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COOLING MEANS FOR ELECTRON TUBES

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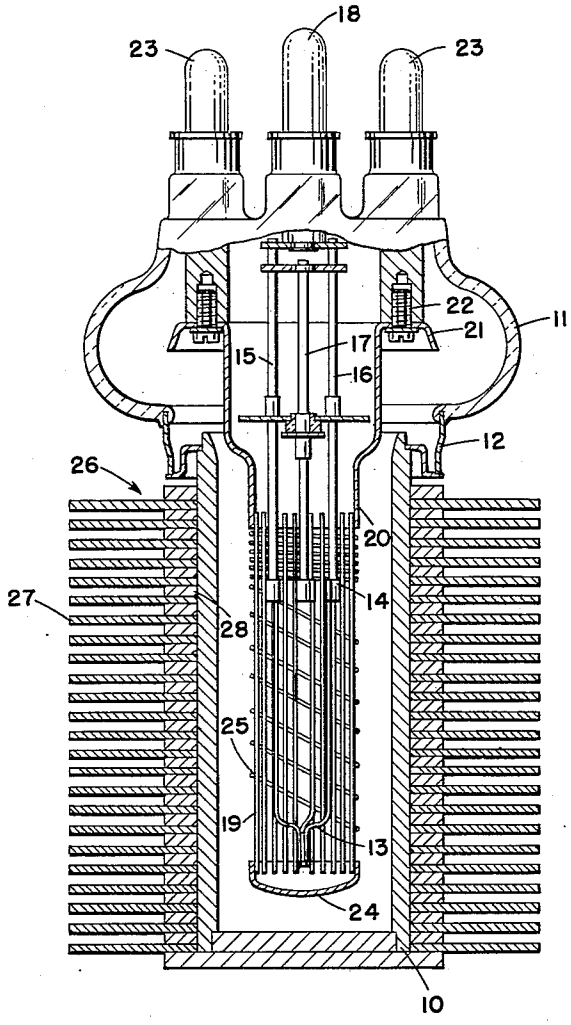

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COOLING MEANS FOR ELECTRON TUBES

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This invention relates to cooling or heat exchange systems for use with thermionic discharge devices and has particular reference to high powered electron tubes having radiators attached to the external anodes thereof.

In the electronics industry it is desirable and common, particularly in the manufacture of high powered electron tubes, to use external anodes formed of copper and to provide means for removing the heat generated therein during operation of the tube. The most common method for accomplishing this is to attach to the anode a radiator comprising a plurality of longitudinally extending copper fins arranged radially about the anode, and to force cool air between the fins to dissipate the heat. It is generally necessary to initially braze the fins to a copper sleeve or core to form the radiator and to subsequently solder the radiator in encircling relation to the anode in a separate assembling operation.

There are, however, a number of objections to such prior art radiators. Copper has been commonly used for the material of the radiator since it can be mounted on a copper anode and has good thermal conductivity. However, it is a relatively heavy material and on some common and extensively used high power electron tubes it is a known fact that the copper radiator alone weighs in the vicinity of 200 lbs. Such heavy tubes thus are very difficult to handle, requiring the use of hoists or other mechanical equipment for handling. Such difficulty in handling also results in increased breakage, particularly of fragile parts within the tube. In addition, packaging and shipping costs of such heavy tubes are high.

Copper also tends to oxidize when heated and consequently is believed to lose some of its heat transfer efficiency.

In prior art tubes of this type there also occur two connections which act as partial heat transfer barriers between the anodes and the fins, these connections occurring at the solder joints between the fins and sleeves and between the sleeves and anodes. Most known efficient soldering media do not possess high thermal conductivity characteristics and, therefore, the reduction in the number of such joints is desirable.

In known prior art tubes provided with radiators of this type, the fins are generally mounted longitudinally of the anode on the copper sleeve which closely encircles the anode, heat being transmitted through the sleeve to the fins. When air is forced in the usual manner onto the bottom of such a radiator, it first strikes one end of the fins and travels along and in the plane of the fins toward the glass envelope of the tube. Thus, by the time it reaches the other end of the fins, the air becomes sufficiently hot to render negligible the cooling effect of the fins at this end and also causes the glass envelope to become undesirably heated.

A still further objection to such prior art radiators is that when soldering copper fins onto the sleeve, for subsequent mounting on an anode, the soldering operation is necessarily performed at such high temperatures that the copper becomes undesirably soft and is thus rendered

structurally weak. This is undesirable since it requires greater care in handling to prevent damage to the fins.

