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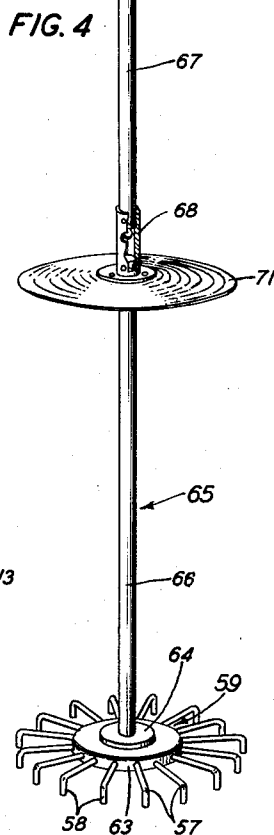
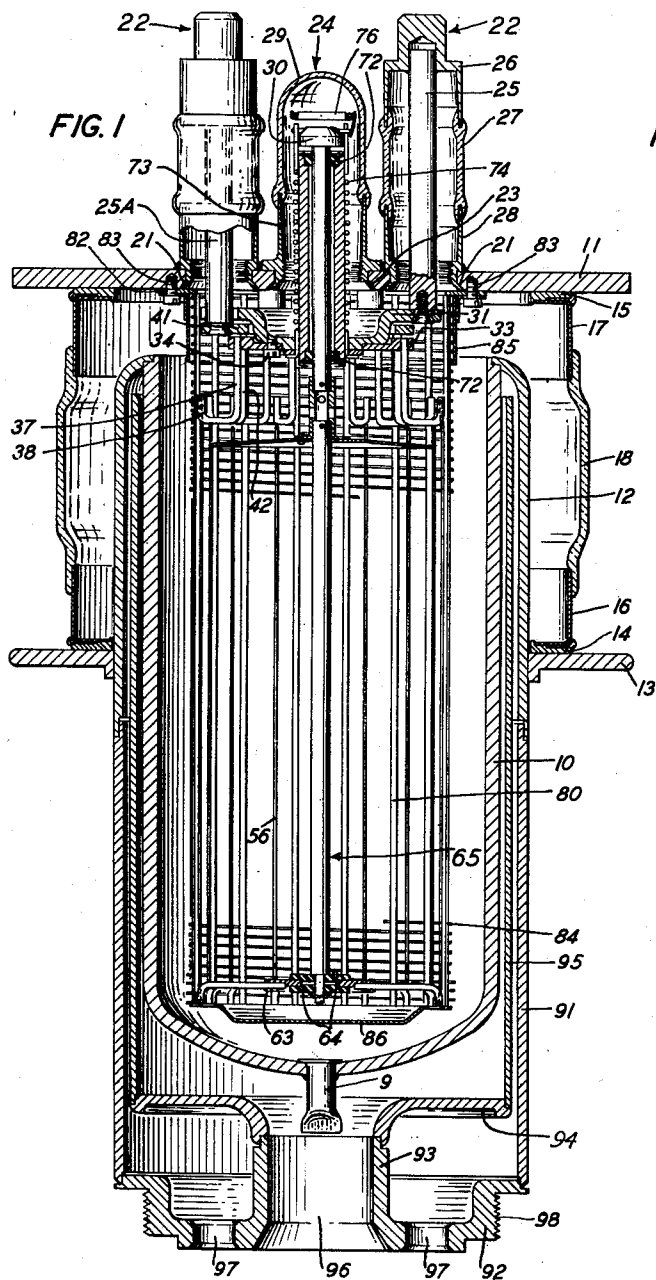
C. E. FAY ET AL

