Aug. 27, 1940.

J. E. CLARK ET AL

2,212,929

HIGH POWER DISCHARGE DEVICE

Filed June 1, 1938

4 Sheets-Sheet 1

FIG. 1

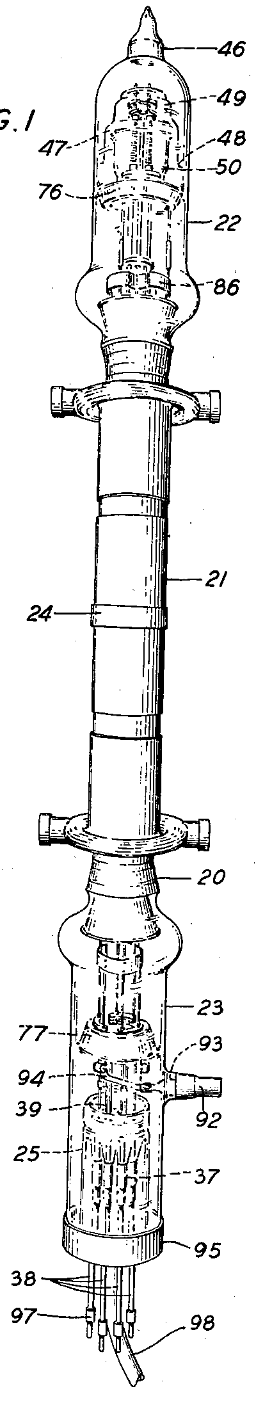
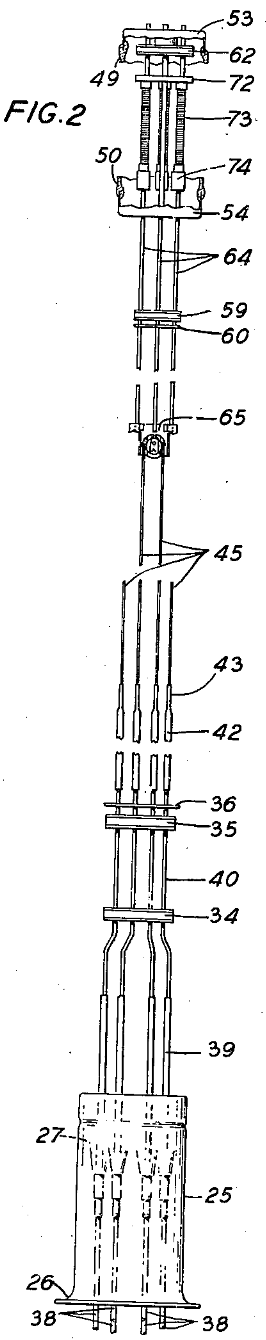


FIG. 2



INVENTORS: J. E. CLARK
S. O. EKSTRAND
V. L. RONCI

BY Walter C. Kiesel

ATTORNEY

HIGH POWER DISCHARGE DEVICE

Filed June 1, 1938 4 Sheets-Sheet 2

FIG. 3

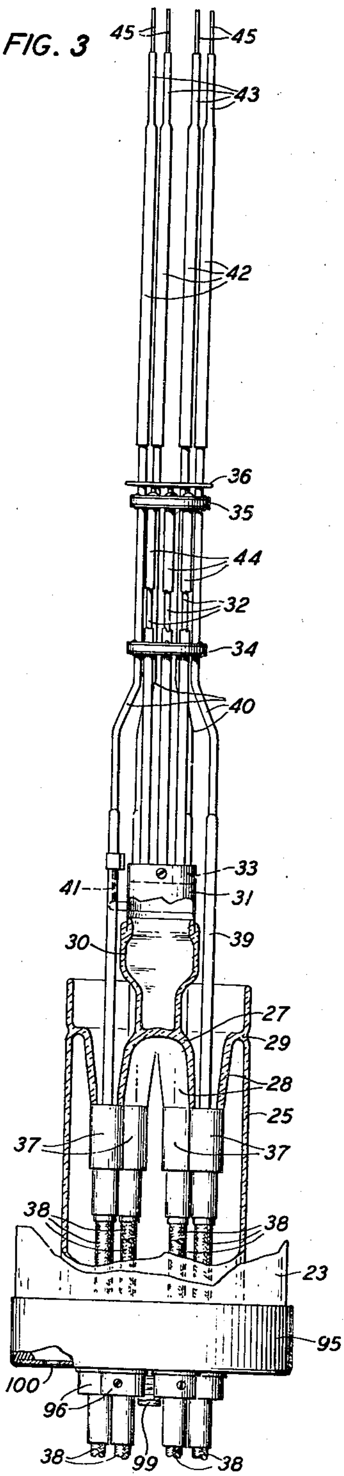
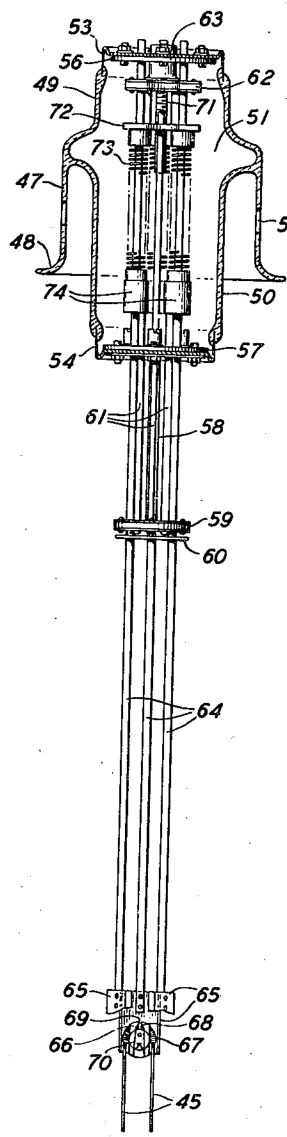