It is, therefore, desirable to construct a radiator which will overcome the foregoing objections, preferably by use of a light-weight material having satisfactory thermal conductivity and tendency toward little or no oxidation when heated, and which remains relatively stiff and hard after conventional fabrication techniques are completed. Aluminum, magnesium, and their alloys are known to possess most of these desirable characteristics.

Aluminum in particular has been tried many times by the industry but up to the time of the conception of this invention has always been discarded for the reason that because aluminum inherently possesses expansion characteristics different from the copper anode on which the aluminum radiator is mounted, when a tube carrying an aluminum radiator has been repetitively heated and cooled, the solder connection between the aluminum and copper becomes ruptured and thus the radiator becomes ineffective.

The present invention, therefore, is directed toward the provision of a radiator formed of aluminum or similar material, which radiator may be satisfactorily permanently attached to and used with a copper anode and which is simultaneously designed to eliminate the problem of efficient cooling at only one end as is the case with known prior art radiators of the aforementioned type.

Accordingly, it is a primary object of this invention to provide an improved radiator for an electron discharge device, which radiator is comprised of fins formed of a light-weight material located in relatively close engagement with the anode and wherein the radiator has expansion characteristics generally similar to the known expansion characteristics of the anode whereby the relatively close engagement between the anode and the radiator will be retained during operation of the electron discharge device and consequent repetitive heating and cooling of the anode.

Another object is to provide a radiator of the above character for an electron discharge device wherein the radiator comprises a plurality of aluminum fins and copper spacers which are disposed in alternate arrangement and positioned in close encircling relation with the anode of the electron discharge device.

Another object is to provide a radiator of the above character wherein the fins and spacers are connected directly to the anode of the discharge device, with no intervening sleeve or core, whereby the heat from the anode is distributed relatively uniformly and efficiently directly to the fins.

Another object is the provision of a composite radiator of the above character wherein the fins and spacers are formed of materials having different coefficients of expansion, and the relative thicknesses thereof are controlled so as to provide the radiator with expansion characteristics such that the stresses on the connection between the radiator and the anode are reduced to a negligible value during operation of the device.

A further object is the provision of an electron tube with a radiator which comprises a plurality of alternately arranged aluminum fins and copper spacers which are shaped for mounting in close encircling relation to the anode of the tube, and which may be easily, quickly, simply and inexpensively soldered in place thereon in a single operation.

A further object is the provision of an electron tube having a radiator of the above character thereon wherein the overall weight and size of the tube are considerably reduced, and wherein the radiator has little or no tendency to oxidize.

Other objects and advantages of this invention will become apparent from the following description taken

in connection with the accompanying drawing, wherein is shown a front elevational view partly in vertical section of an electron tube embodying a preferred form of the invention.

The tube shown in the drawing is an external anode type of power tube wherein a metallic anode **10** is secured to one end of a dielectric envelope **11** as by a seal **12**. Positioned within the anode is a cathode filament structure **13**, the strands thereof being attached by suitable clips **14** to one end of a group of filament-supporting posts **15**, **16**, and **17**. Posts **15** and **16** are connected at their opposed ends to respective terminals which extend through the end of the envelope **11**, one of these terminals only being shown and designated by numeral **18**, the other terminal lying in the plane of and behind terminal **18**. Post **17** terminates short of the connections to the filament terminals and thus functions to aid in properly supporting the filament strands.

The filament structure **13** lies within a grid structure which comprises a cylindrical arrangement of spaced wires **19** having one end extending into a tubular shield **20** and secured to the inner surface thereof. The shield **20** has a radial flange **21** connected by bolts **22** or other suitable means to the adjacent ends of a pair of grid terminals **23** which extend through the envelope **11** and are spaced diametrically apart substantially 90° from the filament terminals.

The opposed ends of the grid wires **19** extend into a metal cup **24** and are secured to the inner surface thereof, and a supporting wire **25** is wound helically around wires **19**.

In operation of a tube of this type it is apparent that electrons will flow from the filament structure **13** through and under control of the grid structure **19** to the anode **10**.

The anode **10** is preferably formed of copper and, upon operation of the tube, is heated and expanded a predetermined amount.

Mounted upon and secured directly to the outer surface of the anode **10** is a radiator **26** which comprises a plurality of radially extending fins **27** and spacers **28** arranged in alternate order, the fins **27** being preferably annular in shape and secured directly to the anode **10** throughout their entire inner peripheries to provide good heat conductivity from the anode **10**. The spacers **28** are also preferably annular in shape and secured throughout their inner peripheries directly to the anode surface. However, the outside diameter of the spacers **28** is relatively small. Thus, a considerable area of both surfaces of each fin is exposed to the air, providing excellent means of dissipating heat from the anode **10**.

