May 5, 1942. J. J. HEGER 2,281,878

VALVE TUBE AND CASING THEREFOR

Filed Aug. 2, 1940

Fig. 1

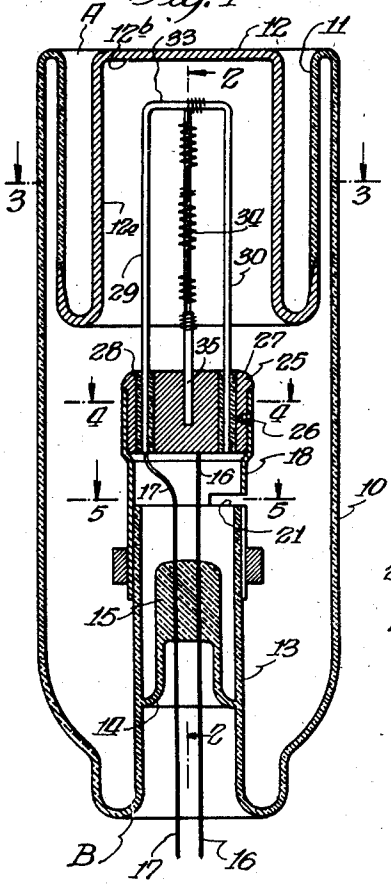


Fig. 2

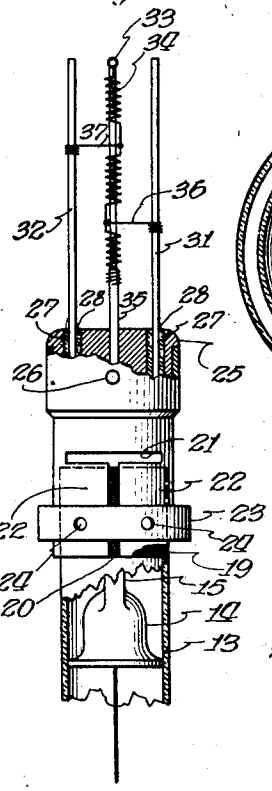


Fig. 3

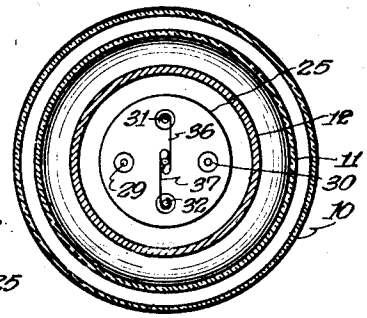


Fig. 4

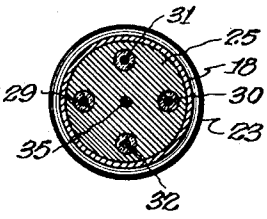


Fig. 5

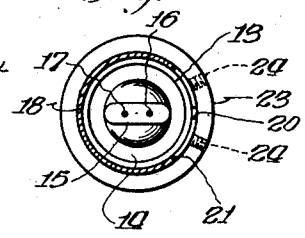
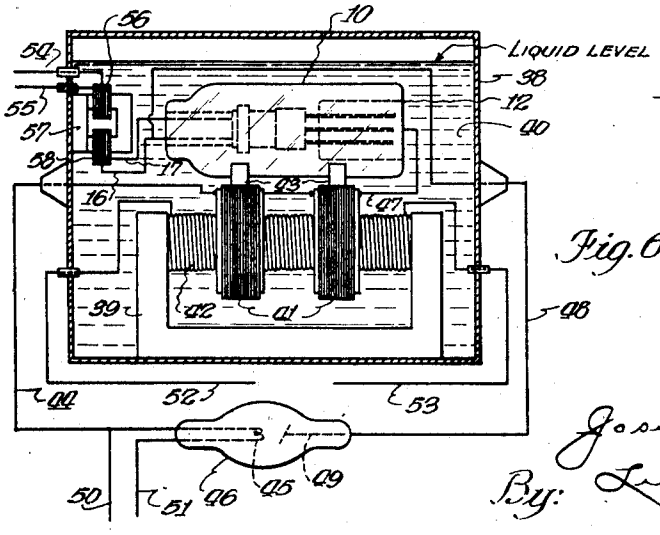


Fig. 6



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VALVE TUBE AND CASING THEREFOR

Joseph J. Heger, Chicago, Ill., assignor to Universal X-Ray Products, Inc., Chicago, Ill., a corporation of Illinois

Application August 2, 1940, Serial No. 349,509

6 Claims. (Cl. 250—27.5)

My invention relates to a thermionic valve arrangement, and in particular to a rectifier tube suitable for use with an X-ray producing device.