FIG. 4



INVENTORS: J.E.CLARK
S.O.EKSTRAND
V.L.RONCI

BY Walter C. Kiesel

ATTORNEY

Aug. 27, 1940. J. E. CLARK ET AL 2,212,929

HIGH POWER DISCHARGE DEVICE

Filed June 1, 1938 4 Sheets-Sheet 3

FIG. 6

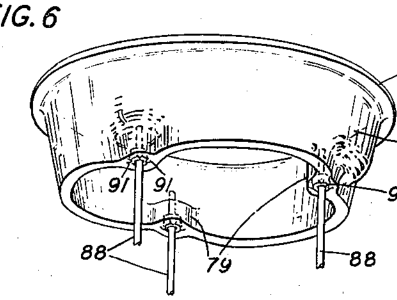


FIG. 7

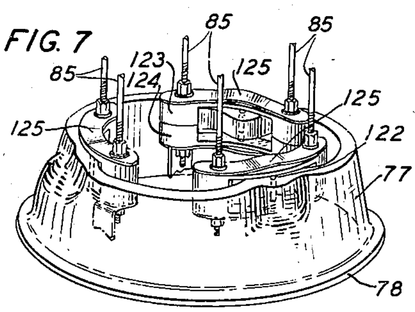


FIG. 5

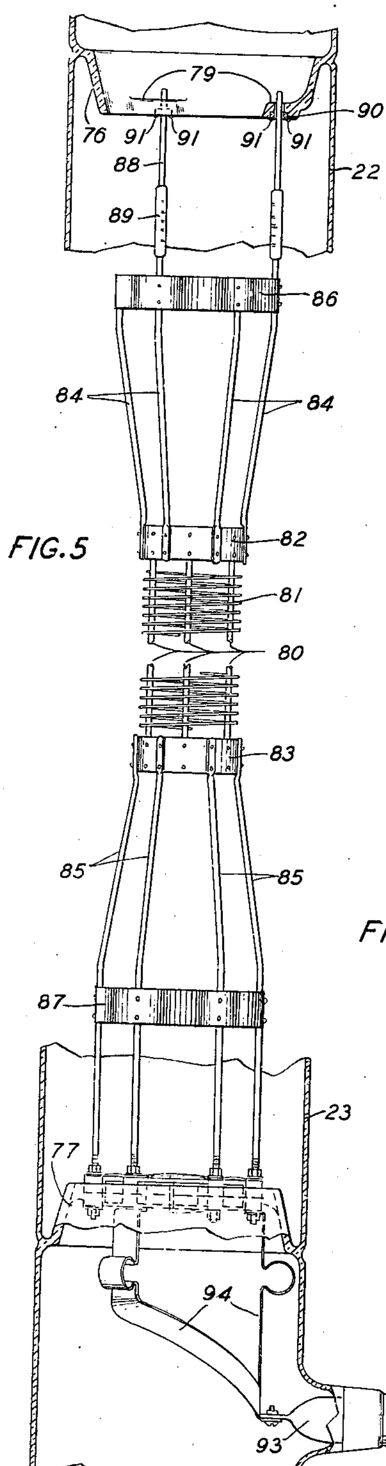
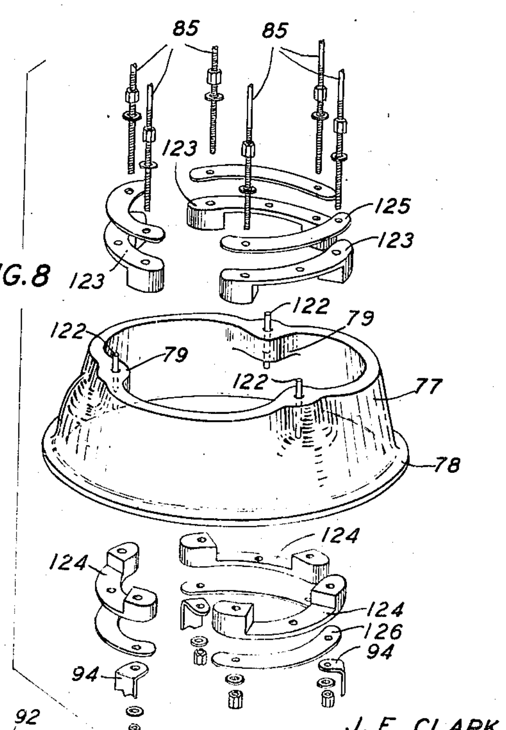