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HIGH-POWER WATER-COOLED ELECTRON DISCHARGE DEVICE

Filed Dec. 30, 1948

4 Sheets-Sheet 1



INVENTORS
C. E. FAY
D. A. S. HALE
BY
[Signature]
ATTORNEY

Dec. 19, 1950

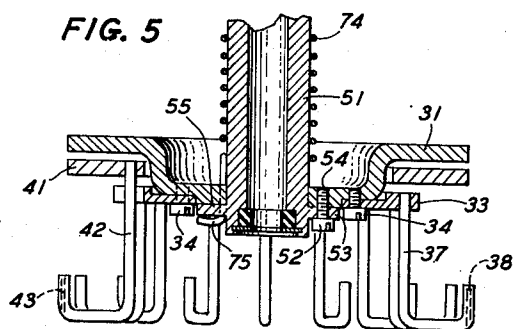
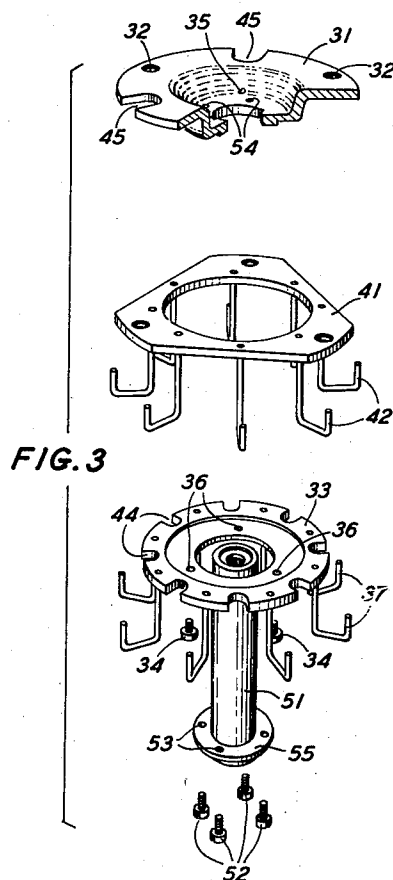
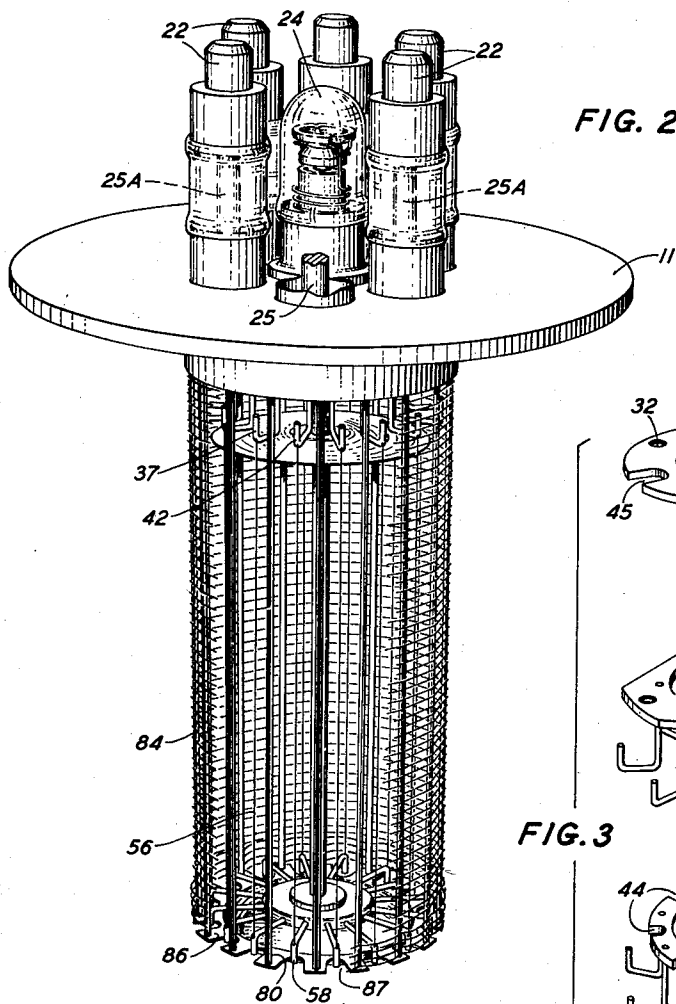
C. E. FAY ET AL.

