Oct. 21, 1952 S. M. DUKE 2,615,137

HIGH-POWER VACUUM TUBE

Filed Jan. 5, 1946 3 Sheets-Sheet 1

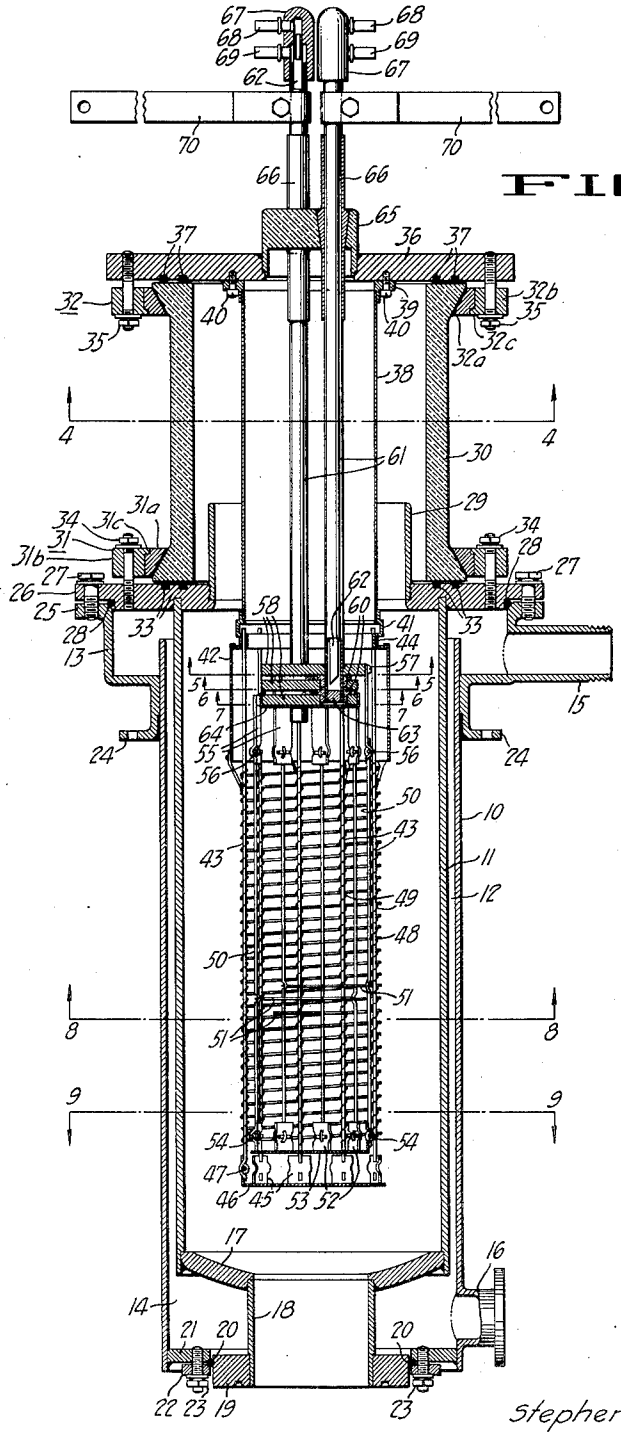


FIG. 1

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HIGH-POWER VACUUM TUBE

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FIG_2_