FIG. 8



INVENTORS: J. E. CLARK
S. O. EKSTRAND
V. L. RONCI

BY Walter C. Kiesel
ATTORNEY

Aug. 27, 1940. J. E. CLARK ET AL 2,212,929

HIGH POWER DISCHARGE DEVICE

Filed June 1, 1938 4 Sheets-Sheet 4

FIG. 9

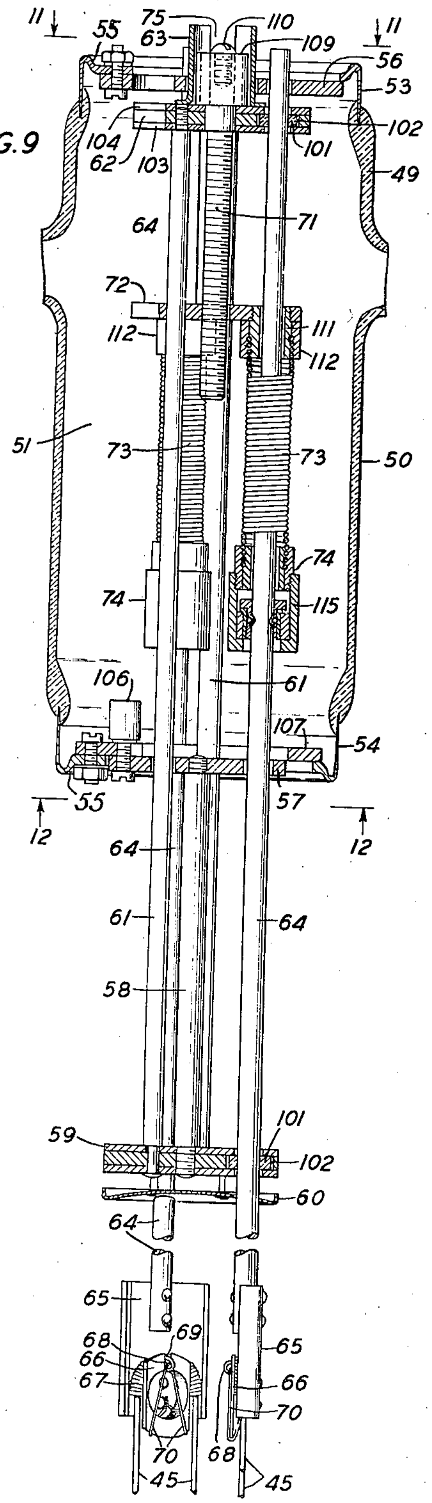


FIG. 11

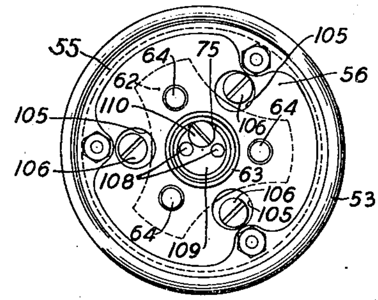


FIG. 12

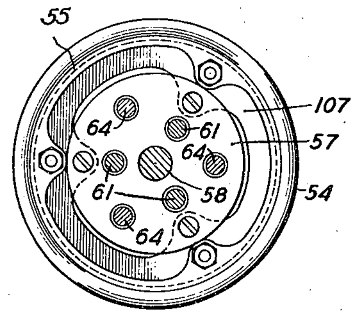
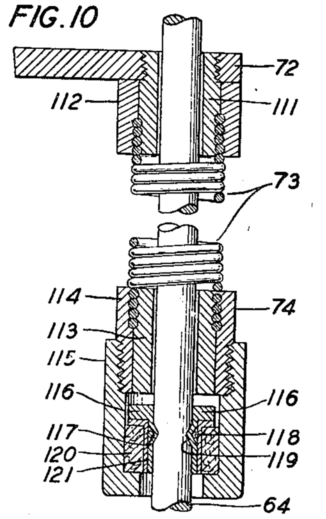


FIG. 10



INVENTORS J.E. CLARK
S.O. EKSTRAND
V.L. RONCI

BY

Walter C. Kiesel

ATTORNEY

Patented Aug. 27, 1940

2,212,929

UNITED STATES PATENT OFFICE

2,212,929

HIGH POWER DISCHARGE DEVICE

James E. Clark, Long Island City, N. Y., Sture O. Ekstrand, Bergenfield, N. J., and Victor L. Ronci, Brooklyn, N. Y., assignors to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application June 1, 1938, Serial No. 211,184

15 Claims. (Cl. 250—27.5)

This invention relates to improvements in space current devices and more particularly to devices for controlling a large amount of power.

In such devices, especially of considerable size and capacity, for instance, devices having a rating of 250 kilowatts or more, it is essential to provide high insulation resistance between the low potential electrodes, such as a cathode and a grid or control electrode and a high voltage anode. Furthermore, under the high temperature conditions prevalent during operation, electrostatic stresses and mechanical strains must be minimized to insure a high power output efficiency. It is also desirable to maintain the cathode under tension to compensate for electrodynamic forces tending to distort the cathode strands and thereby alter the operating characteristics of the device. Under these conditions frictional resistance between cooperating elements of the electrode supporting assemblies must be reduced to insure long operating life and stable spaced relationship between the active electrode surfaces.

An object of this invention is to facilitate the assembly of the various electrodes in a device to insure high power efficiency and high insulation resistance between the electrodes.

Another object of the invention is to preserve the inter-spacial relationship between the several electrodes regardless of the intense heat generated in the device.

A further object of the invention is to alleviate frictional, electrostatic and electrodynamic forces which produce torsional strains and distort the internal electrodes.

It is also an object of the invention to organize the assembly of the device in such a manner that the various electrodes may be fabricated into a compact unit of high power rating with a minimum of skilled labor and at a low cost commensurate with the power capacity.

In accordance with the general aspects of this invention, the high power space current device is particularly applicable to the external metallic anode type in which the anode forms a part of the enclosing vessel and the heat generated in the anode is dissipated by a cooling fluid flowing in a jacket surrounding the anode. The anode is provided with a hollow insulating portion at each end to support the internal electrodes, such as a cathode and a grid, in uniform coaxial relation to the anode and to provide long insulating paths between these electrodes and the high potential anode. The filamentary cathode assembly is mounted coaxially within the anode by the end insulating portions and a control electrode or grid is interposed between the cathode and the anode and is also supported at both ends by the insulating portions. This arrangement insures a compact unit in which the interspacial relationship of the elements is accurately maintained and a large amount of power is generated and controlled with high efficiency. Furthermore, the useful life of the device is materially increased by the high leakage resistance paths between the electrodes.

A feature of this construction, particularly for multi-phase power supply for heating the cathode to its operating temperature for maximum space current conduction in the device, is the distribution of the leading-in conductors in spaced relation in one of the hollow insulating portions and the cooperative tension assembly for the cathode in the opposite insulating portion so that the multiple strands of the cathode extending through the anode portion are uniformly spaced with respect to the anode surface.

