Jan. 23, 1934. I. E. MOUROMTSEFF 1,944,190

VACUUM TUBE

Original Filed March 6, 1929 4 Sheets-Sheet 1

Fig. 1.

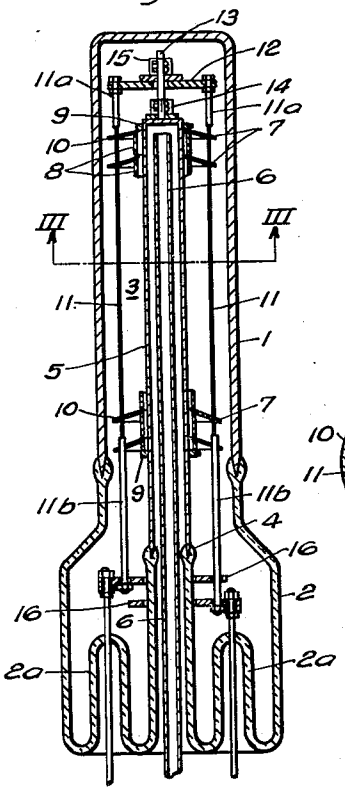



Fig. 2.

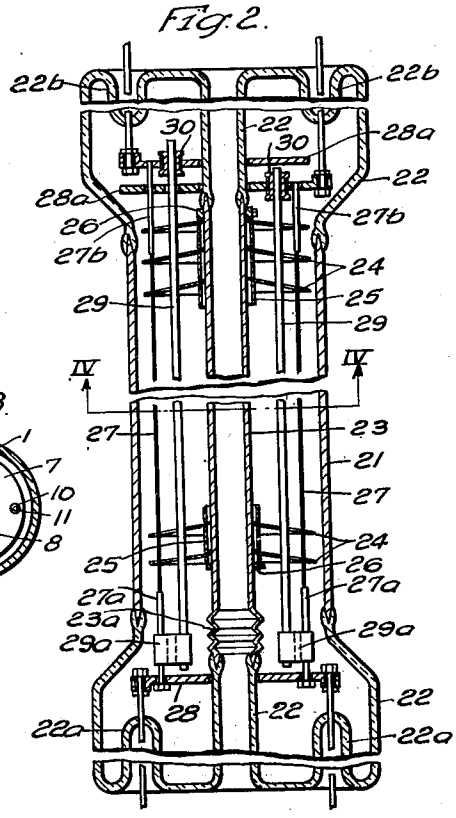



Fig. 3.

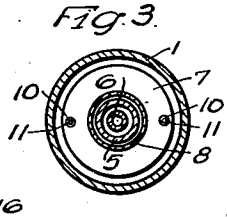



Fig. 4.

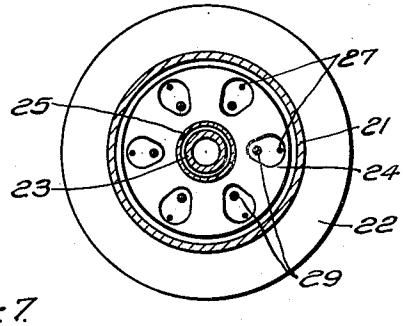



Fig. 5.

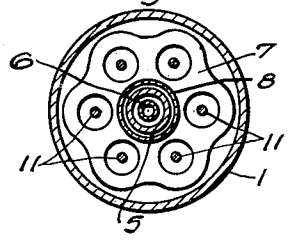



Fig. 6.

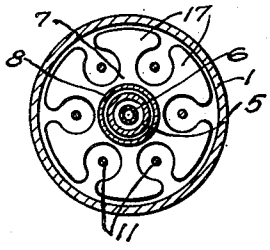
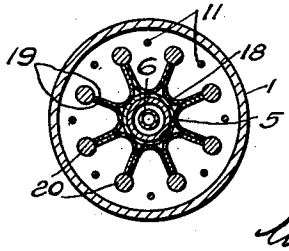



Fig. 7.