To increase the exposed surface area, the fins **27** are formed relatively thin and thus allow for use of fins in greater numbers than would be the case if the fins were thick.

The fins **27** may be made of any suitable light-weight metal such as aluminum, magnesium or their alloys. The spacers **28** may be copper, steel or other material having a different coefficient of expansion than the fins **27**. Aluminum is preferable for the fins since it is light weight, stiff, durable, readily workable, and has good thermal conductivity. Copper, however, is preferred for the spacers **28** because it has a coefficient of expansion similar to the anode **10**.

In accordance with this invention, the fins **27** are made of aluminum or other material having expansion characteristics different than the material of the spacers **28** and it is important, therefore, to control the relative thicknesses of the fins and spacers. For example, if the aluminum fins **27** are made to a thickness of approximately .025 in., and spacers **28** of copper are approximately .050 in. thick, and the known expansion in units per unit length per degree centigrade between 20 and 100 degrees centigrade of commercially available 52 aluminum is

23.5×10^{-6} units and copper 16.5×10^{-6} units, then the resultant axial expansion of the combined fin-spacer radiator unit will be approximately 18.8×10^{-6} units. In addition, since the anode **10** runs about 10% higher in temperature than the adjacent portion of the radiator and consequently expands about 18.15×10^{-6} units, this is sufficiently close to the radiator's expansion of 18.8×10^{-6} units to be satisfactory. Where the relative expansions of the anode and radiator are quite different, separation therebetween is likely to occur during use of the tube with resultant decrease of cooling efficiency of the anode. It is to be understood, however, that if other materials are used for the fins or spacers, the relative thicknesses thereof should be likewise controlled so that the resultant expansion of the radiator will be sufficiently close to the expansion of the anode as to introduce little stress in the connection between the radiator and anode and maintain the close physical relationship therebetween.

It has been found that the heavy prior art tube referred to hereinbefore can be provided with an aluminum radiator of the presently described type, instead of a copper radiator constructed as taught by the prior art, which will not only be smaller in overall size but will be reduced in weight from approximately 200 lbs. to about 30 lbs.

A preferred means of providing a tube with a radiator of this type is to provide the aluminum fins **27** with an initial nickel plating and to initially coat the spacers **28** with cadmium or other selected soldering material. Then the fins **27** and spacers **28** are stacked on a mandrel in alternate order to orient and axially align them. A spring-actuated fixture is preferably applied to compress the group of fins and spacers, after which the mandrel is withdrawn. Then if the fins and spacers are to be connected and the radiator is to be attached to an anode in a single simultaneous operation, the anode is inserted within the structure in place of the mandrel. Then heat is applied of an amount sufficient to melt the cadmium or other soldering material which will flow onto the anode and fins, and upon cooling and hardening, will simultaneously seal the spacers and fins together and to the anode. Additional soldering material may be added as desired in any known manner.

It is to be understood, of course, that the radiators can be made for subsequent attachment to anodes if desired by assembling without presence of the anode.

It is apparent from the foregoing that an improved radiator for electron discharge devices has been provided in accordance with the objects of this invention. It is to be understood, however, that a radiator of the character described may be used with other types of electron discharge devices having external heated elements other than the type shown and described. The presently described radiator is not only light in weight, small in overall size, and relatively rugged and durable, but also is efficient in cooling due to having only a single effective solder connection between the fins and anode, is provided with radial fins, and is formed of a material having little or no tendency to oxidize when heated. While the foregoing description relates primarily to problems encountered with respect to expansion in the axial direction, it is particularly pointed out that radial expansion offers no serious problem since in this direction a condition of compression results due to the greater contraction of the aluminum when the unit is cooled from soldering temperature. Since the temperature of the unit is not thereafter raised during operation to the melting point of the solder, subsequent heating merely results in partial relief of this compression.

While the novel features of the invention have been shown and described, and are pointed out in the annexed claims, it is to be understood that various changes may be made by those skilled in the art without departing from the spirit of the invention. Therefore, all matter shown or described is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. A radiator for an electron discharge device having an anode of known expansion characteristics adapted to be heated during operation of the electron device, the radiator comprising a plurality of fins and spacers mounted in alternate order for close encircling engagement with the anode, the fins and spacers being respectively of materials having different expansion characteristics and being of different thicknesses in accordance with the different expansion characteristics such that the radiator as a unit has expansion characteristics generally similar to the expansion characteristics of the anode whereby upon operation of the electron discharge device and consequent heating of the anode the close relation between the anode and encircling parts of the radiator is retained.

