Aug. 9, 1932. J. H. RAMAGE 1,871,343

HEATER ELEMENT FOR ELECTRON EMISSION DEVICES

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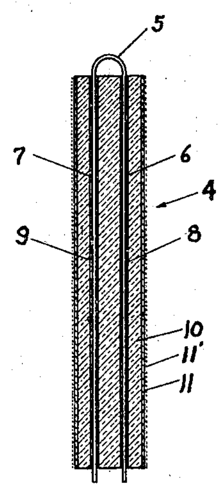

Fig. 1.

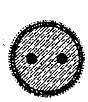

Fig. 2.

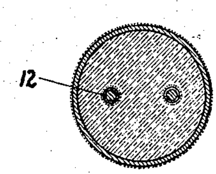

Fig. 3.

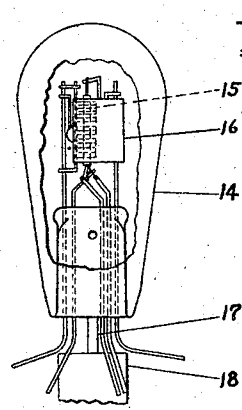

Fig. 4.

INVENTOR
J. H. RAMAGE
BY
ATTORNEY

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UNITED STATES PATENT OFFICE

JOHN HUMPHREYS RAMAGE, OF BLOOMFIELD, NEW JERSEY, ASSIGNOR TO WESTINGHOUSE LAMP COMPANY, A CORPORATION OF PENNSYLVANIA

HEATER ELEMENT FOR ELECTRON EMISSION DEVICES

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This invention relates to heater units for electron emission devices and relates more particularly to heater units as employed in certain types of radio tubes or the like wherein it is desirable to indirectly heat an electron emission material.

In electron emission devices such, for example, as radio tubes which operate by means of an alternating current, it is essential to provide a source of heat, which may be indirectly transferred to an electron emission material, to permit an electron flow between electrodes in the device.

As an example of a device of this character, a radio tube designed to operate on alternating current, such as that known in the trade as the UY-227, may be considered. This tube comprises the usual bulb and base and its internal structure includes a glass press upon which the several electrodes are mounted.

Tubes of this type may employ a plate or anode, a grid or control element and a cathode assembly. The cathode assembly usually consists of a heater element as a length of refractory wire, enclosed in a suitable insulator, such for example as quartz, porcelain, thoria, or a material known as isolantite. The heater element and the surrounding insulator may be termed a heater unit. The insulator of the heater unit is surrounded by a metallic sleeve coated with a suitable electron emitting material, as a carbonate coating which is heated by conduction through the insulator from the heater element, which may be in the form of a filament wire, preferably of tungsten, molybdenum, but which may be of other suitable material as tantalum, or the like.

In the manufacture of the above mentioned type of device, such as a radio tube, it is necessary to attain relatively long life in order to make a tube of economic value in such apparatus where it finds use and especially in connection with radio receiving circuits. Great difficulty has heretofore been encountered in the manufacture of a cathode assembly which would give the required life owing to the gases evolved from the insulators employed. These gases continuously attack the filament at the hotter portions and insulators of different materials have, therefore, been used in an attempt to improve the burnout life of this type of device.

It will also be evident that in addition to the failure of the device by reason of the erosion causing a break in the filament, that any erosion of the filament is a disadvantage since a reduced filament area results in reduced current. Devices of the character to which the present invention relates must be manufactured with accuracy as to their electrical characteristics and if a device is initially constructed with a given filament current this current must be maintained throughout the life of the device. This, however, is not possible where erosion occurs. In the present invention the coating provided on the filament or heater usually flashes off and becomes incorporated as part of the wall of the insulator. Extension tests have shown that the coating does not cause any change in the current flow so that the given electrical characteristics of the device remain constant.

Upon investigation, it has been found that filament burnouts and drop in filament current are caused primarily by a disintegration or erosion of the heater element or filament giving what may be termed a tapered burnout.

It is believed that the tapered burnout, wasting away of the filament at the hotter portions, may be caused by presence of gas released from the porous insulator, which gas may be water vapor, carbon monoxide or dioxide. This gas is given off gradually during the life of the device, causing a continuous attack upon the hottest portion of the heater element or filament with the result that the device will not operate at the rated voltage or the useful life of the device is shortened by a break in the filament.

It is an object of the present invention to provide a thermionic device of the above type having a heater element capable of relatively long life and capable of maintaining uniform filament current.

Another object of the invention is to so protect a heater element or filament as to preserve its usefulness.

Another object of the invention is to provide a cathode assembly with a medium interposed between the heater element and the insulator, whereby detrimental conditions tending to shorten the life of the filament are rendered ineffective.

Other objects and advantages of the invention will be apparent from the following description, together with the accompanying drawing, in which

Figure 1 is a longitudinal sectional view of an insulator with a filament therein.

Figure 2 is a transverse sectional view of the insulator member and filament.

Figure 3 is an enlarged transverse sectional view showing the protective coating about the filament; and

Figure 4 shows a radio tube constructed in accordance with the present invention and applied to an exhaust of a vacuum pump.

In Figure 1 of the accompanying drawing, a cathode assembly 4 is shown in section and, as will be noted, the said assembly includes a filament 5 bent to provide sections 6 and 7 which are disposed in apertures 8 and 9 provided in an insulator member 10. The insulator may be made circular, as shown in the transverse cross section (Figure 2), or it may be non-circular in transverse cross section as desired.