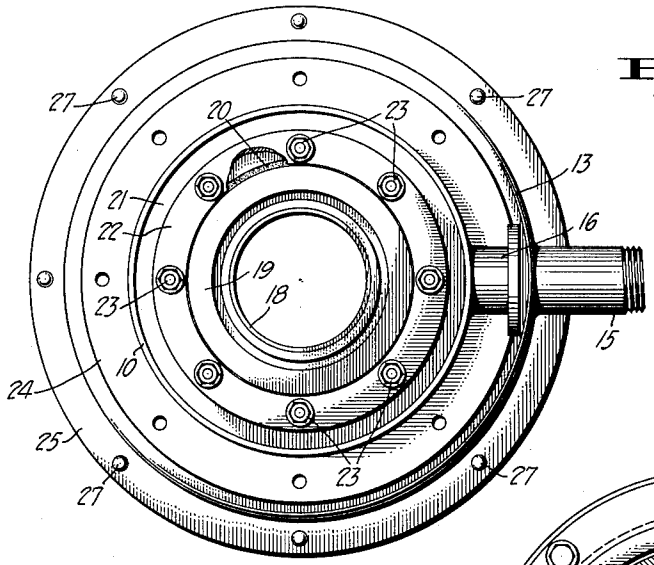
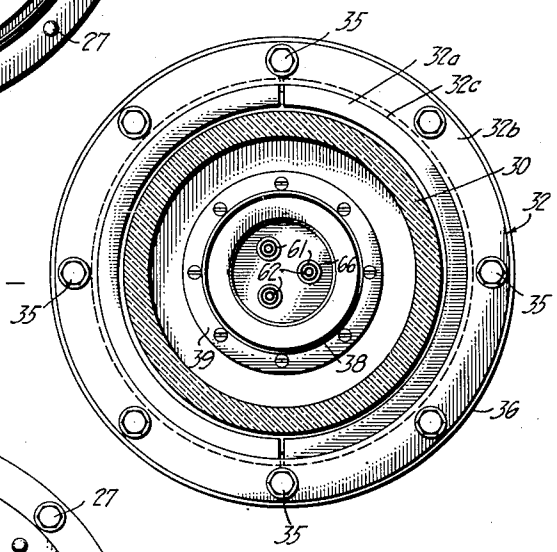


FIG_4_



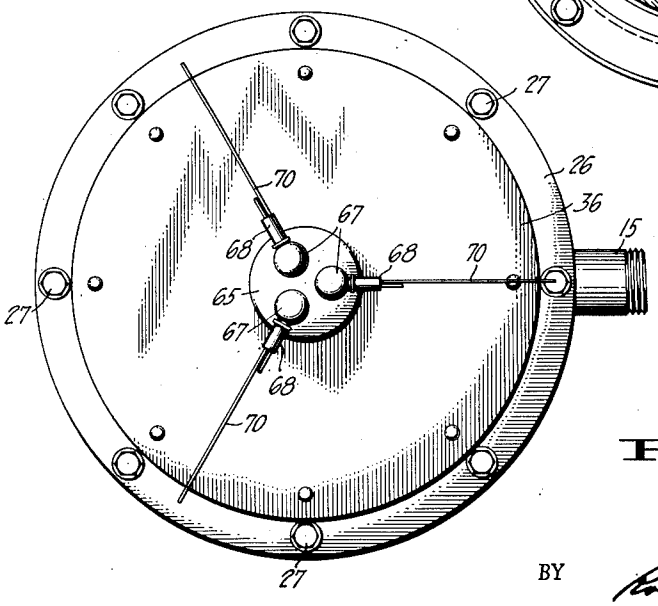


FIG_3_

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HIGH-POWER VACUUM TUBE

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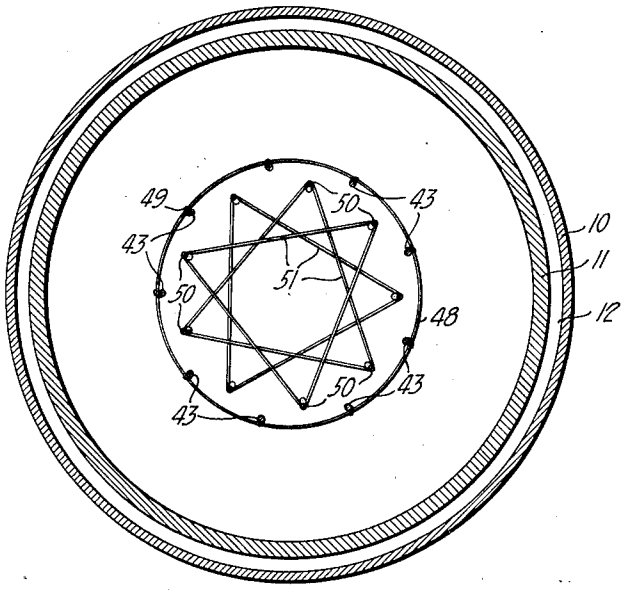


