

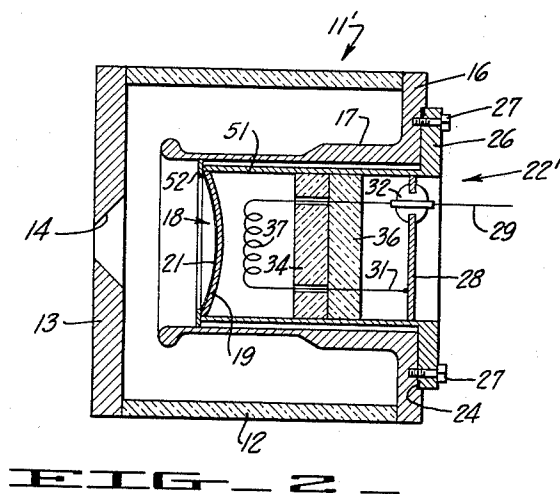
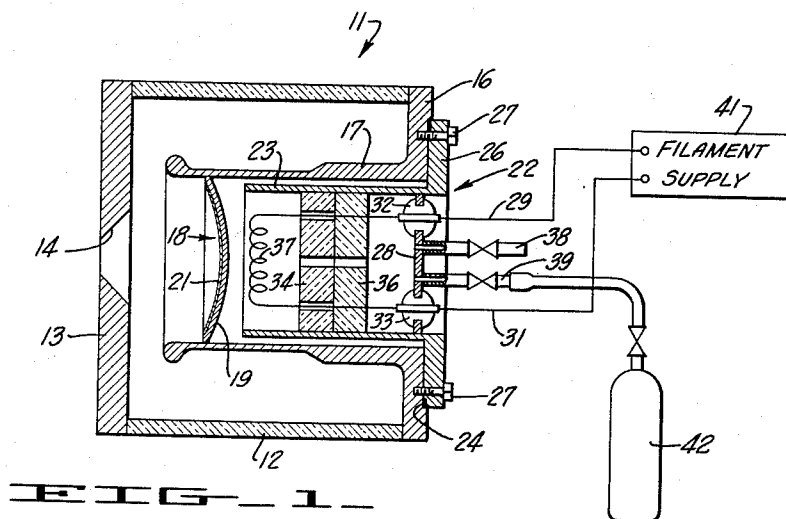
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ELECTRON GUN AND CATHODE

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1

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ELECTRON GUN AND CATHODE

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The present invention relates to an improvement in cathode heating particularly adaptable to high power electronic tubes such as klystrons and the like.

Present day high power electron tubes such as klystrons for example are inherently simple and rugged and consequently have a very long life except for the electron emission portion thereof. Despite advances in the cathode art it is common for the electron gun portion of klystrons to constitute the weak link wherein tube failure results from loss of emission from the cathode surface or mechanical failure of the filament heating the emission surface.

The present invention provides a simple and inexpensive solution to the above-noted difficulty by divorcing at least a part of the cathode from the vacuum system of the tube. The invention provides a removable cathode cartridge that is easily and rapidly removed from or inserted in a high power tube whereby the portions of the tube that are most susceptible to damage or failure are readily replaceable without incurring appreciable periods of tube inactivity. There is additionally provided by the present invention a different and advantageous heat exchange medium whereby other and more desirable electron emission surfaces may be employed than had heretofore been feasible.

It is an object of the present invention to provide an improved electron gun structure for beam power tubes.

It is another object of the present invention to provide a replaceable cathode structure for electron tubes.

It is a further object of the present invention to provide conduction heating for indirectly heated electron emitters of electron tubes.

It is yet another object of the present invention to provide a cartridge cathode element adapted for insertion in and removal from high power electron tubes.

It is a still further object of the present invention to provide for an electron tube improved cathode structure sealing off a replaceable filament element.

It is another object of the present invention to provide a replaceable cathode structure for continuously evacuated electron tubes and having a sealed filament for heating the electron emitter by conduction.