2. A radiator for an electron discharge device having an anode of known expansion characteristics adapted to be heated during operation of the electron device, the radiator comprising a plurality of fins and spacers mounted in alternate order for close encircling engagement with the anode, the fins being relatively thin and of a material having a known coefficient of expansion, and the spacers having a known coefficient of expansion less than the material of the fins and also being formed to controlled thicknesses greater than the thicknesses of the fins, the radiator as a unit having expansion characteristics generally similar to the expansion characteristics of the anode when heated whereby upon operation of the electron discharge device and consequent heating of the anode the close encircling relation between the radiator and anode is retained.

3. A radiator for an electron discharge device having an anode of known expansion characteristics adapted to be heated during operation of the electron device, the radiator comprising a plurality of fins and spacers mounted in alternate order for close encircling engagement with said anode, the fins being thin sheets of light weight metal having a relatively high coefficient of expansion, the spacers being of material heavier than the material of the fins and having a lesser coefficient of expansion, the radiator as a unit having expansion characteristics generally similar to the expansion characteristics of the anode when heated whereby upon operation of the electron discharge device and consequent heating of the anode the close encircling relation between the radiator and anode is retained.

4. A radiator for an electron discharge device having a copper anode of known expansion characteristics adapted to be heated during operation of the electron discharge device, the radiator embodying a plurality of relatively thin aluminum fins and annular copper spacers mounted in alternate order for close encircling relation with the anode, the spacers being of smaller diameter and greater thickness than the respective diameter and thickness of the fins, the respective thicknesses of the fins and spacers being controlled according to the difference in thermal expansion characteristics thereof whereby the radiator as a unit has expansion characteristics generally similar to the expansion characteristics of the anode when heated whereby upon operation of the electron discharge device and consequent heating of the anode the close encircling relation therewith is retained.

5. A high power electron tube comprising an envelope, a cathode within the envelope, an anode secured to the envelope and having a portion extending externally thereof, ahd a radiator mounted on said anode comprising a plurality of fins and spacers mounted in alternate order and in close encircling engagement with the anode,

the fins and spacers being respectively of materials having different expansion characteristics and being of different thicknesses in accordance with the different expansion characteristics such that the radiator as a unit has expansion characteristics generally similar to the expansion characteristics of the anode whereby upon operation of the electron discharge device and consequent heating of the anode the close relation between the anode and encircling parts of the radiator is retained.

6. A high power electron tube comprising an envelope, a cathode within the envelope, an anode secured to the envelope and having a portion extending externally thereof, and a radiator mounted on said anode comprising a plurality of fins and spacers mounted in alternate order and in close encircling engagement with the anode, the fins being relatively thin and of a material having a known coefficient of expansion and the spacers being of a material having a coefficient of expansion less than the material of the fins and also being formed to controlled thicknesses greater than the thicknesses of the fins, the radiator as a unit having expansion characteristics generally similar to the expansion characteristics of the anode when heated whereby upon operation of the electron discharge device and consequent heating of the anode the close encircling relation between the radiator and anode is retained.

7. A high power electron tube comprising an envelope, a cathode within the envelope, an anode secured to the envelope and having a portion extending externally thereof, and a radiator mounted on said anode comprising a plurality of fins and spacers mounted in alternate order and in close encircling engagement with said anode, the fins being thin sheets of light weight metal having a relatively high coefficient of expansion, the spacers being of material heavier than the material of the fins and having a lesser coefficient of expansion, the radiator as a unit having expansion characteristics generally similar to the expansion characteristics of the anode when heated whereby upon operation of the electron discharge device and consequent heating of the anode the close encircling relation between the radiator and anode is retained.

8. A high power electron tube comprising an envelope, a cathode within the envelope, an anode secured to the envelope and having a portion extending externally thereof, and a radiator mounted on said anode comprising a plurality of relatively thin aluminum fins and annular copper spacers mounted in alternate order and in close encircling relation with the anode, the spacers being of smaller diameter and greater thickness than the respective diameter and thickness of the fins, the respective thicknesses of the fins and spacers being controlled according to the difference in thermal expansion characteristics thereof whereby the radiator as a unit has expansion characteristics generally similar to the expansion characteristics of the anode when heated whereby upon operation of the electron discharge device and consequent heating of the anode the close encircling relation therewith is retained.

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