FIG_8_

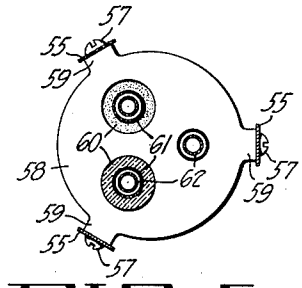


FIG_5_

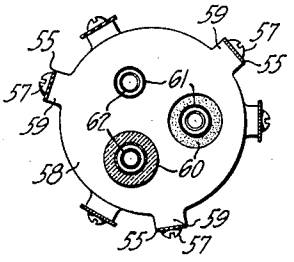


FIG_6_

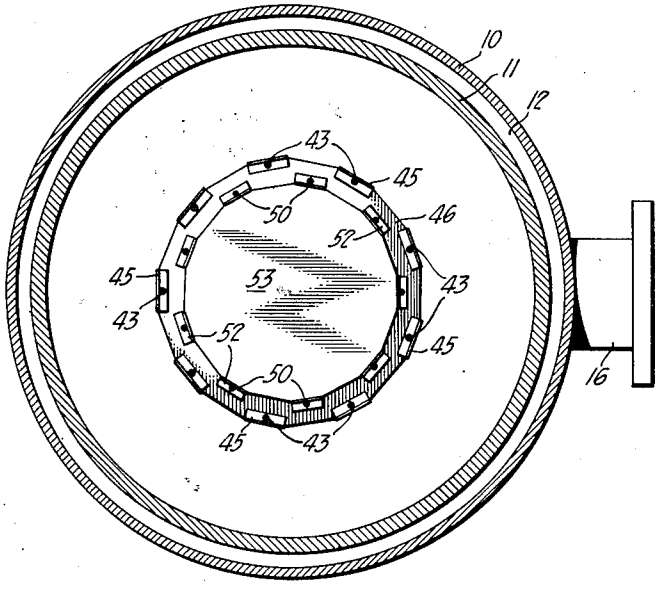


FIG_9_

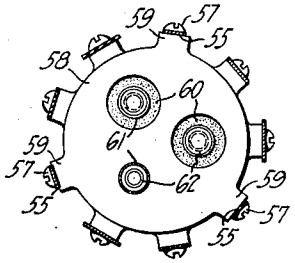


FIG_7_

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UNITED STATES PATENT OFFICE

2,615,137

HIGH-POWER VACUUM TUBE

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Application January 5, 1946, Serial No. 639,276

13 Claims. (Cl. 313—21)

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The present invention relates to electrical discharge apparatus in general and more particularly to high power vacuum tubes of the water-cooled type.

It is an object of the present invention to provide an improved high power vacuum tube built and assembled in such fashion that it can be taken apart and repaired in the field without the aid of factory tools and facilities.

Another object of this invention is to provide the high power vacuum tube of improved construction giving a high degree of accessibility of the operative elements and improved electrical characteristics.

Still another object of this invention is to provide a high power vacuum tube of the water-cooled type with characteristics which lend its application as a high power, high voltage regulator tube of the losser type.

Another object of this invention is to provide a high power vacuum tube of improved cathode construction.

Still another object of this invention is to provide a high power vacuum tube of improved grid electrode construction.

Other and further objects of this invention will be apparent to those skilled in the art to which it relates from the following specification, claims and drawings.

In the drawings, briefly, Figure 1 is a longitudinal sectional view of one embodiment of the high power vacuum tube of this invention;

Fig. 2 is an end view of the high power vacuum tube looking at the tube from the anode end;

Fig. 3 is an end view of the high power vacuum tube looking at the tube from the cathode terminal end;

Fig. 4 is a sectional view taken along the line 4—4 of Fig. 1;

Fig. 5 is a sectional view taken along the line 5—5 of Fig. 1;

Fig. 6 is a sectional view taken along the line 6—6 of Fig. 1;

Fig. 7 is a sectional view taken along the line 7—7 of Fig. 1;

Fig. 8 is a sectional view taken along the line 8—8 of Fig. 1; and

Fig. 9 is a sectional view taken along the line 9—9 of Fig. 1.