It is still another object of the present invention to provide electron tube cathode structure including a removable gas filled filament cartridge.

The present invention is herein disclosed in connection with particular preferred embodiments thereof, however, the invention is not to be limited to specific details thereof and reference is made to the appended claims for a precise definition of the scope of the invention.

Preferred embodiments of the present invention are illustrated in the accompanying drawing, wherein:

Figure 1 is a longitudinal section view of the electron gun structure of a sealed off high power electron tube in accordance with the invention; and

Figure 2 is a longitudinal section view of the electron gun structure of a continuously evacuated high power electron tube in accordance with the present invention.

2

Considering now the structural details of an electron tube, such as a klystron for example, there is provided as a portion thereof an electron gun 11 including an insulating high voltage bushing 12 in the form of a hollow cylinder closed at the inner end thereof by a metal plate or anode 13 having a small transverse central aperture 14. The other end of the cylindrical bushing is closed by a metal back plate or wall 16 having a large central opening transversely therethrough providing communication with the interior of the bushing 12. Formed integral with or attached to the back wall 16 is a large hollow metallic cylinder 17 disposed concentric with the bushing 12 interior thereto and having the inner end thereof adjacent the anode 13. The cylinder 17 preferably has outwardly curved edges at the inner end thereof to prevent electron discharge between the anode and same and the walls thereof may have a reduced thickness immediately behind the rolled inner edge, as shown, for reducing heat dissipation and conduction in this area.

Of the above described elements which are generally conventional in klystrons, the anode 13 and cylinder 17 may be formed of stainless steel and the bushing 12 of suitable insulating material to withstand quite high voltages in vacuum. The bushing 12, anode 13, back wall 16 and cylinder 17 are joined together to form the shell of the electron gun and suitable provision (not shown) is made for mounting same in position in a wall of the housing of a tube with which it is associated, the back wall 16 then forming a part of the outer wall of such housing.

Within the cylinder 17 adjacent the inner end thereof is disposed an electron emitter 18 including a semispherical support member 19 attached to the cylinder walls with the concave side thereof facing the anode 13. The support 19 is disposed in sealing relation to the cylinder walls as by welding thereto and an emitting material 21 is disposed over the concave surface thereof. This structure then defines a cavity in the tube directed toward the anode from the tube exterior and sealed vacuum tight from the tube interior.

Indirect and replaceable heating means for the emitter 18 is provided in the form of a cartridge 22 adapted to slide into the aforementioned cavity and to sealingly engage the back wall 16 of the tube for defining a heating chamber within the cylinder 17. This cartridge 22 includes a thin walled cylinder 23 having a lesser diameter than the tube cylinder 17 and being provided with an exterior flange 26 about the outer end thereof. The cartridge is attached to the tube with the cylinders 23 and 17 in substantially coaxial alignment by bolts 27 through the cartridge flange 26 threaded into bolt holes in the back wall 16 of the gun structure. The cartridge is thus removably disposed with the cylinder 23 thereof inside of the cylinder 17 and a suitable gasket 24 may be provided about the flange 26 for sealing the interior of the cylinder 17 at the outer end thereof. The outer end of the cartridge cylinder 23 is closed by a disc 28 mounted in sealing relation to the cylinder. This disc 28 supports in insulating relation a pair of filament leads 29 and 31 extending therethrough via lead through insulators 32 and 33 respectively. These leads 29 and 31 extend longitudinally of the cartridge cylinder 23 through a pair of insulating discs 34 and 36 to opposite ends of a filament 37 disposed immediately behind the support 19 of the electron emitter 18.