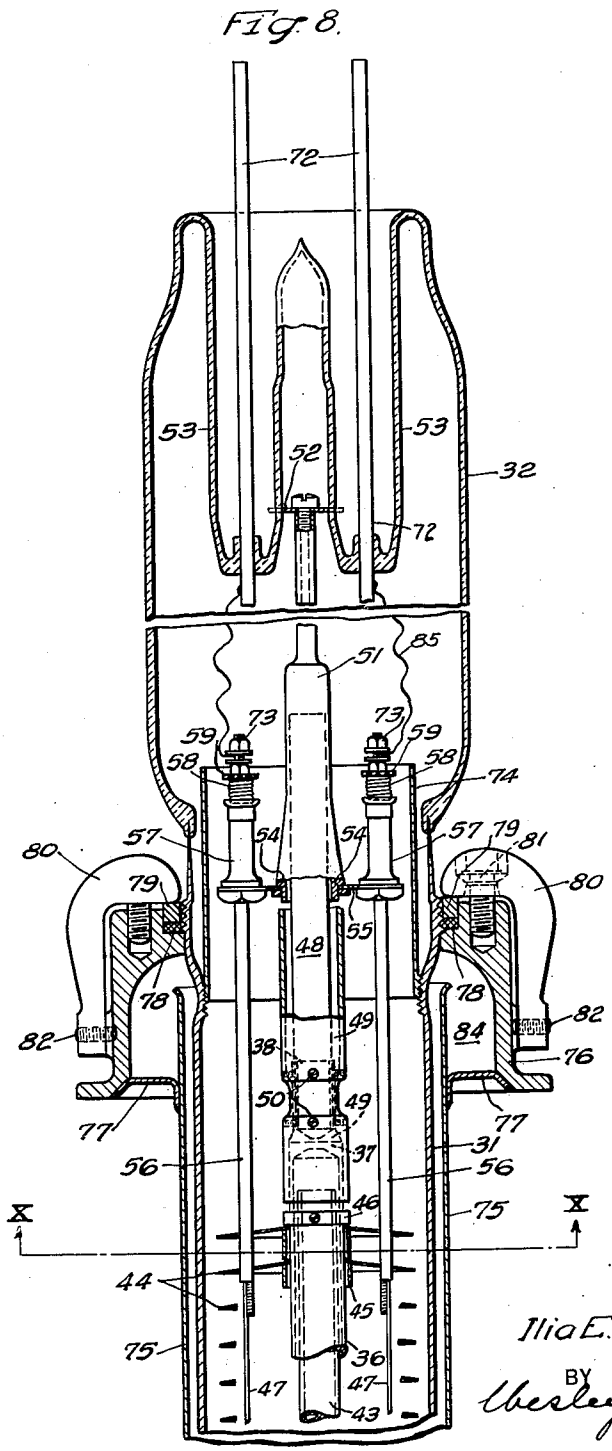

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VACUUM TUBE

Original Filed March 6, 1929 4 Sheets-Sheet 2

Fig. 8.