Referring to the drawings in detail, reference numeral 10 designates a brass jacket of tubular cross section concentric with and displaced from the high power vacuum tube anode 11 so as to provide a water jacket space 12 therebetween, this jacket being connected to the water manifolds 13 and 14 which are connected to the water circulating plumbing, not shown, associated with the threaded pipe 15 and the flanged pipe 16. One end of the anode 11 is hard-soldered to the outer periphery of the annulus 17, this annulus having a large-size aperture substantially in the center thereof which is hard-soldered to the evacuation manifold 18. This evacuation manifold 18 is hard-soldered to a ring 19, the outer periphery of which slidably engages a soft rubber gasket 20 clamped between the rings 21 and 22 by nut and bolt elements 23, the ring 21 being soft-soldered to the end of the brass jacket 10 to define together with the ring 19, one end of the water manifold 14, the gasket 20 functioning to form a water-tight seal between the rings 19 and 21.

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The water jacket 13 cast of brass or similar material, is hard-soldered to the tubular casing 10 and is provided with flanges 24 and 25, the flange 24 functioning as a support for the high power vacuum tube and the flange 25 functioning to engage the peripheral portions of the annulus 26 and being held in close engagement therewith by means of the bolts 27, a gasket 28 of soft rubber being disposed in water-sealing relation between the members 25 and 26. One end of the anode 11 is seated in an annular groove in the lower face of the annulus 26 and is hard-soldered thereto. Threaded into the aperture of the annulus 26 is an electrostatic tubular metal shield 29 extending well into the porcelain tubular insulator 30, the ends of which are flared outwardly gradually. Each end of the porcelain tubular insulator 30 is adapted to be engaged by annular members 31 and 32. The annular member 31 is made up of a split ring 31*a* and annulus 31*b*, the annulus 31*b* being provided with an inwardly extending flange 31*c* for seating in a corresponding groove formed in the split ring 31*a*, the purpose of this construction being to permit the split ring 31*a* to be expanded and slipped over the end of the insulator 30 and thereafter to be fitted into the annulus 31*b*, the annulus 31*b* having an aperture big enough to clear the end of the insulator 30. Likewise the annular member 32 is formed of a split ring 32*a* and an annulus 32*b* having an inwardly extending flange 32*c* for the same purpose. One end of the insulator 30 is held in sealed relationship with respect to the annulus 26 by means of suitable gaskets 33 compressed therebetween by the clamping action of the annular member 31 attached to the annulus 26 by the bolts 34. Likewise the other end of the insulator 30 is sealed to the copper top plate 36 by

means of gaskets 37 compressed therebetween by the annular member 32 fastened to the end plate 36 by bolts 35. The plate 36 is therefore insulated from the annular member 26 and the anode 11 by the porcelain insulator 30.

The stainless steel tubular grid support 38 is attached to the ring member 39 which is attached to the end plate 36 by machine screws 40. The other end of this grid support tube is attached to the steel grid frame 41 which supports the molybdenum grid shield 42 and the molybdenum grid rods 43, of which there are nine. One end of each of the grid rods 43 is positioned in appropriate apertures formed in the grid support 41 so as to leave surfaces of the grid rods between these apertures exposed to the gripping action of the steel tightening band 44 which is placed in position in a groove formed therefor in the grid support 41, after the grid rods 43 are inserted into the apertures provided therefor. The other ends of the grid rods 43 are inserted into suitable apertures formed in the tongues 45 of the grid rod spacer 46 and both these tongues 45 and the end portions of the grid rods 43 are deformed so that pin-receiving spaces are provided therebetween into which the short tapered pins 47 are fitted for the purpose of locking the grid rods 43 and the tongues 45 together in assembled relation. Around the grid rods 43 is wound the spiral grid 48 consisting of a plurality of spaced turns of molybdenum wire of 0.02 inch diameter, these turns being held in proper spaced relation by spacing wires 49 consisting of turns of molybdenum wire of 0.01 inch diameter spiraled around each of the grid rods 43 so as to bind the grid wire 48 in place on these grid rods.