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HIGH-POWER WATER-COOLED ELECTRON DISCHARGE DEVICE

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4 Sheets-Sheet 2



INVENTORS **C. E. FAY**
D. A. S. HALE
BY 
ATTORNEY

Dec. 19, 1950

C. E. FAY ET AL

2,534,548

HIGH-POWER WATER-COOLED ELECTRON DISCHARGE DEVICE

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FIG. 7

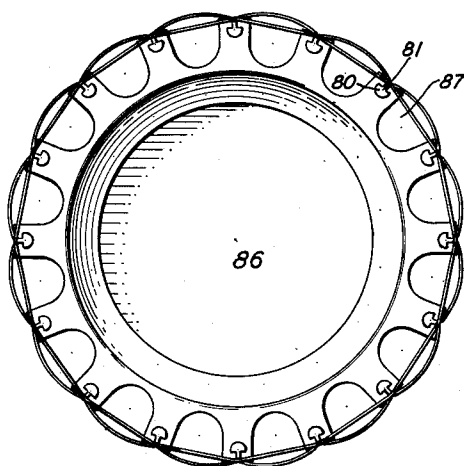


FIG. 8

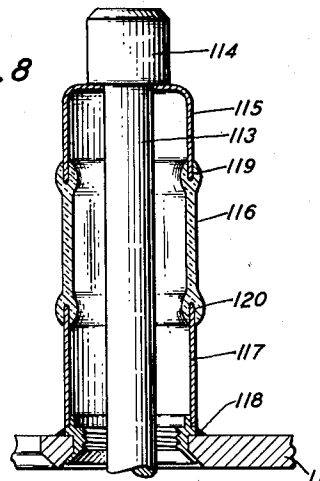
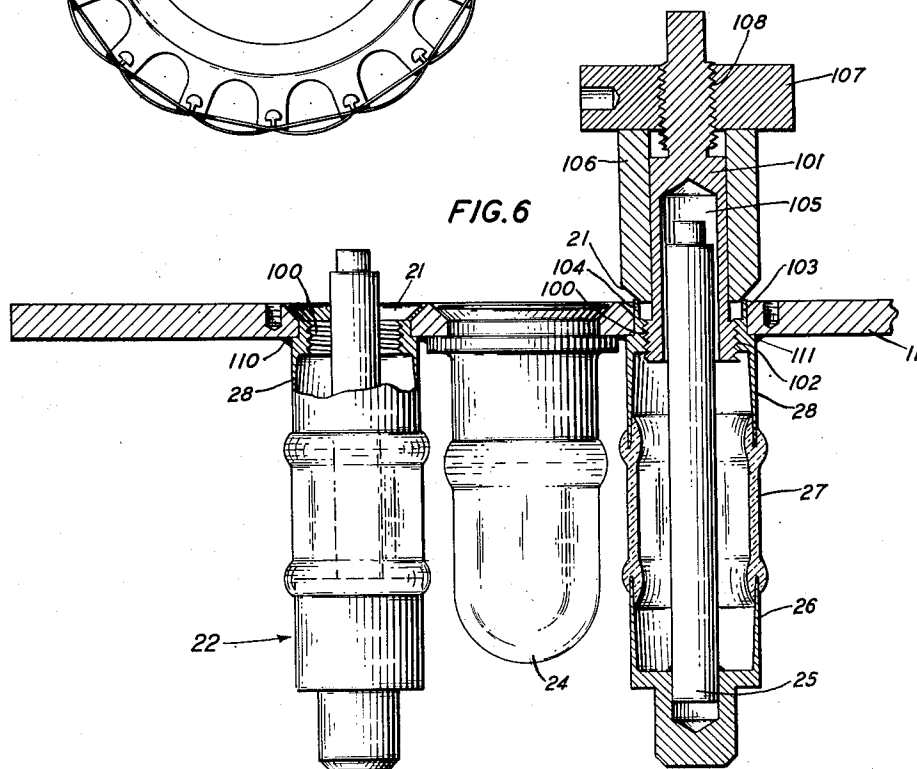


FIG. 6



INVENTORS C.E. FAY
D.A.S. HALE
BY *J. H. H. H.*
ATTORNEY

Dec. 19, 1950

C. E. FAY ET AL

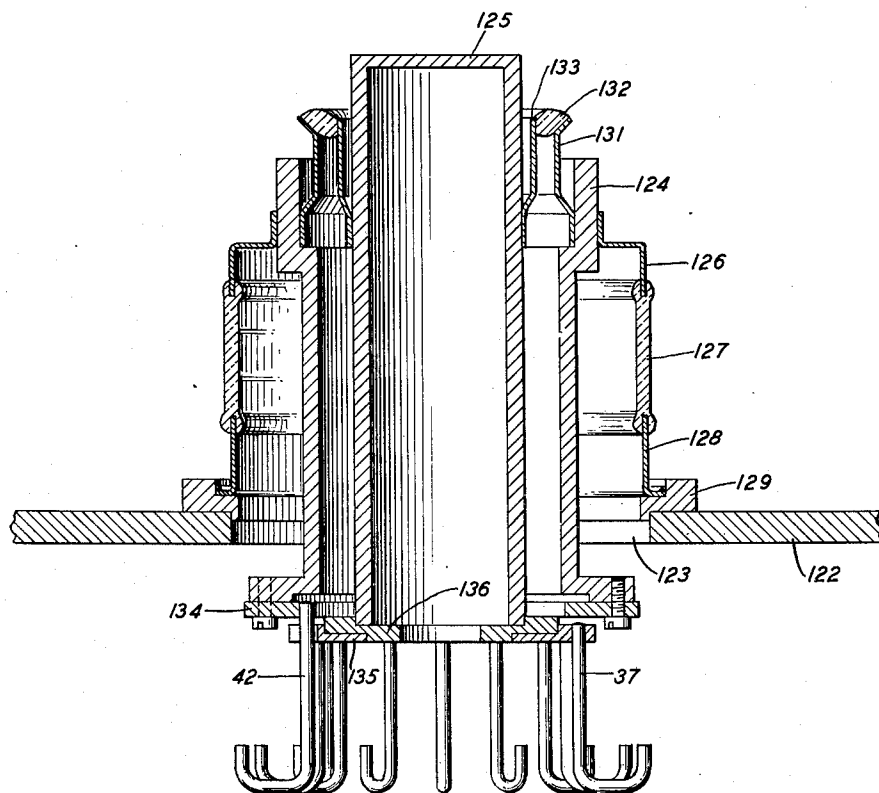
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HIGH-POWER WATER-COOLED ELECTRON DISCHARGE DEVICE

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4 Sheets-Sheet 4

FIG. 9



INVENTORS C.E. FAY
D.A.S. HALE
BY *[Signature]*
ATTORNEY

UNITED STATES PATENT OFFICE

2,534,548

HIGH-POWER WATER-COOLED ELECTRON
DISCHARGE DEVICE

Clifford E. Fay, Chatham, and Douglas A. S. Hale,
Verona, N. J., assignors to Bell Telephone Lab-
oratories, Incorporated, New York, N. Y., a cor-
poration of New York

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14 Claims. (Cl. 250-27.5)

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This invention relates to electron discharge de-
vices and more particularly to such devices
especially suitable for use at high frequencies and
high power levels.