A further feature of the above assembly is the substantially complete shielding of the tension assembly for the cathode from the high temperature zone of the device. This is accomplished by providing an inner insulating chamber within one of the hollow insulating end portions of the device and mounting the tension assembly therein so that it is substantially unaffected by the intense heat generated during operation, thereby materially increasing the operating life of the device.

Another feature of this invention relates to the alignment of the strands of the cathode by a guiding assembly which insures accurate linearity of the strands with their rigid terminal ends to avoid strain on the seals of the leading-in conductors. This arrangement embodies rigid guiding mounts adjacent opposite ends of the multistrand cathode having jewel bearings for the conductors and tension hangers for the cathode assembly. These guiding mounts insure the lowest coefficient of friction at high temperatures and thereby insure the proper tension in the filament strands to compensate for the electrodynamic forces exerted on the strands during operation.

A further feature of the tension assembly of the cathode strands is the axial relationship of the tension springs and hangers for the filament strands whereby the tension force is applied along the axis of the hangers. This is accomplished by placing a spring around each hanger and securing the hanger to the spring by a gripping mechanism which permits the hanger to ride freely in the guide mount along a normal line of low frictional resistance.

An added feature of this assembly is the adjustable mechanism for applying a uniform tension to all the filament strands and the positive locking arrangement for maintaining the required tension on the filament strands. This assembly involves a common adjustable member mounted in one end of the inner chamber of the device which is connected to a platform carrying all the tension spring units. After the proper tension is applied, the adjustment is locked in a sleeve extension on the chamber closure. This arrangement also facilitates assembly and adjustment of the tension mechanism after the filament hangers are fabricated in the chamber.

The hanger gripping mechanism also constitutes another feature of this invention whereby the filament hangers are secured to the tension spring units. This construction comprises a gripping chuck which securely embraces the filament hanger and prevents slippage of the hanger in a longitudinal direction. The chuck includes an insulating sleeve adjacent to the chuck jaws to insulate the individual strands and the chuck jaws are reenforced by an auxiliary member of high tensile strength to prevent deformation of the jaws due to the tension stress placed upon the hanger.

Another feature of the tension assembly involves the location of the spring units between the top and bottom guide mounts to relieve torsional strain on the springs during transitional periods of expansion and contraction incident to the operation of the device.

Several features of the invention are embodied in the grid assembly to insure coaxial and angular relationship of the controlling portion of the grid with the cathode strands and the surface of the anode.

The grid structure is provided with guide extensions which are capable of moving in low friction bearings mounted in an annular ring member formed on one of the hollow end portions of the device to permit the grid to expand and contract without distortion. This arrangement also permits a limited lateral movement of the grid guides and the bearings during expansion periods to prevent torsional strain affecting the contour and alignment of the grid structure.

Another feature of the grid assembly is the mounting of the opposite end of the grid on an annular seating member carried by the opposite end insulating portion of the device. In this construction the grid supporting rods are attached to segmental connectors which are affixed to the annular seating member at their centers by rigid pins fixed in the seating member. These pins extend through the connectors and press against tension strips to compensate for differences in planar relations between the grid supports and the seating member. This arrangement facilitates assembly since it is unnecessary to provide precision alignment of the grid supports with definite apertures in the seating member and limits strains set up by differential expansion of the elements.

The invention, both as to its organization and method of assembly, with further features and advantages will best be understood by reference to the following detailed description in combination with the accompanying drawings showing the preferred embodiment of the device.

Fig. 1 is a general perspective view of the complete device embodying the features of this invention;

Fig. 2 illustrates a straight-line assembly of the principal elements of the cathode supporting structure in the same relation as shown in the device of Fig. 1;

Fig. 3 is an enlarged view of the lower portion of the cathode structure of Fig. 2 with parts in cross-section to show details of the assembly;

Fig. 4 is an enlarged view of the upper portion of the cathode structure of Fig. 2 with certain parts shown in cross-section;

Fig. 5 is an enlarged view of the grid structure employed in the device of Fig. 1 with essential parts of the supporting structure shown to visualize the assembly;

Fig. 6 shows a perspective view of the top mounting stem for the grid of Fig. 5;

Fig. 7 shows a perspective view of the bottom mounting stem for the grid of Fig. 5;

Fig. 8 is an exploded view in perspective of the stem and associated parts shown in Fig. 7;

Fig. 9 is an enlarged view in partial cross-section showing the assembly details of the tension unit for the cathode;

Fig. 10 is a further enlarged cross-sectional view of one of the spring tension units shown in Fig. 9;

Fig. 11 is a plan view of the details of Fig. 9 taken on the line 11—11; and

Fig. 12 is a plan view of the assembly taken on the line 12—12 of Fig. 9.

Reference will now be made to the drawings and particularly to Fig. 1, showing the complete assembly, which has an over-all length of approximately seven feet and a capacity of 250 kilowatts power output. The device involves a highly evacuated enclosing vessel of the general form shown in U. S. 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, preferably of copper, surrounded by an integral metallic cooling jacket 21 and two vitreous bulbous end portions 22 and 23, of relatively hard boro-silicate glass, which are hermetically sealed to the opposite ends of the anode portion 20 in accordance with the method disclosed in U. S. Patent 1,294,466, issued February 18, 1919, to W. G. Housekeeper. The cooling jacket 21 is preferably formed of two half sections, for convenience of manufacture, which are joined together at the center by a ring member 24 brazed over the abutting ends of the half sections and the extreme ends of the jacket are brazed to the wall of the anode portion 20. The whole external surface of the water jacket and the projecting ends of the anode are coated with a protective layer of oxidized silver to prevent deleterious oxide formation and also to improve the physical appearance of the metal parts of the device.