The cathode of this high power vacuum tube consists of a plurality of electron emitting wire-like elements 50 disposed in spaced relation substantially in a circle inside of the grid electrode structure as shown in Fig. 8. Tie wires 51 of substantially triangular configuration, formed of molybdenum wire of 0.01 inch diameter, are employed to tie the cathode wires into three groups at intermediate portions thereof. These tie wires 51 are spaced from each other longitudinally of the cathode wires by a distance of approximately ¼ inch, so that for cathode wires of approximately 9 inches in length these tie wires are positioned approximately 3¼ inches from the ends of the cathode wires, which ends are anchored in tongues 52 of the plate-like member 53 which is positioned well inside of the grid rod spacer 46, as shown in Fig. 9. The tongues 52 are deformed as are also the ends of the cathode wires 50 so that pin receiving apertures are formed therebetween for the tapered pins 54 which hold the tongues 52 and the cathode wires 50 in assembled relation. The member 53 is also of electrically conducting material, being formed specifically of molybdenum. The other ends of the cathode wires 50 are anchored in filament strips 55 which are also deformed together with these ends of the cathode wires 50 to provide pin receiving apertures for receiving the tapered pins 56 which hold the cathode wires and the strips 55 in assembled relation. It will be observed that certain of the molybdenum filament strips 55 are of different lengths from the others so that these strips may be fastened by machine screws 57 to different ones of the copper filament contact plates 58. Three of these filament contact plates are provided and each plate has three projections 59, as shown in Fig. 5, spaced 120° apart around the periphery thereof. Projections 59 are held in engagement with the filament strips 55 by means of the machine screws 57 which are threaded into the aforesaid projections. In Fig. 5 one of these filament plates 58 is illustrated; in Fig. 6 two of these plates are illustrated; and in Fig. 7 all three of the filament plates are shown disposed with respect to each other in such relation that the projections 59 thereof form angles of approximately 40°, the purpose of this angular displacement being to provide clearance between the filament strips 55, to hold the cathode wires 50 in parallel spaced relation and to provide connection between the cathode rods 50 and a source of polyphase current supply. As was pointed out previously, the cathode rods 50 are connected into three groups by the tie wires 51 so that every third one of the cathode wires 50 is in the same group, as shown in Fig. 8, and all of the cathode rods 50 of the same group are connected to the same one of the cathode plates 58 as is apparent from Figs. 5, 6 and 7. Accordingly, these copper plates 58 function to tie the cathode wires 50 together into groups at the power feeding ends of the cathode wires. The plates 58 are insulated from each other by insulation bushings 60 of Lavite disposed therebetween and supported in suitable apertures thereof. The Lavite insulation spacers 60 are machined and fitted to the apertures formed in the plates 58 so as to form a well-fitting unitary structure.

Three-phase power is fed to the cathode structure through tubular members 61 and busbar connector 70 clamped thereto. These tubular conductors 61 are hard-soldered to selected ones of the copper cathode plates 58 so that one of these tubular conductors 61 is hard-soldered to each of the plates 58 as shown in Figs. 5, 6 and 7, but is insulated from the others of said copper plates 58 by the Lavite bushings 60. Thus the plates 58 are connected to different phases of the three-phase power supply through the tubular conductors 61, all of which also function as a well braced support for the entire cathode structure. Auxiliary tubular members 62 are provided in each of the tubular conductors 61 for the purpose of feeding cooling water into the cathode ends of the tubular conductors 61 and it will be observed that the auxiliary tubular members 62 are of somewhat smaller cross section than are the tubular conductors 61 so as to provide clearance between the outside diameter of the auxiliary tubular members 62 and the inside diameter of the tubular conductors 61. The cathode ends of the tubular conductors 61 are sealed by small plugs 63 of copper hard-soldered into the ends of the tubular conductors 61. Furthermore, a molybdenum contact shield 64 is attached to the inner surface of the innermost copper plate 58.

The tubular conductors 61 are supported in spaced relation in apertures of the insulator 65 by means of the stainless steel sleeves 66 which are soft-soldered thereto. The porcelain insulator 65 is soft-soldered in vaccum-tight relation to the end plate 36. Caps 67 threaded to the end of the tubular conductors 61 and sealed thereto by red lead water-tight joints are provided with tubular connections 68 and 69 for feeding cooling water into the auxiliary tube 62 and removing it from the clearance space between the tube 61 and the tube 62.

In operation, the high power vacuum tube of this invention is supported vertically so that the cathode power connections 70 are uppermost and the vacuum pump connection is at the bottom of the tube. For this purpose the flange 24 is provided and this flange is adapted to engage a suitable support, not shown. Connections to the anode of this high power vacuum tube may be made to the flange 24 and inasmuch as the anode of this vacuum tube is adapted to be energized at voltages of the order of 20,000 volts it is obvious that the anode of this tube must be insulated from ground unless the positive terminal of the high voltage power supply is also grounded. In cases where the positive terminal of the power supply is grounded, then of course the cathode power supply must be insulated from ground.