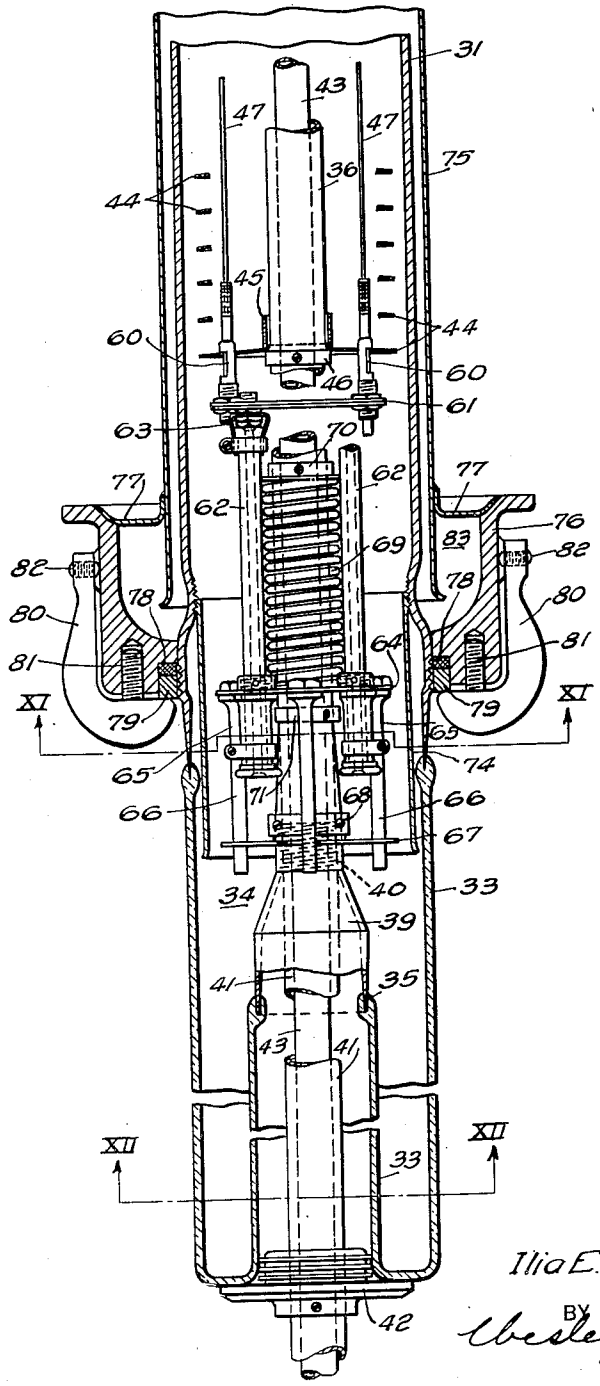

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Original Filed March 6, 1929 4 Sheets-Sheet 3

Fig. 9.




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Jan. 23, 1934. I. E. MOUROMTSEFF 1,944,190

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Original Filed March 6, 1929 4 Sheets-Sheet 4

Fig. 10.

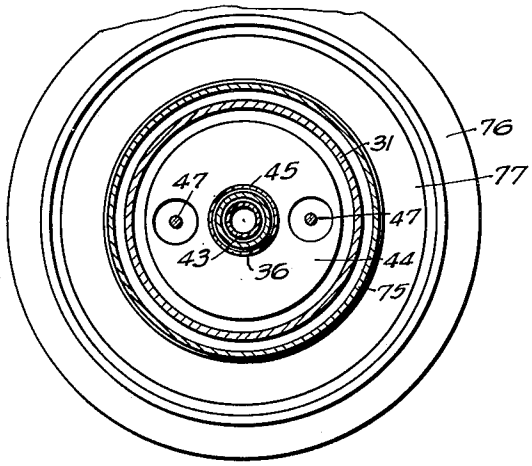



Fig. 11.

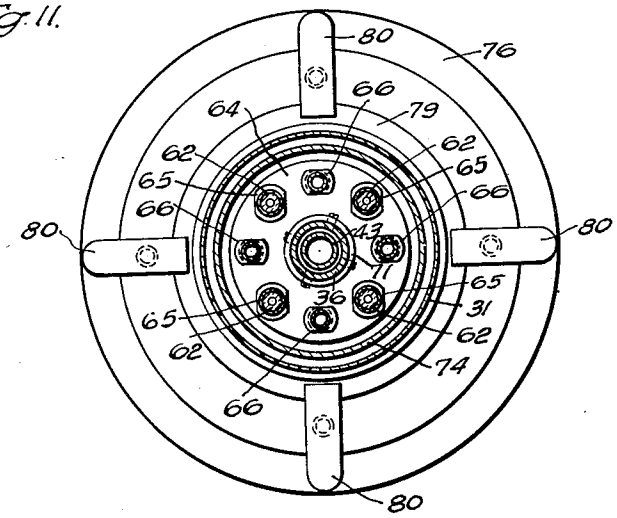
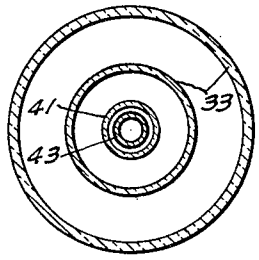



Fig. 12.




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# UNITED STATES PATENT OFFICE

1,944,190

## VACUUM TUBE

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Application March 6, 1929. Serial No. 344,772
Renewed April 14, 1933

10 Claims. (Cl. 250—27.5)

My invention relates to electron-discharge tubes having control electrodes and particularly to electron-discharge tubes designed for generating large amounts of power or for generating very high-frequency currents.

In power tubes of conventional design, difficulty has been encountered because of the control electrode or grid becoming heated to such an extent, during the operation of the tube, that electrons are emitted therefrom. The greater the amount of the power generated and the higher the frequency of the current, the greater is the difficulty encountered.

An object of my invention is to prevent the emission of electrons from the control electrode in an electron-discharge tube of the above-mentioned type by cooling the control electrode.

A further object of my invention is to provide a structure that will permit cooling of both the control electrode and the anode and which, at the same time, is simple in construction and of the necessary mechanical strength.