It is an object of my invention to provide an improved thermionic valve arrangement of this type in which the valve is effectively cooled. My invention preferably contemplates a thermionic valve comprising a cathode having an electron emitting filament and an anode for receiving electrons from the cathode, both sealed in an envelope of electrical insulating material, and it is an object of my invention to provide an improved arrangement of this type in which a liquid circulates about and in contact with the anode adjacent the electron receiving face portions thereof for cooling it.

It is another object of my invention to provide an improved thermionic valve arrangement of this type in which the valve is short and compact but has nevertheless a sufficiently large electrical resistance between its cathode and anode to withstand the high voltages used with X-ray tubes.

It is a further object of my invention to provide an improved thermionic valve arrangement of this type in which the electron emitting filament of the valve is effectively supported in order that the valve may be mounted in any position without danger of breakage of the filament.

It is still another object of my invention to provide an improved arrangement of this type in which the electron emitting filament of the valve is effectively shielded electrostatically from the anode.

It is still a further object of my invention to provide an improved arrangement of this type in which the thermionic valve is of simple construction and may be economically manufactured.

My improved thermionic valve arrangement preferably comprises a tube of electrical insulating material formed with a reentrant portion extending from one of its ends along the tube walls, a cup-like anode for completing the tube sealed substantially at its open end to said reentrant portion and having its sides separated from said reentrant portion, a cooling liquid circulating about the anode, a cathode having an electron emitting filament positioned in the anode and surrounded by a plurality of spaced metal posts for electrostatically shielding the filament, and a plurality of supporting members fastened to certain of the metal posts and supporting the filament at intermediate points thereof.

The invention consists in the novel constructions, arrangements and devices to be hereinafter described and claimed for carrying out the above stated objects and such other objects as will appear from the following description of a certain preferred embodiment illustrated in the accompanying drawing, wherein—

Fig. 1 is a longitudinal sectional view of a rectifier tube involving the principles of my invention;

Figs. 2, 3, 4 and 5 are sectional views of the tube taken on lines 2—2, 3—3, 4—4 and 5—5 respectively of Fig. 1; and

Fig. 6 is a sectional view on a smaller scale of X-ray apparatus including my improved tube.

Like characters of reference designate like parts in the several views.

Referring now to the drawing, the illustrated embodiment of my invention comprises an envelope 10, preferably in the form of a tube. The envelope 10 is of glass or other suitable electrical insulating material and is formed at one end, its end A, with a reentrant portion 11 which is doubled back on the adjacent envelope walls and extends axially inwardly of the envelope, as shown. A cup-like cylindrical anode 12 of metal is sealed, vacuum tight, substantially at its open end to the reentrant portion 11 and serves to complete the envelope. It will be noted that the arrangement is such that the closed end of the cup-like anode 12 is disposed substantially at the end of the envelope.

The envelope 10 on its other end, its end B, is formed with an inwardly and axially extending tubular portion 13. The portion 13 is closed off by a wall portion 14 which terminates in a pinch 15 about two lead wires 16 and 17. The arrangement is such that a vacuum tight seal is made between the wires 16 and 17 and the portion 15.

A metal sleeve 18 is provided on the tubular envelope portion 13, and a sleeve of metal mesh 19 is disposed between the sleeve 18 and the envelope portion 13. The sleeve 18 is formed with a longitudinal slot 20 and a transverse slot 21, and two sleeve portions 22 which may be sprung inwardly by suitable means are thus provided. A ring 23 fits about the sleeve 18 and over the portions 22 and is provided with two screws 24 threaded therein, each of the screws being disposed over one of the portions 22. The sleeve 18 is made to fit tightly on the envelope portion 13 by tightening the screws 24 and thereby forcing the portions 22 inwardly. The metal mesh 19 acts as a resilient means which helps

to prevent breakage of the tubular portion 13 as the sleeve 18 is tightened thereon.

A cylindrical plug-like supporting member 25 is disposed in the sleeve 18 and is held in such position by a screw 26. The supporting member 25 is provided with four openings 27 which are equidistant from and are spaced regularly about the center of the supporting member 25. A sleeve 28 of ceramic or other insulating material is provided in each of the openings 27; and metal posts 29, 30, 31 and 32 are disposed one in each of the sleeves 28. The supporting member 25 forms an anchor for the posts, and the posts are firmly fixed relative to the supporting member. It is apparent that each of the posts is electrically insulated from the other posts and from the supporting member.

The posts 29 and 30 are connected at their tops by a connecting portion 33. A helical filament 34 is attached to the portion 33, and the portion 33 serves as an upper terminal and support for the filament. As shown, the posts 29 and 30 and the connecting portion 33 are preferably formed of a single piece of material. A relatively short post 35 is fixed in the supporting member 25 at its center and constitutes a lower terminal for the filament 34. It will be noted that the filament 34 is disposed in the anode and on the central axis of the anode, and that the posts 29, 30, 31 and 32 are equidistant from and disposed regularly about the filament 34 and extend into the anode in directions substantially parallel to the central axis of the anode.