Connections to the grid of this high power vacuum tube are made to the plate 36 and for this purpose such connections may be anchored at any one of the bolts 35. This plate 36 is connected to the grid through the grid support 38 and is insulated from the anode by the insulator 30 and from the cathode by the insulator 65.

Cooling medium is fed to the anode jacket through the pipe 15 and removed through the pipe 16 and in cases where the tube is to be employed with the anode insulated from ground, suitable lengths of porcelain tubing must be inserted into the plumbing of the cooling medium to provide a sufficient length of water column between the high voltage anode and the grounded water supply.

While there has been set forth in the foregoing specification and drawing a preferred embodiment of this invention, it is not desired to limit this invention to the exact details described and illustrated except in so far as those details may be defined in the claims.

What is claimed is:

1. A high power fluid-cooled vacuum tube comprising a tubular anode, a pair of ring-shaped plate members attached one to each end of said tubular anode, a substantially tubular member surrounding said tubular anode and slightly displaced therefrom, said tubular member having means for sealing the ends thereof to said ring-shaped members to form a water-tight jacket around said tubular anode, plumbing connections provided to said water-tight jacket for circulating cooling medium through said jacket around said anode, a grid electrode positioned inside of said anode and coaxially disposed with respect to said anode, said grid electrode comprising a wire spiral supported upon a plurality of parallel spaced rod-like members, a metallic spacer member for engaging one set of ends of said rod-like members, a perforated annular member for receiving the other set of ends of said rod-like members in the perforations thereof, a metallic sleeve attached to said annular member, a hollow electrical insulator sealed to the uppermost of said ring-shaped members and surrounding said metallic sleeve, a metallic end plate attached to the other end of said hollow insulator and to the other end of said metallic sleeve, a plurality of tubular fluid-cooled conductors, insulation means for supporting said hollow fluid-cooled conductors in said end plate and inside of said metallic sleeve, a cathode assembly including a plurality of rods positioned longitudinally of said grid electrode, and means for connecting said cathode assembly to said fluid-cooled conductors whereby said cathode is suspended in position by said fluid cooled conductors.

2. A high power fluid-cooled vacuum tube comprising a tubular anode, a watertight jacket around said tubular anode, plumbing connections provided to said water-tight jacket for circulating cooling medium through said jacket around said anode, a grid electrode positioned inside of said anode and coaxially disposed with respect to said anode, said grid electrode comprising a plurality of parallel spaced rod-like members, a wire spiral about said plurality of members, and a wire wound about each of said members engaging said wire spiral and securing it in position about said members, a metallic spacer member for engaging one set of ends of rod-like members, a perforated annular member for receiving the other set of ends of said rod-like members in the perforations thereof, a metallic sleeve attached to said annular member, a hollow electrical insulator sealed to said tubular anode and surrounding said metallic sleeve, a metallic end plate attached to the other end of said hollow insulator and to the other end of said metallic sleeve, a plurality of tubular fluid-cooled conductors, insulation means for supporting said hollow fluid-cooled conductors in said end plate and inside of said metallic sleeve, and a cathode structure suspended from said fluid cooled conductors and positioned longitudinally of and interior to said grid electrode.

3. A high power fluid-cooled vacuum tube comprising a tubular anode, a pair of ring-shaped plate members attached one to each end of said tubular anode, a substantially tubular member surrounding said tubular anode and slightly displaced therefrom, said tubular member having means for sealing the ends thereof to said ring-shaped members to form a water-tight jacket around said tubular anode, plumbing connections provided to said water-tight jacket for circulating cooling medium through said jacket around said anode, a grid electrode positioned inside of said anode and coaxially disposed with respect to said anode, said grid electrode comprising a wire spiral supported upon a plurality of parallel spaced rod-like members, a metallic spacer member for engaging one set of ends of rod-like members, a perforated annular member for receiving the other set of ends of said rod-like members in the perforations thereof, a hollow electrical insulator sealed to one of said ring-shaped plate members, a metallic end plate attached to the other end of said hollow insulator for supporting said grid electrode, a plurality of tubular fluid-cooled conductors, insulation means for supporting said hollow fluid-cooled conductors in said end plate and inside of said hollow insulator, a plurality of cathode rods positioned longitudinally of said grid electrode, and means for connecting said plurality of cathode rods to said fluid-cooled conductors.