In the design and construction of such devices
various problems and requirements arise. The
electrode spacing should be small because of the
high frequencies involved and the short electron
transit time required. At the same time, the
heat generated and which must be dissipated
is large. This heat may cause distortion of the
electrodes and may embrittle them to the point
of breaking or cause them to be bent out of proper
position thereby varying the electric characteris-
tics of the device.

The high frequencies further require that all
lead inductance be kept at a minimum. This
could be accomplished by eliminating internal
leads and connecting the elements directly to the
external leads. That is not, however, practicable
for all the leads required. It would be then pre-
ferable to shape the leads in the form of solid
sleeves or to have a plurality of leads approximat-
ing solid sleeves; such construction reduces the
lead inductance.

An object of this invention is to improve the
structure of high frequency, high power electron
discharge devices.

Another object is to improve the mounting of
the internal electrodes whereby they are not del-
eteriously affected by the heat generated or the
resultant temperature stresses.

A further object is to reduce the grid lead in-
ductance.

Still another object is to reduce the filament
lead inductance.

A still further object is to facilitate the fabrica-
tion of such electron discharge devices.

In one particular illustrative embodiment of
this invention, these objects are attained in an ex-
ternal anode tube having a multistrand filamen-
tary cathode and an anode which forms a por-
tion of the enclosing vessel. The anode is at-
tached through suitable insulating seals to a
terminal base plate from which the other elec-
trodes are supported.

In accordance with one feature of this inven-
tion, the parallel separate strands in the filament
assembly are supported in a uniformly tensioned
manner from terminals carried by but insulated
from the base plate. This is accomplished by
providing a helical spring which maintains a fila-
ment support rod under compression thereby ten-
sioning the filament strands which are mounted
by and between hooks supported by the terminals

and a spider-shaped base support attached to one
end of the filament support rod.

In accordance with a further feature of this
invention, the hooks mounting the filament
strands adjacent the base plate are supported
by a plurality of platforms through which the
central standard extends and with which it co-
operates to tension the strands.

In accordance with another feature of this
invention, a helical grid is supported by a plu-
rality of parallel rods of particular form extend-
ing parallel to the filament strands. The close
proximity of the grid and filament provides both
the short electron transit time required in high
frequency devices and a better grid control or
high transconductance. The parallel rods are
each fabricated with a small rib extending its
entire length so that when the rods are arranged
in a circle, the ribs point outward thereby pro-
viding a support to which the grid helix is con-
nected. This improves the connection between
the grid and the rods and facilitates the fabrica-
tion of the grid structure.

In accordance with a still further feature of
this invention, the grid structure is supported by
a ring directly connected to the terminal of the
base plate which is itself the grid terminal, thus
providing a lead-in system having a minimum
of inductance.

In accordance with a still further feature of
this invention, in one embodiment the filament
connections are provided through a plurality of
circularly placed terminals, thus approximating
the desired solid sleeve leads and reducing the
lead inductance.

In accordance with a still further feature of
this invention, in another embodiment the fila-
ment connections are provided through two con-
centric solid sleeves thereby greatly reducing the
lead inductance.

These and other features and advantages of
the invention will be more clearly and fully un-
derstood from the following detailed description
with reference to the accompanying drawings, in
which:

Fig. 1 is a view in section of one illustrative
embodiment of this invention;

Fig. 2 is a perspective view of the terminal base
plate and filament and grid assembly;

Fig. 3 is an exploded view of the platforms
supporting the filament strands;

Fig. 4 is a perspective view of the central
standard showing the spider-shaped base support
and the heat shield attached to the standard;

Fig. 5 is a sectional view of the filament platforms illustrating the method of mounting;

Fig. 6 is a sectional view of a portion of the terminal base plate illustrating the method of mounting the filament terminals and showing the mounting tool used;

Fig. 7 is a detail view of the grid showing the shield disc at the base of the winding;

Fig. 8 is a view mainly in section of another filament terminal; and

Fig. 9 is a sectional view of a base plate and terminal assembly illustrative of another embodiment of this invention.

Referring to the drawing, the cup-shaped anode 10, having a pumping tubulation 9 at its base, is connected to the terminal base plate 11, which may be of Monel, through a metal cylinder 12, a metal flange 13, and a seal assembly. This assembly comprises the metal flanges 14, 15, metal cylinders 16, 17 and an insulating, e. g. glass, cylinder 18. The cylinders 16 and 17 may be of a nickel-iron-cobalt alloy metal known commercially as "Kovar," which readily seals to the glass cylinder 18 and has approximately the same thermal coefficient of expansion as the glass. By coating the "Kovar" with a thin layer of gold prior to sealing the glass to it, the radio frequency resistance in the "Kovar" seal is considerably reduced so that such a seal can be utilized where currents of high density and high frequency are to be handled. The flanges 14 and 15 are preferably of cold rolled steel and may be secured to their respective cylinders 16 and 17 by copper brazing.