A wire supporting arm 36 is fastened to the post 31 and is attached to the filament 34 at an intermediate point thereof approximately one-third the distance from the terminal 35 to the terminal 33. A similar supporting arm 37 is fastened to the post 32 and is attached to the filament at an intermediate point thereof approximately two-thirds the distance from the terminal 35 to the terminal 33.

The wire 16, leading into the tube, is connected to the supporting member 25, and the other wire 17 is connected to the post 29 as shown. A voltage applied between the leads 16 and 17 causes a current to flow through the lead 17, the post 29, the filament 34, and the terminal 35 and finally through the supporting member 25 to the lead 16.

It will be readily understood that the envelope 10 has the air substantially exhausted therefrom, and the cathode of the tube which includes the filament 34, the posts 29, 30, 31 and 32 and the supporting member 25, is in a substantial vacuum. With a suitable voltage applied between the leads 16 and 17, sufficient current flows through the filament 34 so that electrons are emitted therefrom. When the anode 12 is substantially more positive than the cathode, the electrons emitted from the filament 34 travel to the anode. The principal part of the electrons from the filament 34 travels to the internal side face portion 12*a* of the anode, and a smaller part of the electrons travels to the internal end face portion 12*b* of the anode. Inasmuch as the anode 12 surrounds the filament 34, substantially none of the electrons therefrom reach the glass side walls of the tube, and substantially no electrical charge builds up on the tube walls. As a result, the possibility of tube rupture due to excessive electrical charge on the tube walls is minimized, and voltage drop across the tube due to such a charge is minimized. It will be noted that the electron receiving face portions 12*a* and 12*b* of the anode complete the envelope of the rectifier tube; that is to say, the face portions 12*a* and 12*b* form a part of the inner surface of the envelope.

The metal posts 29, 30, 31 and 32, disposed about the filament 34, serve as electrostatic shields for the filament. The filament 34 is positioned as closely as possible on the central axis of the anode 12, and the electrostatic stresses in the filament due to the high voltages between the anode and cathode of the tube are thus made small. However, when the filament is operated at the high temperatures necessary for high quantity electron emission, as is desirable when rectifying a voltage for an X-ray tube, the filament is quite soft, and it is desirable to reduce the electrostatic stresses in the filament still further. The metal posts 29, 30, 31 and 32 electrostatically shield the filament and reduce the electrostatic stresses therein, and the posts thus protect the filament from breakage. The supporting arms 36 and 37 operate to hold the filament substantially on the central axis of the anode 12 regardless of the position in which the tube is operated. It is apparent that the posts 29, 30, 31 and 32 have a two-fold function; the posts electrostatically shield the filament, and in addition the posts, with the supporting arms 36 and 37 and the connecting portion 33, support the filament at its top and at intermediate points. The post 29 further serves as an electric supply lead for the filament.

My improved rectifier tube is quite short and compact, yet it has the high electrical resistance between its anode and cathode necessary to withstand the high voltages used on X-ray tubes. The electrical resistance between the anode and cathode of the valve tube varies with the distance on the glass portion of the envelope between the anode and cathode. This distance in my improved valve tube includes not only the distance on the tubular portion 13 from the sleeve 18 to the end B of the tube plus the distance on the outer walls of the envelope 10 from the tube end B to the tube end A, but it also includes the distance on the reentrant tube portion 11 from the tube end A to the anode 12. By doubling the outer walls of my improved tube back to form the reentrant portion 11, I have produced a tube having the requisite high electrical resistance between cathode and anode, and yet one that is substantially shorter in length than prior tubes having substantially the same electrical resistance. It will be noted that in my tube the reentrant portion 11 extends along and is separated from both the outer side walls of the tube and the sides of the anode 12.

My improved rectifier tube is preferably operated immersed in an electrically insulating heat conducting liquid, preferably oil. A housing 38 for X-ray apparatus including my tube and a high voltage transformer 39 is shown in Fig. 6. The housing 38 contains a body of electrically insulating heat conducting liquid 40 which surrounds the tube and transformer. In the arrangement shown the high voltage secondary coils 41 are disposed over the primary winding 42, and the rectifier tube is supported by arms 43 mounted on the coils 41. The coils 41 are connected in series, and one of the coils is connected by a lead 44 with the cathode 45 of an X-ray tube 46. The other coil 41 is connected by a lead 47 with the anode 12 of the rectifier tube. The conductor 16 of the rectifier tube is connected by a lead 48 with the target 49 of the

X-ray tube. Voltages are applied between the leads **50** and **51** connected to the cathode **45** of the X-ray tube for heating the cathode, between the leads **52** and **53** connected to the primary winding **42** of the transformer, and between leads **54** and **55** connected to the primary winding **56** of the filament transformer **57** which is immersed in the liquid **40** and has its secondary winding **58** connected with the leads **16** and **17** for heating the cathode of the rectifier tube. In this arrangement, the rectifier tube rectifies the voltage of the secondary windings **41**, and this rectified voltage is impressed across the X-ray tube **46**.