The bulbous end portion 23 is provided with a reentrant tubular glass portion or sleeve 25 having a flare 26 fused to the open end of the portion 23. A precast or molded dish-type stem 27 shown more clearly in Fig. 3 is provided with six tubular sleeves or ferrules 28 arranged in circular formation and projecting outwardly toward the joined ends of the tubular portion 25 and the end portion 23. The stem 27 has a flanged rim 29 which is fused to the inner wall of the tubular portion 25, adjacent the inner end thereof. The stem 27 is also provided with a central integral tubular extension 30 which projects towards the anode 20 and is coaxially arranged with respect to the axis of the device. A metallic collar or sleeve 31, preferably of copper, is sealed into the end of the tubular extension 30 and forms a supporting base for a guiding mount. This mount consists of a plurality of steel spindles 32 attached to a supporting plate 33 which is securely fastened in the collar or sleeve 31. The spindles carry a pair of spaced guide plates 34 and 35 and the mount also supports a metallic shielding disc 36 adjacent the top guide plate 35. The steel spindles provide a rigid supporting structure for the guide plates and are protected against serious corrosions by nickel sleeves 44 between the plates 33, 34 and 35 of the mount.

Each of the ferrules 28 in the stem 27 has a metallic cup 37 hermetically sealed to the rim of the ferrule to form the conductor seals for supplying heating energy to the cathode of the device. A flexible heavy conductor 38 is brazed to the outer end of the cup 37 and a composite conductor is connected to the interior of the cup 37. This conductor consists of a length of copper rod 39 brazed at one end in the interior of the cup 37 and extends vertically beyond the collar 31. A tungsten rod section 40 extending into a counter-bored end of the copper rod 39 is bent inwardly above the joint to extend through guide holes in the plates 34 and 35 and also extends through clearance holes in the shield 36. Beyond the shield 36 the rod 40 is joined to a counter-bored molybdenum section 42 which is provided with a reduced end portion 43. All of the composite conductors are arranged on the boundary of a cylinder and therefore surround the guide mount supporting collar 31 with the tungsten sections 40 bent inwardly to pass through the guide apertures in parallel relation in the plates 34 and 35. The arrangement of the conductors insures a structure which is free from subsequent mechanical defects since the bend in the conductors is provided in the tungsten section 40 which does not develop fatigue stress and the molybdenum section 42 and the copper section 39 are free from bends so that no mechanical stresses can develop in the conductors. An electron emitting cathode formed of a plurality of loop strands 45, preferably of tungsten, have their parallel ends fused or welded into the reduced end 43 of the molybdenum section of the conductors.

The glass end portion 22 on the opposite end of the anode 20 is provided with a sealed tip 46 through which the device is exhausted prior to the sealing operation. An annular sleeve 47, of glass, having a flare portion 48 sealed to the inner wall of the end portion 22 intermediate the tip and the anode 20, extends in a direction toward the tip with the rim thereof fused to the flares of the two cylindrical glass members 49 and 50 so that the cylinder 49 extends toward the tip 46 while the cylinder 50 extends toward the anode and together form an inner chamber 51. The sleeve 47 is also provided with a plurality of ports 52 as shown in Fig. 4 which form outlets for gases and vapors generated by the electrodes during the evacuation process which are pumped out through the space leading to the tip 46 of the device. A metallic ring 53, of copper, is sealed into the rim of the glass cylinder 49 and a similar ring 54 is sealed into the rim of the cylinder 50. These rings are provided with an inwardly flanged rim 55 to support metallic closure plates 56 and 57, respectively. The chamber 51 is removed from the high temperature zone within the area of the anode proper and therefore forms an enclosure which is substantially unaffected by heat radiation or conduction in the device. Furthermore, the chamber being substantially formed of vitreous insulating material the mass of the structure is materially reduced and there is less chance for the chamber structure to be impaired by high frequency heating usually employed in degassing some of the internal electrodes and elements of the device. However, the chamber may also be formed of a metal wall in devices of lower capacity where the change is desirable for manufacturing reasons.

A central spindle 58 is secured to the closure disc or plate 57 and extends downwardly in the direction of the anode and is coaxial therewith. A guiding plate 59 is secured to the end of the spindle and a metallic shield 60 is arranged across the face of the guiding plate and attached to the center thereof. The guiding mount suspended from the lower closure plate 57 carries a plurality of vertical steel rods 61 which extend through the closure plate 57 and support a second guiding plate 62 having a cylindrical sleeve 63 projecting through an aperture in the closure plate 56. This arrangement insures an axial alignment of the bearing mount since the guiding sleeve 63 cooperates with a central opening in the top closure plate to align the apertures in the guide plates 59 and 62 for receiving a plurality of rigid hanger rods 64, preferably of tungsten, which extend successively through the top closure plate 56, guiding plate 62, closure plate 57, guiding plate 59 and shield 60. The end of the hanger rod within the anode area is provided with a curved shield member 65 having a rigid sheave 66 attached to the inner surface thereof to receive a loop end of the cathode strand 45. A helically wound wire sleeve 67 surrounding the filament strand is seated over the sheave and the wire sleeve is provided with an eccentric loop 68 at the center thereof which is seated in a slot 69 of the sheave and secured thereto by a tie wire 70 which passes through the eccentric loop and is threaded through small holes in the bottom of the sheave. This arrangement prevents the sleeve 67 being displaced from the sheave and also prevents the filament strand from being displaced from the sheave race. However, the filament strands may move through the sleeve 67 depending on the expansion and contraction of the parallel strands of the filament without any danger of the filament being welded to the sheave 66 when it is heated to operating temperature.