Provision is made for employing an atmosphere of inert gas interiorly of the cartridge and behind the electron emitter. As previously noted, the emitter support 19 seals the cylinder 17 and the cartridge flange 26 seals the outer end of the cylinder 17 as by a gasket 24 against the back plate 16, so that with the interior of the cartridge 22 sealed by the back disc 28, there is provided a

3

sealed chamber separate from the evacuated interior of the tube. A pair of tubes 38 and 39 are provided through the back disc 28 of the cartridge with simple valves therein whereby an inert gas supply, not shown, may be connected to one tube and with the valves open the cartridge purged through the other tube; closing of the valves then sealing an inert atmosphere within the cartridge. One or more openings may be provided transversely through the insulating discs 34 and 36 for ready gas passage or the porosity of the discs relied upon.

The filament 37 is supported in position behind the emitter 18 by means of the filament leads 29 and 31 and these in turn are supported by the insulating disc 36 contacting the filament wires. The other disc 34 adjacent the filament has enlarged transverse apertures through which the filament wires extend out of contact with the insulating disc. Inasmuch as the filament operates in a gas atmosphere a lightweight ceramic insulating material such as foamed ceramic may be used for the discs 34 and 36. These insulating discs serve to support the filament leads in insulated relation to the cartridge cylinder 23 and to provide heat insulation behind the filament. The stepped apertures through the insulating discs provide additional filament lead length between filament and disc contact to allow maximum cooling of the leads before contact with the disc whereby disc damage is minimized. Of course the discs 34 and 36 may be combined in a single unit with stepped transverse apertures therethrough.

Considering now the operation and use of the above described embodiment of the invention, the insulating bushing 12 together with attached anode 13 and back plate 16 are mounted in a high power vacuum tube such as a klystron with suitable power supplies, not shown, connected to maintain the anode 13 at a highly positive potential with respect to the emitter 18 and surrounding cylinder 17, the latter normally being electrically grounded. A current supply 41 is connected between the filament leads 29 and 31 causing a heating current to flow through the filament 37. The filament is heated by the current flowing therethrough and emits heat by radiation to the support member 19 and by conduction through the atmosphere of inert gas also to the support 19. The gaseous atmosphere provides a good heat conducting medium between filament 37 and support 19 so that the latter may be readily raised to a much higher temperature than is possible with radiation alone, as in a vacuum. The small cross section of the cartridge cylinder 23 and outer cylinder 17 limits heat transfer therealong toward the outer wall of the tube, here formed by the plate 16, and the insulating discs 34 and 36 limit heat conduction back through the cartridge.

The electron emission surface 21 is heated by the support 19 therefor so as to thermally emit electrons which are then attracted by the relatively positive potential of the anode 13 and these electrons are collimated by the anode to pass in a beam through the aperture 14 therein for additional operations within the remainder of the tube. Because of the improved heat transfer between filament and electron emitter it is possible to raise the temperature of the latter without forcing the filament to undesirable temperatures and it thus becomes feasible to employ newer and more efficient emission materials than has heretofore been possible. Thorium emitters, for example, may be employed in tubes utilizing the present invention and more efficient utilization of cathode power is attained with any emission surface, such as conventional oxide emitters.

In operation of the tube the filament will most likely be the first element thereof to fail because of the particularly rugged construction of tubes such as klystrons and despite the lower temperatures at which it may be operated owing to the improved heat conducting atmosphere surrounding same. Conventionally, filament failure can only be repaired by complete tube disassembly which is a

4

major project requiring the tube to be removed from service for a considerable period of time. With the present invention, however, a filament may be replaced in the matter of a few minutes. The cartridge 22 of the present invention is sealed-off from the vacuum system of the tube so that it may be removed without affecting the remainder of the tube. Removal of the bolts 27 frees the cartridge 22 so that it readily slips out of the tube cylinder 17. With the cartridge removed the filament 37 may be repaired or replaced to ready the cartridge for reinsertion in the tube or if time is of great importance a replacement cartridge may be used with the damaged one later repaired for subsequent use as a spare part. The cartridge with a whole filament is then inserted in the tube cylinder 17 and aligned by inserting the bolts 27 in the holes in the back plate 16. Tightening of the bolts fixes the cartridge and included filament in correct position. A source of inert gas 42 is then connected to one of the tubes 38 and with the valves in the tubes 38 and 39 opened, gas is admitted to the cartridge interior and same is purged of air so that an inert gas atmosphere remains therein upon closure of the valves in the tubes 38 and 39. With the attachment of a filament supply 41 across the filament leads 29 and 31 the tube is again in operating condition.