In my improved rectifier tube arrangement, the reentrant portion **11** of the envelope being separated from the sides of the anode **12**, the fluid **40** on operation of the tube circulates about the sides of the anode as well as about its closed end for cooling the anode. The anode **12** is of suitable metal of thin gauge and constitutes a part of the tube envelope in contact with the fluid **40**, and heat developed at the electron receiving surfaces **12***a* and **12***b* is effectively transferred to the fluid **40**. The heat in the fluid **40** is transferred from the fluid to the housing **38**, and from the housing the heat is dissipated in the surrounding air. The fluid **40** is electrically insulating and does not allow electric arcs to form between any of the leads or other apparatus in the housing **38**.

My improved thermionic valve is compact and requires only a small housing space. Even though short, my improved valve nevertheless has a high electrical resistance between cathode and anode and is suitable for use with the high voltages used on X-ray apparatus. The cathode of my improved valve is of such construction that the filament is electrostatically shielded, and the high voltage applied between the anode and cathode of the valve does not break the filament even though the filament is heated to a high temperature as is preferable. The filament is supported by auxiliary supports, and my improved valve may be operated in a horizontal or other position. The valve in my improved arrangement is effectively cooled and even under high instantaneous overload conditions the anode of the valve does not become heated unduly. My improved thermionic valve arrangement is simple in construction and may be economically manufactured.

I do not intend to limit my invention to the details of construction shown and described except only insofar as certain of the claims may be so limited as it will be apparent to those skilled in the art that changes in the construction and arrangement of the parts may be made without departing from the principles of the invention.

I claim:

1. In a valve of the type described, the combination of a hollow anode, an electron emitting filament in said anode, a plurality of spaced metal posts extending along and disposed about said filament, two of said posts being connected at their tops by a connecting portion which constitutes a terminal and support for one end of said filament, at least one of the other of said posts being provided with a supporting arm extending to an intermediate point of said filament for supporting the filament, and a terminal for the other end of said filament.

2. In a valve of the type described, the combination of a hollow anode, an electron emitting filament in said anode, a pair of metal rods extending along and disposed on opposite sides of said filament, and a pair of supporting arms fastened to more than one of said rods, said arms extending to and connected at spaced intermediate points of said filament for supporting the filament.

3. In a valve of the type described, the combination of a hollow cup-like anode, an electron emitting filament in said anode lying in substantially the axis thereof, a plurality of metal posts extending along and parallel to said filament and all disposed equidistantly from one another and from said filament and said anode axis, two of said posts being connected together at similar ends by a connection intersecting the anode axis, said connection constituting a terminal and support for one end of said filament, a terminal for the other end of said filament disposed in the anode axis, and supporting connections from different intermediate points of said filament to more than one of the other posts.

4. In a valve of the class described, the combination of a hollow cup-like anode, an electron emitting filament in said anode lying substantially in the axis thereof, a pair of metal posts along and on opposite sides of said filament and interconnected at their tops, said interconnection constituting a terminal and support for one end of said filament, a second pair of metal posts along and on opposite sides of said filament with their tops separated, a support from an intermediate point of said filament to one of said second pair of posts and another support from another intermediate point of said filament to the other of said second pair of posts, and a terminal for the other end of said filament.

5. In a valve of the class described, the combination of a hollow cup-like anode, an electron emitting filament in said anode lying substantially in the axis thereof, a pair of metal posts along and on opposite sides of said filament and interconnected at their tops, said interconnection constituting a terminal and support for one end of said filament, a second pair of metal posts along and on opposite sides of said filament with their tops separated, a support from an intermediate point of said filament to one of said second pair of posts and another support from another intermediate point of said filament to the other of said second pair of posts, and a terminal for the other end of said filament, said second pair of posts being diametrically opposite each other to thereby maintain said filament substantially in the axis of the anode regardless of the angular position of the valve.

6. In a valve of the class described, the combination of a hollow cup-like anode, an electron emitting filament in said anode lying substantially in the axis thereof, a plurality of spaced metal posts extending parallel to the anode axis and along and equidistantly and radially spaced from said filament, two of said posts diametrically opposite to each other being interconnected at the ends thereof within said anode, said interconnection constituting a terminal and support for one end of said filament, supports extending from different intermediate points of said filament to all of the others of said posts to apply holding forces in more than one direction to thereby maintain said filament substantially in the anode axis regardless of the angular position of the valve, and a terminal for the other end of said filament coincident with the anode axis.

JOSEPH J. HEGER.