In practicing my invention, I employ an evacuated vessel having a metal wall which constitutes the anode, a metal tube positioned within the metal wall, a plurality of filaments supported within the vessel to constitute the cathode, and a plurality of discs mounted on the metal tube. The discs have openings around their peripheries, and the filaments are so supported that they extend through these openings. The discs, together with the metal tube, constitute the control electrode or grid. The grid is cooled by circulating water or air through the metal tube, as is more fully described hereinafter.

Other features and advantages of my invention will appear from the following description, taken in connection with the accompanying drawings in which:

Figure 1 is a view, in longitudinal, section, of a power tube constructed in accordance with one form of my invention;

Fig. 2 is a view, in longitudinal section, of a power tube constructed in accordance with a modification of my invention;

Fig. 3 is a view, in lateral section, taken on the line III—III of Fig. 1;

Fig. 4 is a view, in lateral section, taken on the line IV—IV of Fig. 2;

Fig. 5 is a view, in lateral section, of a modification of the grid structure which may be employed in any of the power tubes illustrated;

Fig. 6 is a view, in lateral section, of a further modification of the grid structure which, also, may be employed in any of the power tubes illustrated.

Fig. 7 is a view, in lateral section, of a still further modification of the grid structure which may be employed in any of the power tubes illustrated.

Fig. 8 is a view, in longitudinal section, of the upper part of a power tube constructed in accordance with a further modification of my invention;

Fig. 9 is a view, in longitudinal section, of the lower part of the above-mentioned power tube;

Fig. 10 is a view, in lateral section, taken on the line X—X of Fig. 8;

Fig. 11 is a view, in lateral section, taken on the line XI—XI of Fig. 9; and

Fig. 12 is a view, in lateral section, taken on the line XII—XII of Fig. 9;

Referring to Figs. 1 and 3 of the drawings, the apparatus comprises an evacuated vessel formed by an outer metal tube 1 which acts as the anode and which is closed at the upper end by a metal piece integral with the tube. The lower end of the tube is closed by means of a glass member 2 which is sealed to it and by means of a metallic re-entrant portion 3 sealed to a re-entrant portion of the glass member 2 at a seal 4.

The metallic reentrant portion 3 forms part of the grid of the power tube and is in the form of a metal tube 5 closed at the upper end by means of a metal piece integral with it. A pipe 6 is positioned within, and spaced from, the tube 5. By means of this structure, the grid may be cooled by forcing water or some other cooling fluid into the reentrant portion 3 between the tube 5 and the pipe 6 and out through the pipe 6.

The reentrant metal portion 3 alone may act as a control electrode if a very low amplification factor would not interfere with the tube performance; otherwise, metal pieces are so mounted thereon that they project to points in proximity to the filaments, as in the construction shown in Figs. 1 and 3 and as in the modified construction shown in Figs. 2 and 4 to 7.

In the structure illustrated in Fig. 1, the control electrode comprises a plurality of metal discs 7 (only the end discs are shown) mounted on the reentrant portion 3 and spaced apart by washers 8. The discs 7 are held in position by collars 9 fastened to the reentrant tube 5 by means of set screws. Holes 10 are located near the peripheries of the discs 7, as shown in Fig. 3, and the discs are so positioned that the holes are in alignment.

Since the filaments 11 are so supported that they extend through the holes 10, part of the grid is positioned between the filaments and the

anode, while another part of the grid is positioned on the side of the filaments remote from the anode. As previously pointed out, however, it is not essential that the control electrode shall extend completely around the filaments.

The upper ends of the filaments 11 are supported and electrically connected by means of rods 11*a* secured to a metal ring 12. The supporting structure for the ring 12 comprises a rod 13 of insulating material, such as quartz, that is clamped in a split supporting member 14 which is welded or otherwise attached, in any suitable manner, to the upper end of the reentrant portion 3. The ring 12 is attached to the upper end of the rod 13 by means of another split supporting member 15 which is attached to the ring 12 and clamped to the rod 13.

The lower ends of the filaments 11 are attached to rods 11*b* supported by means of rings 16 which are bolted to terminal rods seated in the reentrant portions 2*a* of the glass member 2. In practice, several filaments would be supported by each of the rings 16 instead of the single filament which appears in the sectional views.