4. A high power fluid-cooled vacuum tube comprising a tubular anode, a pair of ring-shaped plate members attached one to each end of said tubular anode, a substantially tubular member surrounding said tubular anode and slightly displaced therefrom, said tubular member having means for sealing the ends thereof to said ring-shaped members to form a water-tight jacket around said tubular anode, plumbing connections provided to said water-tight jacket for circulating cooling medium through said jacket around said anode, a grid electrode positioned inside of said anode and coaxially disposed with respect

to said anode, said grid electrode comprising a plurality of parallel spaced rod-like members, a wire spiral about said plurality of members, and a wire wound about each of said members in fixed relation thereto and engaging said wire spiral whereby said spiral is secured about said members, a perforated annular member for receiving one set of ends of said rod-like members in the perforations thereof, a metallic sleeve attached to said annular member, a hollow electrical insulator sealed to the uppermost of said ring-shaped member and surrounding said metallic sleeve, a metallic end plate attached to the other end of said hollow insulator and to the other end of said metallic sleeve, a plurality of tubular fluid-cooled conductors, insulation means for supporting said tubular fluid-cooled conductors in said end plate and inside of said metallic sleeve, a cathode structure including a plurality of parallel rods positioned longitudinally of and internal to said grid electrode, and means for connecting said cathode structure to said fluid-cooled conductors, whereby said cathode structure is supported in spaced relation with said grid electrode.

5. A high power fluid-cooled vacuum tube comprising a tubular anode, a pair of ring-shaped plate members attached one to each end of said tubular anode, a substantially tubular member surrounding said tubular anode and slightly displaced therefrom, said tubular member having means for sealing the ends thereof to said ring-shaped members to form a water-tight jacket around said tubular anode, plumbing connections provided to said water-tight jacket for circulating cooling medium through said jacket around said anode, a grid electrode positioned inside of said anode and coaxially disposed with respect to said anode, said grid electrode comprising a wire spiral supported upon a plurality of parallel spaced rod-like members, a substantially circular metallic spacer member having tongues around the periphery thereof with a pair of aligned apertures in each tongue for engaging the ends of said rod-like members, and tapered pins engaging said rods and tongues for securing said rods to said tongues, a perforated annular member for receiving the other set of ends of said rod-like members in the perforations thereof, a metallic sleeve attached to said annular member, a hollow electrical insulator sealed to one of said ring-shaped plate members and surrounding said metallic sleeve, a metallic end plate attached to the other end of said hollow insulator and to the other end of said metallic sleeve, a plurality of tubular fluid-cooled conductors, insulation means for supporting said hollow fluid-cooled conductors in said end plate and inside of said metallic sleeve, a plurality of cathode rods positioned longitudinally of said grid electrode, and means for connecting said plurality of cathode rods to said fluid-cooled conductors, whereby said cathode is suspended by said conductor.

6. A high power vacuum tube as defined in claim 2 further characterized by said cathode structure comprising three substantially circular metallic plates, each of said plates having three peripheral projections thereon spaced approximately equally about the periphery thereof, said plates each having a pair of substantially equal-sized holes cut therethrough and a third smaller hole, insulation spacing means positioned in said substantially equal-sized holes, said insulation spacing means having flanges thereon for spacing said metallic plates, three tubular fluid-cooled electrical conductors, different ones of said tubular conductors being attached to different ones of said metallic plates in said smaller apertures, said insulation spacing means having apertures corresponding to said smaller apertures for receiving selected ones of said tubular conductors, strip-like members attached to said projections, and electron emissive filament members adapted to be heated to electron emission temperature attached to said strip-like members.

7. Grid electrode structure for a high power vacuum tube comprising a plurality of substantially parallel rod-like members, each of said rod-like members having a kink formed therein in one end thereof, said rod-like members being disposed in parallel spaced relation about a circle, a cup-like member having apertures formed in surfaces thereof for receiving the kinked portions at one of the ends of said rod-like members, a plurality of tapered pins, said tapered pins being adapted to engage the kinked portions of said rod-like members and surfaces of said cup-like member to retain said rod-like members and said cup-like member in assembled relation, an apertured annular member having a groove formed around the outside thereof, said groove exposing intermediate portions of the apertures of said apertured annular member and said apertures being of a size adapted to receive the other ends of said rod-like members, and a binding member adapted to be positioned in said groove to engage surfaces of said rod-like members and binding said rod-like members against surfaces of said apertures.