The terminal base plate 11 is provided with a plurality of circularly placed countersunk apertures 21 through which extend the terminal assemblies 22. A central countersunk aperture 23 is also provided for a central cap 24. Each terminal assembly 22 comprises a lead 25 which is attached as by silver brazing to a metal cup 26 which is sealed to the glass cylinder 27. The glass cylinder 27 is in turn connected to the terminal base plate 11 through a metal cylinder 28 in a manner to be described in detail later. The lead 25, the cup 26, and the cylinder 28 may all be of copper. The central cap 24 comprises a glass dome 29 and a metal cylinder 30 which is attached in countersunk aperture 23 to the base plate 11 in the same manner as the terminal assemblies 22.

The filament assembly includes three superimposed apertured platforms best seen in Fig. 3. The base platform closest to the terminal base plate 11 is an apertured cup 31 attached to the terminal leads 25 as by screws extending through apertures 32. A ring platform 33 is connected to the cup 31 as by screws 34 through appropriate apertures 35 and 36 toward the center of the cup and ring respectively. The ring 33 supports a plurality of hooks 37 with parallel drilled apertures 38 at the end of each as best seen in Fig. 5. A triangular platform 41 also supports a plurality of hooks 42 with parallel drilled apertures 43 at the end of each and is secured to the remaining three terminal leads 25A. The leads 25A are slightly longer than the other terminal 25 to which the cup 31 is attached thereby providing insulating space between the platforms. The leads 25A pass through clearing slots 45 in the cup 31 and are thereby insulated from it. The platform 41 is spaced between the cup 32 and the ring 33 and is separated from them. The hooks 42 pass through clearing slots 44 in the

ring 33 and are slightly longer than the hooks 37 so that the two groups of hooks are in parallel alternate relation in a circular boundary as best seen in Fig. 5.

The compact platform assembly thus constructed provides a low inductance connection to the filament strands and an equalization of the inductance to any one strand on one platform, because of the symmetry of the construction. Further the inductances to the indicated strands on both platforms are approximately equal because of the close positioning of the two platforms. The platforms themselves are also devoid of insulating material, the various parts of the assembly being separated by insulating space.

A sleeve member 51 extends through the apertured platforms 31, 33 and 41 and is secured to the cup platform 31 as by screws 52 extending through appropriate apertures 53 and 54 in a flange 55 on the sleeve and in the cup respectively. The sleeve 51 thus extends through the platforms and the terminal base plate 11 into the central cap 24.

The filament strands 56 are attached at one end to the hooks 37 and 42, in the parallel drilled apertures 38 and 43 and may be secured by arc welding. At the other end, the strands 56 pass through the parallel drilled apertures 57, in the hooks 58 of a spider-shaped base support 59. The base support comprises a conducting ring 63 which forms a common connection for the filament strands and insulating members 64 which insulate the filament from a central standard or rod 65. Each of the filament strands therefore forms one-half of a series loop connected to the other half through the conducting ring 63. Series loops are thus achieved without having to bend the strands which bending or changing of the strands from a single straight path might cause them to embrittle and break when subject to the temperature stresses produced in the device in operation. In the embodiment of the invention shown, there are eight loops of wire in parallel and thus eight positive and eight negative leads. The eight positive leads are connected to three of the terminals through one platform and the eight negative leads to the other three terminals through the other platform. Each wire for the filament heating circuit is attached to the respective group of three alternate terminals so that one platform is one side of the heating circuit and the other platform is the other side.

The central standard 65 may be composed of two separate parts 66 and 67 coupled together by a sleeve 68, this multiple construction providing a higher heat impedance. Or, alternatively, the central rod may be a solid rod of molybdenum. A heat deflecting shield 71 is mounted on the standard 65 close to the hooks on the platforms. The standard extends slidably into the sleeve 51 through bearing rings 72 at both the top and the bottom of the sleeve. These bearing rings 72 allow the standard to slide endways during the heating and cooling of the filament. These bearings may be of sapphire, a material that has been found to provide a satisfactory bearing condition in vacuum and under heat. A shoe 73 is carried by the standard 65 at the end in the central cap 24 and has bearing against it the free end of a helical spring 74. The other end of the spring 74 is anchored at 75 to the sleeve flange 55 through the platform cup 31. The central standard 65 is thus kept under compression, the force being applied through the standard to

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the outer end of the filament support which is the spider-shaped base member 59 thereby providing a uniform tension on the filament strands. A getter 76, which may be of barium in a nickel sheet, is attached to the shoe 73 in the central cap 24 and provides a means of cleaning up remnants of gas after pumping or gases that may be evolved during the tube's life.