The hangers 64 are resiliently supported by a tension assembly or unit mounted within the inner chamber 51. The tension assembly includes an adjustable tension member or screw 71, which extends through the guiding plate 62 and carries a threaded platform 72 slidably centered on the rods 61. The platform also carries a plurality of helical tension springs 73 which surround the hanger members 64 and support gripping units or chucks 74 which frictionally engage the hanger rods 64. The adjustable screw 71 is locked in position after the proper tension is applied to the hanger members by a set screw which is also locked in position by a slot 75 in the guiding sleeve 63. This arrangement provides a tension support for the filament strands in which the tension forces are applied to the hangers along lines parallel with the axis of the device and strains caused by electrodynamic forces acting on the heated filament strands are minimized to ensure freedom from mechanical faults.

The control electrode or grid assembly and the details thereof are shown clearly in Figs. 5 to 8, inclusive. This assembly embodies a supporting structure in each of the end glass portions 22 and 23 which includes an annular dish-type glass mounting or stem 76 fused to the inner wall of the glass end portion 22 adjacent the lower end of the inner chamber 51 with its smaller diameter end projecting toward the anode 20. A similar annular dish-type mounting or stem 77 is fused to the inner wall of the end portion 23 just beyond the position of the metallic sleeve 31 supporting the guiding mount for the filament. This stem also has its smaller diameter end projected toward the anode 20. The shape of this annular support is shown more clearly in Fig. 6 in which the larger diameter end is provided with a flange rim 78 which is sealed to the wall of the end portion. The smaller diameter end of the support has three equaly spaced depressed sides so that the aperture forms an outline of a clover leaf, the subtended portions being provided with bearing seats 79.

The grid assembly is composed of vertical spaced rods 80 which support a helical winding 81 which forms the grid proper and is located between the cathode 45 and the anode 20 in coaxial relation thereto. The grid supporting rods 80 are attached to end collar members 82 and 83 which also carry rod extensions 84 and 85, respectively, projecting in opposite directions from the grid proper. These rods are reenforced by additional collars 86 and 87, respectively, which are provided with bent portions which clear the bearing projections 79 on the glass supporting stems 76 and 77. Three of the rods 84 at spaced positions on the collar 86 project beyond the collar and are connected to tungsten guide rods 88 by molybdenum sleeves 89. The guide rods 88 pass slidably through a synthetic jewel bearing 90 enclosed in a bearing seat formed in the portion 79. Glass beads are fused over the seat opening and the bearings are retained within the seat although the bearing is free for limited movement within the seat in all directions. These bearings are formed of highly fused aluminum oxide which has been subjected to such high temperatures that the bearing exhibits characteristics of a sapphire of commercial grade having a very low coefficient of friction at the temperatures encountered during the manufacture and use of the device. Other suitable bearing material may be employed having the above properties. The bearings may be completely polished although it is only necessary to polish the inner surface thereof to provide a low friction surface for the guide rods 88.

The supporting rods 85 of the grid structure extending beyond the ring 87 are connected in pairs to arcuate metal members by a threaded connection and the members are secured to the annular support 77 at suitable bearing points. The grid structure is supplied with controlling current through an external terminal 92 sealed to the side wall of the end portion 23 and this terminal carries an inner metallic plug 93 which is provided with a flattened end to be secured to a bifurcated flexible conductor 94 having three arms which are connected to the arcuate members supporting the grid structure. A metallic base 95 is also attached to the end glass portion 23 and carries a number of metallic bushings 96 for the leading-in conductors 33 which are provided with terminal lugs 97 exterior to the device. The base is provided with apertures for circulating air through the hollow cavity enclosing the terminal seals 37 of the conductors and these apertures are arranged in the base so that an air hose 98 may be threaded to a central nipple 99 on the base to inject air into the seal chamber. A ring of outlet holes 100 is provided around the bushings 96 in the base as outlet ports for the air.

In addition to the jewel bearings 90 for providing a low friction sliding support for the grid structure, similar bearings 101, as shown in Fig. 9, are also provided in the bearing plates 34, 35, 59 and 62 for the cathode assembly so that the current conductors are free to expand in a longitudinal direction with the least amount of friction and the cathode hangers 64 may be slidably movable in normal planes to the cathode strands. The details of the bearing plate in the guide mount are shown in Fig. 9 and a description of one of the plates 62 will suffice for the remaining guide plates associated with the cathode structure. The main bearing plate is a disc, such as 62, having apertures 102 slightly larger in diameter than the jewel bearing 101 so that the bearing has a limited movement in the bearing plate. The bearings are held in position by end cover plates 103 and 104. While all the bearing plates are substantially the same in general structure and form, the upper bearing plate 62 has a configuration in which the bearings are located in three arms of the plate as shown in Fig. 11. The bearing plate 62 also carries the guiding sleeve 63 for aligning the guiding mount for the hangers 64. Figs. 9 and 11 also show the closure plate 56 provided with three holes or apertures 105 to provide clearances to the lock nuts 106 for attaching the lower closure plate 57 to a backing ring 107 which is fastened to the collar 54. These apertures permit a tool to be inserted into the chamber 51 to lock the nut 106 in position. The cut-out portions of the three-armed plate 62 provide clearances for the tool.

The bearing plate 62 also forms a mounting for the adjustable tension screw 71 which is threaded to the tension platform 72. The tension is applied to this screw by a special tool which is inserted in the holes 108 in the head 109 of the screw and the tension is maintained by a set-screw 110 which is locked in the slot 75 of the guiding sleeve 63.