8. Grid electrode structure for a high power vacuum tube comprising a plurality of substantially parallel rod-like members, each of said rod-like members having a kink formed in one of the ends thereof, said rod-like members being disposed in parallel spaced relation about a circle, a cup-like member having apertures formed in surfaces thereof for receiving the kinked portions of said rod-like members, and a plurality of tapered pins, said tapered pins being adapted to engage the kinked portions of said rod-like members and surfaces of said cup-like member to retain said rod-like members and said cup-like member in assembled relation.

9. A high power fluid-cooled vacuum tube comprising a tubular anode, a grid electrode and a cathode, an annular member attached to one end of said tubular anode, a metallic sleeve having one end attached to one end of said grid electrode, a disc-like plate attached to the other end of said metallic sleeve, a hollow electrical insulator for spacing said annular member from said disc-like plate, said hollow electrical insulator having flared ends, clamping means for engaging and clamping the flared ends of said insulator to said annular member and to said disc-like plate, said disc-like plate having a substantially centrally disposed hole formed therein, an insulator positioned in said hole, and a plurality of tubular conductors connected to said cathode and passing through said last-mentioned insulator, in fixed relation thereto, whereby said cathode is suspended within said grid electrode.

10. In a high power fluid-cooled vacuum tube, a cathode, a grid electrode and an anode, means for insulating said cathode, said grid electrode and said anode from each other, tubular means connected to said cathode for feeding current thereto, means for sealing the ends of said tubular means connected to said cathode in fluid-tight relation, auxiliary tubular means positioned inside of said tubular conductors for feeding cooling

medium into said tubular conductors adjacent to said cathode, said tubular conductors and said auxiliary tubular members having spaces therebetween for passing the aforesaid cooling medium, electrical connectors engaging said tubular conductors in clamping relation, and plumbing connections fitted to said tubular conductors and said auxiliary tubular members for feeding the aforesaid cooling medium therethrough.

11. In a high power fluid-cooled vacuum tube, a cathode, a grid electrode and an anode, means for insulating said cathode, said grid electrode and said anode from each other, a water jacket around said anode, plumbing connections for connecting a supply of cooling medium to said water jacket, tubular means for feeding current to said cathode, means for sealing the ends of said tubular means connected to said cathode in fluid-tight relation, auxiliary tubular means positioned inside of said tubular conductors for feeding cooling medium into said tubular conductors adjacent to said cathode, said tubular conductors and said auxiliary tubular members having spaces therebetween for passing the aforesaid cooling medium, electrical connectors engaging said tubular conductors in clamping relation, and additional plumbing connections fitted to said tubular conductors and said auxiliary tubular members for feeding the aforesaid cooling medium therethrough.

12. A high power fluid-cooled vacuum tube comprising a tubular anode, a grid electrode and a cathode, an annular member attached to one end of said tubular anode, a metallic sleeve having an end attached to one end of said grid electrode, a disc-like plate attached to the other end of said metallic sleeve, a hollow electrical insulator surrounding at least a part of said metallic sleeve for spacing said annular member and said disc-like plate, said hollow electrical insulator having flared ends, clamping means for engaging and clamping the flared ends of said insulator to said annular member and to said disc-like plate, said disc-like plate having a substantially centrally disposed hole formed therein, an insulator positioned in said hole, a plurality of tubular conductors connected to said cathode and to said last-mentioned insulator, and passing through said last-mentioned insulator, and said metallic sleeve, whereby said cathode is suspended within said grid electrode.

13. A high power fluid-cooled vacuum tube comprising a tubular anode, a grid electrode, a cathode, an annular member attached to one end of said tubular anode, a metallic sleeve having one end attached to one end of said grid electrode, a disc-like plate attached to the other end of said metallic sleeve, a hollow electrical insulator for spacing said annular member from said disc-like plate, said hollow electrical insulator having flared ends, clamping means for engaging said insulator and clamping the flared ends thereof to said annular member and to said disc-like plate, an insulator positioned in a hole in said disc-like plate and conductors passing through said last insulator for feeding current to said cathode.

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