The grid assembly comprises support rods 80 which are fabricated in such a manner that a rib 81 extends the whole length of the rod, as best seen in Fig. 7. The rods 80 are arranged in a circle, the ribs pointing outward radially, and are attached, as by arc welding, to a ring 82 which in turn is secured directly to terminal base plate 11 by screws 83. Onto these ribs the lateral wires 84 of the grid helix are secured. The rods 80, the ring 82 and the wires 84 may be of molybdenum. A shield 85, which may also be of sheet molybdenum, is provided to protect the seal between the metal cylinder 17 and the glass cylinder 18 against electron bombardment from the filament and hot filament leads. The rest of the glass seal assembly is shielded by the reentrant anode 10. The shield 85 is secured by the screws that hold the grid itself in position. A grid shield 86 is attached to the ends of the rods 80 adjacent to the spider-shaped base support 59 as by welding and is provided with slots 87 into which the hooks 58 can extend; the grid helix 84 is also bent outwardly its last few turns to clear the hooks, as best seen in Fig. 2.

Heating of the grid, and the resultant thermionic emission of electrons from the grid, is avoided because the improved structure aids in the dissipation of heat from the grid. The heating results from bombardment of the grid by electrons and from heat radiated by the filament being absorbed by the grid. The grid loses heat by radiation, mainly through the anode, and by conduction to its support, the terminal base plate 11 by which the grid is directly supported. In the device disclosed, the loss of heat through conduction is greatly increased, the rods 80 serving not only to support the helix and to supply the radio frequency current to the structure, but also to conduct heat from the grid to the ring 82 and the terminal plate 11. Radiation to the anode 10 may be assisted by roughening the surface of the anode to reduce its reflectivity.

In the embodiment of the invention shown, the electron discharge device is water cooled. Connecting cylinder 91 is attached to the cylindrical section 12 and to an end nut member 92 which has a collar section 93 attached as by soldering to a collar member 94. A baffle 95 is attached as by soldering to the collar member 94 and extends between the anode 10 and the cylindrical members 12 and 91. Water enters by way of the central port 96 in the collar section 93, goes up between the baffle 95 and the anode 10, then returns between the baffle 95 and the cylindrical members 12 and 91 and exits through a number of ports 97 in the nut 92. A screw thread 98 on the nut 92 provides a means of securing the device to the water system.

In the manufacture of the device, a special tool 101, shown in Fig. 6, is used for securing the terminal assemblies 22 to the terminal base plate 11. An internal thread 100 is provided in the metal cylinder 28, as best seen in Fig. 6, and is adapted to fit the threaded end 102 of the tool 101. The cylinder 28 is placed in the aperture 21 in the base plate 11 and a conical washer of solder 103 is placed over the projecting sleeve

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104 of the cylinder 28. The terminal lead 25 or 25A fits into a hollowed-out portion 105 in the tool 101. A tapered nut 106 is pushed down over the tool 101 and a screw nut 107 is run down to contact it, the upper end 108 of the tool 101 being threaded to engage the screw nut 107. The conical surface of the tapered nut 106 then engages the sleeve portion 104. By holding the tool 101 fixed and turning the screw nut 107 pressure is applied to the sleeve portion 104 tending to open it bell-wise. The washer of solder 103 is compressed in the space between the sleeve portion 104, now belled out, and the countersink of the aperture 21. This operation is repeated for all the terminals, in this embodiment of the invention there are six, and for the control cap 24, though there a separate tool is used fitting inside a larger diameter thread and not having a hollowed-out portion, there being no lead to avoid.

The whole assembly is then brazed, the brazing being done in a neutral or reducing atmosphere, using a high frequency coil to heat the plate 11 up to the melting point of solder. An additional ring of solder wire 111 is placed around each cylindrical portion 28 on the face opposite the countersink and serves to form a smooth fillet at the point of jointure.

The usual procedure of winding the lateral wires on the support rods and then welding them may result in an inaccurate out-of-round grid and the making of one weld may break those previously made. A special technique should be used whereby the lateral wire 84 is welded at each support 80 as it is wound; thus the prior welds are not affected. Grids made in this manner are very symmetrical and no trouble is experienced with them due to weld collapsing.

In assembling the filament, each filament strand 56 is first passed through the aperture 38 or 43 on the hook 37 or 42, respectively. Arc welding may be used for securing the strands to the hook and they are welded one at a time. At the outer end, the strands pass through the apertures 57 in the hooks 58. The strands are secured to these hooks by placing a small amount of solder, such as a mixture of cobalt and molybdenum, finely divided and made into a paste, on each protruding wire and simultaneously heating all the hooks by high frequency coils, thereby melting the solder and securing the filament strands. In this way, uniform and equal tension is assured in the filament strands.