The tension platform 72 carries three gripping sleeves or members formed of a two-part coupling composed of an internal sleeve 111 threaded at both ends having a central aperture for the passage of the hanger 64 and an external member 112 internally threaded for gripping the end turns of the tension spring 73 as shown in Fig. 10. The friction chuck 74 on the opposite end of the tension spring 73 is composed of a sleeve coupling having an inner member 113 and an outer member 114 gripping the opposite end of the tension spring 73 and the outer member is threaded to a chuck body 115 which encloses a pair of split jaws 116 having semicircular ridges 117 reenforced by a backing piece of molybdenum rod 118, the ridges 117 fitting into a detent 119 on the hanger 64. An insulating sleeve 120 is mounted in the chuck between the split jaws and the body member 115, to insulate each hanger in the tension assembly and a spacer sleeve 121 separates the split jaws from the insulator as shown in Fig. 10.

The tension mounting of the grid assembly as shown in Figs. 7 and 8 facilitates the fabrication of the grid structure in the device and provides a support in which differences in alignment of the grid rods and the supporting stem are compensated and precision coupling is eliminated by providing pin bearings for connecting the lower end of the grid to the supporting stem. As shown in Fig. 8 the three bearing seats 79 have individual pins 122 sealed therein and these pins extend beyond the surfaces of the bearing seats to form pivots which enter the central apertures of a pair of arcuate connectors 123 and 124 located above and below the bearing seat 79 as shown in Fig. 7. These connectors are provided with a central cut-out portion so that the ends are in abutting relation and clear the depth of the bearing seat 79 in the stem 77. A pair of resilient metallic springs 125 and 126, preferably of molybdenum, having the same contour as the connectors lie over the outer faces of the connectors. These springs and the associated connectors are drilled at the ends to receive a pair of threaded rods 85 of the grid structure so that each pair of rods is attached to an individual arcuate connector or segmental ring and the centers of the connectors are coupled to the pins 122 in the stem for supporting the grid. When the associated nuts are applied to the grid supports 85 extending through the lower connectors and springs, the associated pair of connectors are drawn together and the pin bears against the resilient spring to apply a tension force to the mounting and thereby securely fasten the grid structure to the stem.

The combined units as heretofore described produce an assembly in which high efficiency may be obtained from the device with a minimum of mechanical defects even at high temperatures. The assembly also insures long operating life for a high power device by providing an organization which compensates for electrodynamic and electrostatic forces and differential expansion present in the device under high power operating conditions.

While the various structures have been described in connection with a specific embodiment of the invention, it is, of course, understood that various modifications may be made in the detailed assembly and the association of the related parts without departing from the scope of this invention as defined in the appended claims.

What is claimed is:

1. A discharge device including a metallic anode portion, vitreous portions sealed to opposite ends of the anode portion, a filament supporting assembly in said device including a plurality of filament strands, terminal conductors attached to said strands and extending through one of said vitreous portions, and a tension assembly for said strand enclosed in the other vitreous portion, said assembly comprising hanger members, a plurality of guiding means for said members, and spring tensioned elements for said members between said guiding means.

2. A high power discharge device having a metallic anode portion and a hollow glass portion sealed thereto, a multistrand filament within said anode portion, a plurality of hangers for said multistrand filament, an insulating chamber portion within said glass portion, a tension supporting assembly for said hangers mounted in said chamber, and means including said chamber portion protecting said assembly from radiation of heat generated in the high temperature region of said anode portion.

3. A high power space current device having a cylindrical metallic anode portion terminated by end insulating portions, a plurality of leading-in conductors sealed into one of said insulating portions and extending into said anode portion, a plurality of electron producing strands joined to said conductors and extending through said anode portion in coaxial relation thereto, a hollow chamber portion mounted within the other insulating portion, metallic closure members for the opposite ends of said chamber, parallel hanger members passing through said closure members and extending into said anode portion to support said strands, and a tension unit mounted in said chamber, said unit including spring assemblies individually surrounding and frictionally embracing said hangers to apply a tension force to said strands.

4. A high power space current device having a cylindrical metallic anode portion terminated by end insulating portions, a plurality of leading-in conductors sealed into one of said insulating portions and extending into said anode portion, a plurality of electron producing strands joined to said conductors and extending through said anode portion in coaxial relation thereto, a hollow chamber mounted within the other insulating portion, a metallic closure member for each end of said chamber, parallel hanger members passing through said closure members and extending into said anode portion to support said strands, a metallic guide plate adjacent each of said closure members, a support for each plate engaging its respective closure member, a plurality of bearing elements of low frictional coefficient at high temperatures located in each guide plate, said hangers slidably engaging said bearing elements, and a tension unit for said hangers positioned within said chamber between a guide plate and one of said closure members.

5. A high power spaced current device having a cylindrical metallic anode portion terminated by end insulating portions, a plurality of leading-in conductors sealed into one of said insulating portions and extending into said anode portion, a plurality of electron producing strands joined to said conductors and extending through said anode portion in coaxial relation thereto, a hollow chamber mounted within the other insulating portion, metallic closure members for the opposite ends of said chamber, parallel hanger members passing through said closure members and extending into said anode portion to support said strands, and a tension unit mounted in said chamber, said unit including a platform and spring assemblies surrounding said hangers, a guiding plate adjacent said tension unit having a tubular sleeve extending through one of said closure members, and a tension adjusting element within said sleeve and engaging said platform.

6. A high power space current device having a cylindrical metallic anode portion terminated by end insulating portions, a plurality of leading-in conductors sealed into one of said insulating portions and extending into said anode portion, a plurality of electron producing strands joined to said conductors and extending through said anode portion in coaxial relation thereto, a hollow chamber mounted within the other insulating portions, metallic closure members for the opposite ends of said chamber, parallel hanger members passing through said closure members and extending into said anode portion to support said strands, and a tension unit mounted in said chamber, said unit including a platform and spring assembly surrounding said hangers, a

guiding plate adjacent said tension unit, a tubular sleeve having a slot supporting said plate on one of said closure members, a tension adjusting element extending through said sleeve and engaging said platform, and means engaging said slot for locking said adjusting element in a set position.