There are of course a multitude of variations that may be made within the scope of the present invention and there is illustrated in Figure 2, as an example thereof, a unit suitable for use in a continuously evacuated tube as may be employed in connection with equipment having evacuation means. In the embodiment of Figure 2 elements which are the same as in Figure 1 are similarly numbered and a cartridge 22' is attached by bolts 27 through the cartridge flange 26 into holes in a back wall 16 of the electron gun 11'. As is conventional, a high voltage bushing 12 surrounds the electron gun and spaces the anode 13 from the back wall which has a cylindrical portion 17 extending toward the anode with the inner rolled end thereof spaced therefrom.

The cartridge 22' includes a thin walled cylinder 51 similar to the cylinder 23 of Figure 1 but carrying at its inner end a flange 52 having an outer diameter substantially equal to the inner diameter of the tube cylinder 17 for sliding therein. This flange 52 positions the cartridge 22' coaxially within the cylinder 17 while providing for longitudinal motion of the cartridge therein. The cartridge 22' further differs from the one previously described in that it includes the electron emitter 18. The emitter support 19 is mounted in the inner end of the cartridge cylinder 51 with the emission surface 21 on the outer side of the support. By this means the electron emitter is made a part of the removable cartridge 22' and the support 19 seals the inner end of the cylinder 51 to form a closed chamber.

The interior of the cartridge 22' is much the same as that previously described and there is included a filament 37 adjacent the emitter 18 and separated from a back disc 28 by a pair of insulating discs 34 and 36. Filament leads 29 and 31 maintained in position by the insulating discs support the filament and extend to the back disc 28 where at least one lead 29 is brought out of the cartridge via a lead-through insulator 32 in the back disc 28. As a ground return may be employed for the filament circuit the other filament lead 31 may be electrically connected to the back disc 28 which is grounded and a filament supply (not shown) is connected between lead 29 and ground.

It is contemplated in this modification of the invention that an inert gas atmosphere shall be provided between filament and emitter, and a sealed system therefor is herein provided. The cartridge is adapted for filling with inert gas during assembly, or reassembly following repair, so that no gas need be added when the cartridge is inserted in the tube. The contained atmosphere of the

cartridge may be provided through tubes or apertures

5

sealed following assembly or final assembly may be made in the desired atmosphere.

The above described embodiment of the present invention is employed as a replaceable unit of the continuously evacuated tube in which it is mounted. Upon filament failure or emitter poisoning as by exposure to air at a high temperature as may result from air leaks in the tube or associated equipment, the cartridge is readily removed by threading out the bolts 27. The cartridge including the emitter 18 at the inner end thereof is then slid out of the tube cylinder 17 and another new or repaired cartridge slid in and secured. As the tube is continuously evacuated no harm results from opening the electron gun portion thereof to air for upon reinsertion of a cathode cartridge the gun is again sealed and continued pumping rapidly restores vacuum within the tube. This cartridge has the advantage of being a complete sealed unit containing a gaseous atmosphere so that no gas equipment is required during cartridge replacement and it will be appreciated that such a unit may be employed with sealed-off tubes as by forming an inner cartridge end to mate with the emitter support in heat exchange relationship, the illustrated embodiments being herein described merely as examples of structure in accordance with the invention.