Fig. 8 shows another form of terminal assembly which may be used. The lead 113 and cap 114 are made in one piece of cold rolled steel and are attached as by copper brazing to a cup-shaped member 115 of "Kovar." The edge 119 of the cup-shaped member 115 is gold plated and then joined to glass cylinder seal 116. The other end of the glass cylinder seal 116 is similarly joined to a cylindrical member 117 of "Kovar" which also has its edge 120 gold plated. The other edge of the member 117 is joined to a shoe member 118 which may be of cold rolled steel. The terminal assembly is then attached to the terminal base plate 11 in the same manner as the previously described terminal assembly. However, before turning the screw nut 107 on the tool 101 to apply pressure to the sleeve portion 104 to open it up bell-wise, a number of slots are made endwise in the sleeve portion 104 to reduce the pressure needed. When using a copper sleeve portion, it will easily open without the aid of the slots. While "Kovar" may be used for the metal

portions of the seal because of its superior strength and the ease of making such a seal, the material is nevertheless of very high resistivity so that there is considerable loss where radio frequency currents flow in the material and this loss can be great enough to cause the seal to develop excessive temperature. In order to reduce this effect, after annealing the seal portion, the "Kovar" can be plated with a material of lower resistivity such as copper. However, at the point where the glass welds the metal, the copper plating would be oxidized in the sealing operation. Therefore, it is necessary to use the gold plating there to provide the desired lower resistivity.

As explained above the filament lead inductance in the embodiment of the invention shown in Figs. 1 to 8 is low due to the plurality of leads arranged in a circle approximating a solid sleeve. Fig. 9 shows another illustrative embodiment of a terminal base plate assembly according to this invention in which the filament lead inductance is diminished even further by the use of solid sleeve terminals. The terminal base plate 122 is provided with a central aperture 123 through which extend the terminal cylinder 124 and the terminal cap 125. The terminal 124 is attached to the terminal base plate 122 through metal cylinder 126, glass cylinder 127, metal cylinder 128, and metal connecting ring 129. Terminal 125 is in turn supported by the base plate 122 through the terminal 124 to which it is connected by metal ring 131, glass ring 132, and metal ring 133. An apertured platform 134 is connected to the terminal 124 and an apertured platform 135 to terminal 125 through a connecting ring 136. Hooks 42 and 37 are connected to platforms 134 and 135, respectively. The sleeve 51 is carried by the connecting ring 136 and extends into terminal cap 125. The grid and filament structure are the same as with the plurality of terminals shown in the other embodiment. The terminal glass-to-metal seals may be "Kovar" seals of the type previously described.

While specific detailed constructions illustrative of this invention have been set forth above, it is of course understood that various modifications may be incorporated in the device and the manner of assembly without departing from the scope and spirit of this invention.

What is claimed is:

1. An electron discharge device comprising a terminal plate, a first electrode electrically attached to said plate, a plurality of terminals mounted on said plate and insulated therefrom, a plurality of apertured platforms supported by said terminals, each of said platforms being directly attached to said terminals at a plurality of points, said points being on the circumference of circles formed by said terminals, a central standard extending through said platforms, attaching means supported by said standard, a second electrode comprising a plurality of strands supported between said platforms and said attaching means, and spring means tensioning said filament strands.

2. An electron discharge device comprising a terminal plate, a plurality of terminals mounted on said plate and insulated therefrom, a plurality of apertured platforms secured to said terminals, each of said platforms being secured to said terminals at more than one point, said points being on the circumference of circles formed by said terminals, a connector comprising a conducting ring and hooks of conducting material attached to said ring, a central stand-

ard attached to said connector and insulated therefrom and extending through said platforms, a plurality of filament strands connected to said hooks and said platforms, and a spring cooperating with said standard for tensioning said filament strands.

3. An electron discharge device comprising a metallic terminal plate having an aperture therein, hollow insulated terminals on said plate and distributed in a circular boundary, a cap extending from said plate over said aperture and positioned within said boundary, a first apertured platform secured to certain of said terminals, a second apertured platform adjacent to but separate from said first platform and secured to certain other of said terminals, a sleeve carried by said second platform extending through the aperture therein, through the aperture in said first platform, and into said cap, a central standard projecting through said sleeve, a support on the end of said standard, said support comprising a conducting ring insulated from said standard and hooks of conducting material attached to said ring, a plurality of parallel filament strands connected to said hooks and said platforms, a helical grid surrounding said filament strands and electrically connected to said terminal plate, and a tension spring member surrounding said sleeve and bearing against said standard.

4. An electron discharge device comprising an anode, a terminal plate, a terminal extending through said plate and insulated therefrom, a plurality of parallel filament strands within said device attached to said terminal, a ring attached to said plate, a plurality of rods extending from said ring, each of said rods having a longitudinal rib, and a grid attached to the ribs and extending along the length of said rods adjacent said plate, said grid surrounding said filament strands.

5. An electron discharge device comprising a terminal plate, an anode, a plurality of terminals mounted on said plate and insulated therefrom, a plurality of apertured platforms secured to said terminals, a central standard extending through said apertures, anchor means attached to said standard, a plurality of filament strands connected to said platforms and said anchor means, a ring attached to said plate, a plurality of rods extending from said ring, a grid attached to said rods and extending along the entire length of said rods, said grid surrounding said filament strands, and a grid shield attached to said rods adjacent said anchor means whereby said filament strands are entirely enclosed within said grid and shield.

6. An electron discharge device in accordance with claim 5 wherein said rods each have a longitudinal rib and said grid is attached to the ribs.