In the modification of the grid structure shown in Fig. 5, portions of the grid discs 7 are cut away to improve the characteristics of the power tube without decreasing the control effect of the grid. Also, six filaments instead of two are utilized, although, obviously, a larger or smaller number of filaments may be utilized if desired.

In the modification of the grid structure shown in Fig. 6, sections of the grid discs 7 have been cut away so that the grid comprises the reentrant tube 5 together with a plurality of pieces 17 which do not completely encircle the filaments 11. Obviously, the projecting pieces 17 may assume various forms, other than the exact form shown. While six filaments have been illustrated in this modification, it is obvious that the number of filaments may be increased or decreased as desired.

The structure shown in Fig. 5 may be modified by cutting pieces out of the edges of the discs 7, as shown in Fig. 6, so that the filaments are not completely encircled thereby.

In the modified grid structure shown in Fig. 7, the discs 7 and washers 8 of Fig. 6 are replaced by a unitary structure comprising a tube 18 to which a plurality of U-shaped members 19 of sheet material are welded or otherwise suitably attached. These members are assembled in contact with each other to form ribs projecting radially from the tube 18. Each rib supports a rod 20 (welded or otherwise suitably attached thereto) in such position that it is parallel and adjacent to a filament 11, whereby a very effective grid control is obtained. In this modification, the greater part of the control effect is exerted by the rods 20, while the ribs formed by members 19 conduct the heat away from the rods.

Referring to the modification shown in Figs. 2 and 4, the apparatus comprises an evacuated vessel formed by an outer metal tube 21 which acts as the anode and which is closed at both ends by means of glass members 22 which are sealed to it and by means of a metallic tube 23 sealed to the glass members.

As in all the other modifications, the metal tube 23 alone may act as a control electrode, but, when more effective control is desired, the grid is constructed in accordance with one of the modifications illustrated. The grid structure illustrated is similar to that shown in Fig. 1 and comprises a plurality of metal discs 24 mounted on the metallic tube 23 and held in position by washers 25 and collars 26. The lower end of the metal tube 23 is made in an expansible bellows-like form, as indicated at 23*a*, in order to prevent the glass members 22 from cracking when the inner and outer tubes 23 and 21, respectively, expand unequal amounts. If desired, the tube 23 may be secured to the central reentrant portion of member 22 by means of a flexible disc, in the same way that member 76 (Fig. 8) is secured to tube 75 by means of the flexible disc 77.

The filaments 27 are supported, at the lower end of the power tube, by means of rods 27*a* of conducting material. The rods 27*a* are secured to a metallic ring 28 which is bolted to rods sealed in the reentrant glass portions 22*a* of the glass member 22.

The upper ends of the filaments 27 are attached to conducting rods 27*b* supported by means of rings 28*a* which are bolted to terminal rods sealed in the reentrant glass portions 22*b* of the upper glass member 22. It will be noted that the rings 28*a*, and, consequently, the upper ends of the two filaments 27, shown in Fig. 2, are insulated from each other.

As described in connection with Fig. 1, each ring 28*a* preferably supports a plurality of filaments, as indicated in Fig. 4, instead of only the one filament shown in Fig. 2. Fig. 4 is a view, in lateral section, of the structure shown in Fig. 2, with the exception that four additional filaments are shown, i. e., two filaments have been added to each ring 28*a*.

When a grid structure is employed in which part of it is on the inside of the filament (as are the washers 25 and central portion of discs 24), this part of the grid will absorb some of the electrons when it becomes positive. This high grid current or absorption of electrons may be reduced considerably by employing the screening arrangement illustrated in Figs. 2 and 4.

The screen comprises rods 29 which are at the same potential as the filaments 27 and which are positioned adjacent and parallel thereto. Each rod 29 is supported, at its lower end, by means of a metal sleeve 29*a*, preferably of tantalum, welded or otherwise secured to the rod 29 and to the filament-supporting rod 27*a*. Each rod 29 is supported, at its upper end, by means of a bushing 30 of insulating material, such as quartz mounted in one of the rings 28*a*. As shown in Figs. 2 and 4, each rod 29 is located between a filament 27 and the portion of the grid on the inside of the filament referred to above.

The anodes of the power tubes constructed in accordance with the forms shown in Figs. 1 and 2 are cooled in any suitable manner.

