forming a cylindrical boundary, a metallic sheave secured to each plate, each sheave engaging a separate looped strand of
 5 said cathode, resilient springs attached to said rods within said shield, an adjustable disc supporting said springs, and tension regulating means
 10 extending from said other disc and supporting said adjustable disc.

12. In an electron discharge device, a tension support for a cathode comprising a tubular shield
 15 having a disc closure at each end, one of the discs having apertures, insulated guides mounted in said apertures, slidable rods extending through said guides, a cathode consisting of a plurality of looped strands, curved plates attached to said
 20 rods and forming a sectional cylindrical shield, a sheave hanger rigidly attached to the inner surface of each plate, each hanger supporting a separate looped strand of said cathode to ar-
 25 range the strands in a circular boundary, and a separating wire helix embracing each looped strand across each hanger.

13. In an electron discharge device, a tension support for a cathode comprising a perforated
 25 tubular shield, apertured closure members for said shield, a guiding disc intermediate the ends of said shield, parallel rods extending through said guiding disc and one of said closure members, a movable disc carried by said other closure mem-
 30 ber, means on one of said closure members slidably engaging said movable disc, resilient springs connecting said rods to said movable disc, and a plurality of cathode strands supported by said rods.

14. An electron discharge device of the water-
 35 cooled type having a tubular metallic intermediate portion and a vitreous portion on each end, a cathode unit and a grid structure, the method of fabricating the assembly which comprises seal-
 40 ing a bulbous vitreous portion to each end of the metallic portion, fusing a molded vitreous annular member to the inner wall of each vitreous portion adjacent the ends of the metallic
 45 portion, inserting the grid structure into one end of the device, simultaneously mounting the op-
 50 posite ends of said grid structure in said annular members, securing a flexible conductor between said grid structure and a terminal on one of said end portions, inserting the cathode unit into the
 55 same end of said device, securing the cathode unit to the opposite vitreous end portion, sealing the remaining end of the cathode unit to the vitreous end portion through which it is inserted, and finally sealing the other vitreous end por-
 60 tion.

15. An electron discharge device of the water-
 65 cooled type having a tubular metallic intermediate portion and a vitreous portion on each end, a cathode unit and a grid structure, the method of fabricating the assembly which com-
 70 prises, sealing a vitreous portion to each end of the metallic portion, fusing a molded vitreous annular member to the inner wall of each vitreous portion adjacent the ends of the metallic portion, inserting the grid structure into one end of the
 75 device, simultaneously mounting the opposite ends of said grid structure in said annular members, securing a flexible conductor between said grid structure and a terminal on one of said end portions, inserting the cathode unit into the same
 70 end of said device, securing the cathode unit to the opposite vitreous end portion, adjusting the tension applied to the cathode, sealing the remaining end of the cathode unit to the vitreous end portion through which it is inserted, and re-

ducing the other vitreous end portion to a tubulated form.

16. In an electron discharge device, a cathode unit having rigid securing means at opposite ends, tension applying means carried by one of said securing means, a plurality of long cathode strands extending between said tension means and the other securing means, said strands having crimped portions intermediate their ends, and transverse wire braces engaging said crimped portions.

17. In an electron discharge device, a cathode unit having rigid securing means at opposite ends, tension applying means carried by one of said securing means, three looped cathode sections forming six strands extending between said tension means and said other securing means, said strands having crimped portions intermediate their ends, and triangular wire braces tying groups of three strands together.

18. An electron discharge device comprising an enclosing vessel including a cylindrical metallic anode portion, vitreous portions sealed to opposite ends of said metallic portion, compound stems projecting into each of said vitreous portions, one of said stems having an inner coaxial portion and an outwardly extending dish portion, the other stem having an inner dish portion and an outwardly extending tubular portion, a helical grid structure extending through said anode and rigidly fastened to one of said stems at one end of said device, the other end of said grid structure being slidably supported by said inner dish portion, a multi-strand filamentary cathode arranged in a circular boundary within said grid structure, rigid conductors secured to said strands, said conductors being sealed in said outwardly extending dish portion in the same relation as the strands of said cathode, and a tension device engaging said strands and being enclosed in said tubular portion of one of said compound stems.

19. A high voltage, water-cooled external anode type discharge device comprising a metallic water jacket surrounding a tubular metallic

anode portion having a glass bulbous portion sealed to each end, a hollow stem projecting into each bulbous portion, a molded glass dish stem having its edge fused to the wall of one stem, a plurality of conductors sealed in said dish stem in circular formation, a chimney-type stem spaced from said dish stem and fused to the wall of said hollow stem and arranged in opposed relation to said dish stem, said conductors extending through the smaller end of said chimney stem, a spacer shield extending beyond said chimney stem and surrounding said conductors, looped filament strands attached to pairs of said conductors, tension members engaging said looped strands at the opposite ends, a cylindrical casing enclosing said tension members, means for attaching said casing to the hollow stem on the other end of said device, a guiding sleeve supported by the adjacent bulbous glass portion engaging said casing, regulating means attaching said tension members to said casing, a molded glass conical ring member fused to each bulbous portion intermediate said hollow stem and the adjacent end of said anode, said ring member surrounding the filament assembly and having metallic bearings extending parallel to the axis of the device, a plurality of rigid rods forming a grid structure projecting through said bearings in each ring member, a helical grid supported by said rods, a cap terminal on one of said bulbous glass portions, and a flexible connection between said grid structure and said cap terminal.

20. An electron discharge device comprising a vessel having a stem at each end, a cathode assembly centrally positioned in said vessel and supported at each end by a stem, a surrounding electrode coaxially positioned with respect to said cathode, annular means projecting from the wall of said vessel independent of said stem at each end thereof, and means on said surrounding electrode engaging said annular means.

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