7. An electron discharge device in accordance with claim 5 wherein said anchor means comprises a rigid distributor spider and said grid shield is provided with peripheral cut-out portions into which the arms of said spider fit.

8. An electron discharge device comprising a metallic terminal plate having terminals therein and insulated therefrom, a first apertured platform secured to certain of said terminals, a second apertured platform adjacent to but separate from said first platform and secured to certain other of said terminals, a plurality of hooks attached to each of said platforms, a sleeve carried by said second platform and extending

through the aperture therein and through the aperture in said first platform, a central standard projecting through said sleeve, a rigid distributor spider on the end of said standard, said spider comprising a ring of conducting material and hooks of conducting material attached to said ring, a plurality of parallel filament strands connected to said spider hooks and said platform hooks, a ring attached to said plate, a plurality of rods extending from said ring, a grid helix attached to said rods and enclosing said strands, a grid shield attached to the end of said rods and having bifurcated portions therein into which the arms of said spider fit, and a tension spring member surrounding said sleeve and bearing against said standard for tensioning said filament strands.

9. In an electron discharge device, an apertured terminal base plate, said aperture being countersunk, and a hollow terminal assembly, said assembly comprising a first metallic cylindrical member extending through said aperture, a glass cylindrical member attached to said first metallic cylindrical member, a second metallic cylindrical member attached to said glass member and a terminal lead attached to said second metallic cylindrical member and extending through said aperture into said device, said first metallic cylindrical member having an internal thread and a belled-out portion fitting into said countersunk aperture.

10. In an electron discharge device, a hollow terminal assembly in accordance with claim 9 in which said first metallic member comprises a steel shoe and a cylinder of a nickel-cobalt-iron alloy and said second metallic cylindrical member is of a nickel-cobalt-iron alloy and said lead is made of steel, said metallic members and said leads being copper plated and said metallic members being gold plated adjacent said glass cylindrical member.

11. An electron discharge device comprising a metallic terminal plate having concentric terminal sleeve cylinders thereon, a first platform secured to one of said terminal sleeves, a second platform adjacent to but separate from said first platform and secured to another of said terminal sleeves, a sleeve portion carried by said second platform, a central standard projecting through said sleeve portion, a rigid spider distributor on the end of said standard, a plurality of parallel filament strands connected to said spider and said platform, a tension spring member surrounding said sleeve portion and bearing against said standard, a ring attached to said plate concentric with and of larger diameter than said terminal sleeve cylinders, a plurality of rods extending from said ring, and a grid helix attached to said rods extending along their entire length and encompassing said filament strands.

12. An electron discharge device comprising a metallic terminal plate having two concentric terminal cylinder sleeves therein, a first apertured platform secured to one of said terminal sleeves, a second apertured platform adjacent to but separate from said first platform and secured to the other of said terminal sleeves, a sleeve portion carried by said second platform extending through the aperture therein through the aperture in said first platform and into said concentric terminal sleeves, a central standard projecting through said sleeve portion, a rigid spider distributor on the end of said standard, said spider comprising a conducting ring insulated from said standard, and hooks of conductive ma-

terial attached to said ring, a plurality of parallel filament strands connected to said hooks and said platforms, a helical grid surrounding said filament strands and electrically connected to said terminal plate, and a tension spring member surrounding said sleeve portion and bearing against said standard.

13. An electron discharge device comprising a terminal plate, a plurality of terminals mounted on said plate and insulated therefrom, a pair of apertured platforms adjacent each other but separate from each other, mounted by said terminals, each of said platforms being directly attached to said terminals at a plurality of points, said points being on the circumferences of concentric circles formed by said terminals, a central standard extending through said platforms, attaching means supported by said standard, a plurality of filament strands supported between said platforms and said attaching means, spring means cooperating with said standard and one of said platforms for tensioning said filament strands, a ring of conducting material attached to said plate and concentric with and of larger radius than said circles, a plurality of rods extending from said ring, and a grid helix attached to said rods and extending along the length of said rods adjacent said plate, said grid helix encompassing said filament strands.

14. An electron discharge device comprising a metallic terminal plate, a plurality of terminals mounted on said plate and insulated therefrom, a pair of apertured platforms adjacent each other but separate from each other, mounted by said terminals, each of said platforms being directly attached to said terminals at a plurality of points, said points being on the circumferences of concentric circles formed by said terminals, a plurality of hooks attached to each of said platforms, a sleeve carried by one of said platforms and extending through the aperture therein and through the aperture in said other platform, a central standard projecting through said sleeve, a rigid distributor spider at one end of said standard and insulated therefrom, said spider comprising a ring of conducting material and hooks of conducting material attached to said ring, a plurality of parallel filament strands connected to said platform hooks and said spider hooks, a ring attached to said plate, a plurality of rods extending from said ring, a grid helix attached to said rods and enclosing said strands, a grid shield attached to the end of said rods and having bifurcated portions therein into which the arms of said spider fit, and a tension spring member surrounding said sleeve and bearing against said standard for tensioning said filament strands.

CLIFFORD E. FAY.
DOUGLAS A. S. HALE.

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