7. A high power space current device having a cylindrical metallic anode portion terminated by end insulating portions, a plurality of leading-in conductors sealed into one of said insulating portions and extending into said anode portion, a plurality of electron producing strands joined to said conductors and extending through said anode portion in coaxial relation thereto, a hollow chamber mounted within the other insulating portion, closure members on opposite ends of said chamber, parallel hanger members passing through said closure members and extending into said anode portion to support said strands, and a tension unit mounted in said chamber, said unit including a platform through which said hangers pass, a plurality of gripping elements engaging said hangers, a plurality of tension springs surrounding said hangers between said platform and said gripping elements, and spring gripping connectors affixing said springs to said platform and said elements.

8. A high power space current device having a cylindrical metallic anode portion terminated by end insulating portions, a plurality of leading-in conductors sealed into one of said insulating portions and extending into said anode portion, a plurality of electron producing strands joined to said conductors and extending through said anode portion, a hollow chamber mounted within the other insulating portion, closure members on the opposite ends of said chamber, parallel hanger members passing through said closure members and extending into said anode portion to support said strands, and a tension unit mounted in said chamber, said unit including a platform through which said hangers pass, a plurality of friction chucks engaging said hangers, a plurality of tension springs surrounding said hangers between said platform and said chucks, and spring gripping connectors affixing said springs to said platform and to said chucks.

9. A high power space current device having a cylindrical metallic anode portion terminated by end insulating portions, a plurality of leading-in conductors sealed into one of said insulating portions and extending into said anode portion, a plurality of electron producing strands joined to said conductors and extending through said anode portion, a hollow chamber mounted within the other insulating portion, closure members on the opposite ends of said chamber, parallel hangers passing through said closure members and extending into said anode portion to support said strands, and a tension unit mounted in said chamber, said unit including a platform through which said hangers pass, a plurality of gripping elements engaging said hangers, a plurality of tension springs surrounding said hangers between said platform and said gripping elements, and threaded sleeve members on said platform and said elements, respectively, embracing the ends of said springs to couple said hangers to said platform.

10. A high power space current device comprising a metallic anode portion and an insulating end portion having a reentrant tubular section, a dish-type stem sealed to said section having a central extension projecting toward said anode portion and ferrules projecting in an opposed direction, a plurality of leading-in conductors sealed through said ferrules and concentrically arranged about said extension, a guiding mount supported by said extension having apertures spaced in relation with said ferrules whereby said conductors extend through said mount, and a plurality of filament strands supported in spaced relation to said anode and connected to said conductors.

11. A high power space current device comprising a metallic anode portion and an insulating end portion having a reentrant tubular section, a dish-type stem sealed to said section having a central extension projecting toward said anode portion and spaced ferrules projecting in an opposed direction, a plurality of leading-in conductors sealed through said ferrules and concentrically arranged around said extension, a guiding mount supported by said extension having apertures spaced in relation with said ferrules whereby said conductors insulatingly extend through said mount, a plurality of filament strands supported in spaced relation to said anode and connected to said conductors, and means for connecting said mount to a conductor.

12. A high power discharge device comprising a metallic anode portion, vitreous portions sealed to opposite ends of the anode portion, a filament supporting assembly coaxially mounted within and by said vitreous portions, a control electrode interposed between said filament and said anode portion, a guiding member carried by one of said vitreous portions for one end of said control electrode, an annular member carried by said other vitreous portion, and tension supporting means connecting the other end of said control electrode to said annular member.

13. A high power space current device having a metallic anode portion and an insualting end portion having a reentrant stem therein, a multistrand filament supported in said anode portion, a plurality of leading-in conductors for said filament sealed in said stem, an annular insulating dish stem carried by said insulating end portion adjacent said reentrant stem, a cylindrical grid electrode coaxial with said filament and said anode and including spaced supports extending toward said annular stem, and means including tension springs attaching said supports to said annular stem.

14. A high power space current device comprising a metallic anode portion and an insulating end portion having a reentrant stem therein, a multistrand filament supported in said anode portion, a plurality of leading-in conductors for said filament sealed in said stem, an annular insulating stem carried by said insulating end portion adjacent said reentrant stem, a cylindrical grid coaxial with said filament and said anode and including spaced supports extending toward said annular stem, segmental ring members attached to pairs of said supports, and pins in said annular stem engaging said ring members.

15. A double-ended electron discharge power device comprising an external anode, glass portions sealed thereto at opposite ends, a reentrant stem in one of said glass portions, a plurality of leading-in conductors sealed in circular formation in said stem, a guiding mount having jewel bearings therein secured to said stem, said leading-in conductors slidably extending through said bearings, a hollow insulating chamber opened at both ends supported in said other glass portion, metallic rings sealed to the open ends of

said chamber, apertured metallic closure plates affixed to said rings, individual guiding mounts supporting jewel bearings carried by said plates, a plurality of slidable hangers extending through said bearings and closure plates, a tension assembly enclosed in said chamber and including helical springs surrounding said hangers and clamped thereto at an intermediate point, a plurality of filament strands resiliently supported at one end by said hangers and secured at the other end to said conductors, a cylindrical grid surrounding said strands, supports on said grid extending into both glass portions, annular dish-type stems affixed to said glass portions, said supports slidably extending through one of said dish stems and being resiliently connected to said other dish stem, a terminal sealed to the side wall of one of said glass portions, a bifurcated conductor strap connecting said grid supports to said terminal, and a metallic base on the same glass portion associated with said leading-in conductors having inlet and outlet air ports formed in said base concentric with said conductors for cooling the reentrant stem enclosing said conductors.

JAMES E. CLARK.
STURE O. EKSTRAND.
VICTOR L. RONCI.