Referring to the modification shown in Figs. 8 to 12, inclusive, the apparatus comprises an evacuated vessel formed by an outer metal tube 31 which is closed at the upper end by being sealed to a glass member 32. It is closed at the lower end by means of a second glass member 33, which is sealed to it, and by means of a metallic reentrant portion 34 sealed to the glass member 33 at a seal 35.

The reentrant portion 34 comprises a pipe 36 closed at one end by a partition 37. The pipe is extended for a short distance beyond the partition as a split portion 38 of reduced diameter. The other end of the pipe is enlarged to form a section 39 of increased diameter and the edges therefore reduced in thickness to form the seal 35. An inner section 40 of the enlarged section 39 is threaded.

A pipe 41 is held in screw-threaded engagement with the threaded section 40 and supported in fixed relation to the glass member 33 by means of a circular element 42 attached to the pipe 41. A pipe 43 of smaller diameter is positioned within, and spaced from, the pipe 41 and the reentrant pipe 36 to provide means for cooling the grid as described in connection with the modification shown in Fig. 1.

In the modification illustrated in Figs. 8 to 11, the control electrode is similar to that shown in Fig. 1 and comprises a plurality of metal discs 44 mounted on the reentrant pipe 36 and held in position by washers 45 and collars 46. The structure may assume any of the modified forms previously described.

In order to prevent the upper end of the grid structure from swaying out of position and in order to provide means for supporting the filaments 47, a rod 48 of quartz or other suitable insulating material is inserted into the split end portion 38. A metal cylinder 49 is so positioned that it provides an electrostatic shield for the quartz rod 48 and prevents conducting deposits from forming thereon. The cylinder 49 is held in position by set screws 50 which also serve to clamp the quartz rod 48 in the split end portion 38.

The rod 48 extends into a hole drilled in the lower end of a metal rod 51. The upper end of the rod 51 is attached to a piece 52 of sheet material which is so shaped that the rod 51 is firmly but slidably supported by the reentrant tube portions 53 of glass member 32.

A support of this character is required because the grid structure expands as the temperature of the power tube increases during operation. The lower end of the rod 51 is enlarged and provided with projecting portions 54 to which a ring member 55 is attached.

The upper end of each filament 47 is supported from the ring member 55 by means of a structure comprising a rod 56 to the lower end of which the filament 47 is attached. The upper end of the rod 56 extends through a hollow supporting member 57 which is bolted to the ring 55. A spring 58 is mounted on the rod 56 between a washer 59 attached to the rod and the top of the supporting member 57 and is maintained in compression for keeping the individual filaments 47 taut.

The lower end of each filament 47 is attached to a short supporting rod 60 bolted to a metal ring 61. The ring 61 has a central hole therein of sufficient diameter to prevent the ring from coming into contact with the pipe 36.

The ring 61 is so supported that it holds the filaments 47 taut and keeps them insulated from the pipe 36 and the remaining grid structure.

The ring-supporting structure comprises four rods 62 of insulating material, preferably quartz. The ring is attached to each quartz rod by means of a strap 63 which is bolted to the ring 61 and clamped to the rod 62. The other ends of the rods 62 are attached to another ring 64 by being clamped to split members 65 which are bolted to the ring. The ring 64 is firmly supported on the reentrant portion 34 and in slidable relation thereto by means of a plurality of rods 66 bolted to the ring. The rods 66 are slidably supported in holes drilled in a ring 67 which is clamped to the reentrant portion 34 by means of a collar 68.

A helical spring 69, usually made of tungsten, is supported on the reentrant portion 34 between the ring 64 and a collar 70 which is secured to the reentrant portion by a set screw. In this way, the spring 69 is held in compression to push the ring 64 toward the lower end of the tube and hold the filaments 47 taut. A second collar 71 is attached to the reentrant portion 34 by means of a set screw to limit the movement of the ring 64 when attaching the filaments to their supporting structure.

At the lower end, the filaments 47 are electrically connected by means of the ring 61. At the other end, the filaments 47 are connected to the terminal rods 72 by means of binding posts 73 and flexible conductors 85, one filament being insulated from the ring 55. While only two filaments have been shown for the sake of clearness, obviously more holes may be drilled in the discs, 44, and any number of filaments desired (usually six or eight or more) mounted around the peripheries of the supporting rings 55 and 61. In the latter modification, each alternate filament is insulated from the ring 55.