What is claimed is:

1. Cathode structure for an electron tube comprising an electron emitter adapted for indirect heating, wall structure defining together with said emitter a sealed tube boundary, and an externally accessible cartridge including a heating filament and heat shields behind same with enveloping wall structure open at one end adapted for removable sealing relation to said tube adjacent the emitter thereof with said filament adapted for electrical energization to heat said emitter whereby said filament is removable without affecting tube vacuum.

2. Cathode structure as defined in claim 1 further characterized by said cartridge having gas inlet and outlet means for admitting an atmosphere of inert gas and sealing same therein whereby heat from said filament conducts through said gas to said emitter.

3. Cathode structure for an electronic vacuum tube comprising wall structure defining a chamber, an externally accessible cartridge adapted for removable disposition in said chamber and including a heating filament adapted for electrical energization, and an inert gas atmosphere within said cartridge about said filament and sealed from said tube by an electron emitter whereby the latter is heated by gas conduction from said filament.

4. An electron gun for a vacuum tube comprising wall structure defining a cavity with an electron emitter forming a part of said wall structure and sealing the tube interior from said cavity, a filament cartridge open at one end and adapted for externally removable disposition in said cavity in sealing relation thereto to form a sealed chamber therein, said cartridge having a heating filament adapted for electrical energization to emit heat therefrom, and an atmosphere of inert gas disposed within said chamber about said filament and extending substantially to said emitter for heating the latter through conduction from the filament.

5. An electron gun for a vacuum tube comprising cylindrical wall structure extending into the tube with the inner end thereof sealed by an electron emitter adapted for indirect heating and together defining a cavity sealed from the tube interior and a cylindrical cartridge having an externally accessible flanged outer end and open inner end adapted for removable insertion in said cavity with said flange sealing same, said cartridge having a heating fila-

6

ment at the inner end thereof and gas connections for filling with a gaseous atmosphere whereby said filament is externally removable from said tube without affecting tube vacuum.

6. An electron gun for a continuously evacuated electron tube comprising an apertured anode; a high voltage bushing extending from said anode; an open ended tube cylinder extending from the free end of said bushing toward said anode at the aperture thereof and defining a cylindrical cavity into said tube from the exterior thereof; and a cathode cartridge including a cylinder with an electron emitter sealing the inner end thereof adapted for externally removable insertion in said tube cavity in sealing relation to said tube cylinder, a filament within said cartridge adjacent the emitter thereof, and an atmosphere of inert gas contained within said cartridge between filament and emitter.

7. A filament cartridge for use with a vacuum tube comprising a thin walled cylinder having an exterior flange about one end thereof, and open at the other, a heating filament mounted in insulated relation to said cylinder adjacent the unflanged open end thereof, externally accessible attachment means for removably securing said cartridge to a vacuum tube adjacent an electron emitter thereof, and sealing means for establishing a vacuum seal between said flange and vacuum tube to thereby define a chamber about said filament whereby same is adapted to contain a gaseous atmosphere for conductive heat transfer to the electron emitter.

8. A filament cartridge as defined in claim 7 further characterized by at least one insulating disc transversely of said thin walled cylinder with said disc being heat insulating and electrically insulating, a pair of metal supporting leads extending through said disc in spaced relation and supported thereby with said leads joined to opposite ends of said filament and fixing the position thereof, and a cover sealing the flanged end of said thin walled cylinder with said leads extending therethrough in insulated relation thereto for attachment to a current supply to energize said filament.

9. A cathode cartridge comprising wall structure defining a gas tight chamber with a portion of the wall being electron emissive on the outer surface thereof, a heating filament mounted in insulated relation with said chamber adjacent the electron emissive wall thereof and adapted for electrical energization to heat same, a gaseous atmosphere contained within said chamber about said filament for conducting heat to the electron emissive portion of said wall structure, and externally accessible means removably securing the above-described parts of the cathode cartridge in a wall of a vacuum tube with the electron emissive surface defining a portion of the wall of the vacuum tube for comprising the cathode thereof.

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