One advantage of the tube structure described above is that the quartz rod 48, which forms part of the grid support, is prevented from melting. A further advantage is that, by employing a cooled grid and a glass member sealed to each end of the anode, the springs 69 and 58 are prevented from becoming heated to such an extent that they lose their resiliency.

Obviously, the filament-supporting structure shown in Figs. 8, 9, and 11 may be (and preferably is) employed in the modified power tubes shown in the preceding figures.

The seals are protected by means of metal shields 74 which are attached to the outer metal wall 31.

The anode-cooling structure comprises a tube 75 which surrounds, and is spaced from, the anode 31. An annular supporting member 76 is attached, in liquid-tight relation, to each end of the tube 75 by means of a ring-shaped flexible element 77. The flexible element 77 prevents the breakage of parts due to unequal expansion of tubes 31 and 75. Each annular supporting member 76 is mounted on the anode 31 and is held in liquid-tight relation thereto by means of a gasket 78 which is positioned over a threaded or grooved portion of the anode 31.

In order to form a liquid-tight joint, the gasket 78 is compressed and forced into the threaded portions. This is accomplished by employing a ring 79 held against each gasket 78 and in slidable relation to the anode 31, and a plurality of levers 80 in the form of hooks mounted around the periphery of each annular supporting member 76. As shown in Fig. 8, each lever 80 is pivoted on the head of a screw 81 so that the head of the screw forms the fulcrum of the lever. The gaskets 78 are compressed as much as is convenient by turning the screws 81, thereby drawing the rings 79 against the gaskets. They are compressed the additional amount necessary for obtaining a liquid-tight joint by turning the screws 82 at the ends of the levers 80 in such direction that the ends of the shorter arms of the levers are pressed against the rings 79 to further compress the gasket.

The cooling liquid is forced into the lower chamber 83 through an opening (not shown), through the space between the anode 31 and the tube 75 into the upper chamber 84, and out through another opening (not shown).

Various modifications may be made in my invention without departing from the spirit and scope thereof, and I desire, therefore, that only such limitations shall be placed thereon as are shown by the prior art and set forth in the appended claims.

I claim as my invention:

1. An electron-discharge tube comprising a cathode, an anode and a control electrode, said control electrode having portions positioned on a side of the cathode remote from said anode, rods positioned between said cathode and said portions, said rods being adapted to be maintained at substantially the same potential as said cathode.

2. An electron-discharge tube comprising a cathode, an anode and a control electrode, said control electrode having portions positioned on a side of the cathode remote from said anode, and means comprising a shield for reducing the flow of electrons from said cathode to said portions.

3. An electron-discharge tube comprising a cathode, an anode, a control electrode having portions positioned between said cathode and said anode and other portions positioned on a side of the cathode remote from said anode and a shield positioned between said cathode and said other portions.

4. An electron-discharge tube comprising a cathode, an anode, a control electrode having portions positioned between said cathode and said anode and other portions positioned on a side of the cathode remote from said anode and a shield positioned between said cathode and said other portions, said shield being adapted to be maintained at a predetermined potential relative to said cathode.

5. An electron-discharge tube comprising a cathode which includes a plurality of filaments, an anode, a control electrode having portions positioned between said cathode and said anode and other portions positioned on a side of the cathode remote from said anode and a shield positioned between said cathode and said other portions, said shield comprising a plurality of conducting rods parallel to said filaments.

6. An electron-discharge tube comprising a cathode which includes a plurality of filaments, an anode, a control electrode having portions positioned on a side of the cathode remote from said anode and a plurality of conducting rods positioned between said filaments and said portions and parallel to said filaments, each rod being connected to its corresponding filaments at one point only.

7. An electron-discharge tube as claimed in claim 1 in which the rods are supported by means of tantalum sleeves.

8. An electron-discharge tube as claimed in claim 5 in which the conducting rods are supported by means of tantalum sleeves.

9. An electron discharge device comprising an anode structure, cathode structure and grid structure, said grid structure comprising a slender control portion and a sturdier supporting portion and shielding means interposed between said cathode structure and said sturdier supporting portion whereby the absorption of electrons by this sturdier supporting portion is considerably reduced.

10. An electron discharge device comprising an anode, cathode and grid structure, said grid structure surrounding said cathode structure and comprising small mass portions and large mass portions, and shielding means interposed between said cathode structure and the large mass portions of said grid structure whereby the absorption of electrons by the large mass portions of the grid structure is considerably reduced.

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