The cathode assembly shown is given as an example of one practical embodiment of the invention and it will be seen from the drawing that the outer surface of an insulator 10 is enclosed in a metallic sleeve 11 upon which an electron emission material 11′ is deposited. The coating which protects the filament is indicated at 12 in Figure 3 as being incorporated in the surrounding walls of the insulator, although this coating may be free from the said wall.

In practice, apertures 12 and 13 which receive the filament are about 6.5 mils to 7.5 mils diameter and the wire is about 5 mils diameter. This gives a close spaced relation between the insulator and the filament and when using an insulator such as isolantite the walls thereof often fuse about and bind the filament. With the present method, the insulator will not adhere to the filament even though a compact mass intimately surrounds each section or portions of the sections of the filament. This is due to the character of the protective agent employed which does not alloy with or otherwise adhere to the filament.

It has been found that regardless of the insulator material employed, the surface of the filament after use indicated that the eroding agent was water vapor. This conclusion was supported by further investigation when the filament was heated during the operation of exhausting the device and also upon a fusing of the insulator, as for example, isolantite, around the filament.

The present invention, therefore, provides the filament with a protective medium capable of fixing oxygen and thus breaking up the water cycle. Materials for this purpose may be chromium, thorium, zirconium, uranium, tantalum, boron, silicon, vanadium, titanium, etc., or any other elements capable of forming compounds with and holding indefinitely any gases detrimental to the life of the filament or capable of causing an erosion of the filament.

Although the above substances will give the required results, chromium has been found to be preferable and chromium plated wire may be used. Ordinarily a plated wire may be brittle, although devices using chromium plated wire were successful and showed no filament erosion or other detrimental effects after long burning (over 1000 hours).

In order to avoid embrittling the wire, the chromium may be applied by mixing chromium powder with a binder as amyl acetate. The method of applying the chromium in the binder may be the same as that practiced for the gettering of filament wire, viz., the wire may be passed through a mixture of chromium powder and binder or the wire may be dipped or sprayed.

It has been found that good results are obtained by mixing 10 grams of chromium powder, passed through a 200 mesh screen, with 15 cc. of a 3% solution of film dope in amyl acetate. These ingredients may be thoroughly mixed in a ball mill. The wire may then be passed through the mixture at a speed of about 6 meters per minute. The filament will then be coated and may be formed in V or hairpin shaped sections. These sections are then threaded through the bores 8 and 9 or apertures in the insulator 11′. The insulator may then be assembled in what has been termed the cathode assembly 4 and mounted in a bulb 14 with the other elements as the grid 15 and anode 16, thus making the interior structure of the device complete and ready for the exhausting operation, whereupon it is applied to a vacuum pump (not shown) by inserting exhaust tube 17 into an exhaust port 18.

In practice, the exhausting operation is performed in what is termed a 20 second cycle, the filament being moved through six positions unlighted, eight positions while lighted with a potential of 5.5 volts and twelve positions at 4.5 volts. This voltage is relatively high inasmuch as the normal voltage of the filament is 2.5 volts. The heating of the filament is primarily to break down the carbonates of the cathode to the oxide, but in the present invention the heating is utilized as an aid to heat the chromium so that oxides or compounds will be produced around the hotter portions of the filament by reason of the gases released from the insulator or otherwise during the heating. Due to the high heat treatment, gases injurious to the life of the filament are driven from the insulator, which gases form stable compounds by reason of their greater chemical affinity with the chromium than with the filament and the gases are thus prevented from attacking the filament. It will be evident that if desirable the chromium powder employed for the coating of the wire may be partially chromium oxide.

It has been found that when coating the filament wire with the above mixture and employing an insulator element such as isolantite, that the isolantite being fusible at a relatively low temperature will fuse about the filament along its length except at cooler portions adjacent to the ends of the insulator. In non-fusible insulators as porcelain, quartz, etc., in the event that gases are evolved the chromium powder will be precipitated to the wall of the insulator around the hot portions of the filament. Inasmuch as the chromium powder is disposed as a protective layer in the wall of the insulator, the filament will be free from any erosive action, as would otherwise occur from gases liberated from the insulator, and at the same time the filament will be free to move relative to the insulator under varying temperature conditions.

The chromium powder, when combined with the constituents of the insulator, may form a slag around the filament. This slag is, however, neutral and does not adhere to or attack the tungsten but forms a protective layer or barrier capable of receiving and holding gases detrimental to the life of the filament.

It has been found that when the chromium powder is precipitated to the wall of the insulator, the wall becomes permeated with chromium and that the diameter of the insulator does not change, and in practicing the invention it may be desirable instead of coating the filament to apply the coating to the wall of the insulator prior to the heat treatment to produce the protective layer. Primarily, the protective medium employed serves to guard the filament against erosion caused by the attack of the gases which are released. Secondly, the coating provides a protective agent which is neutral to the filament and does not alloy with it, thus the voltage of the filament remains unchanged. Thirdly, the protective agent is of such a character, particularly when used with an isolantite insulator which fuses about the filament, that the filament remains free for relative movement with respect to the insulator under variable temperature conditions. When using an insulator of quartz, porcelain or other material having a high fusing point, the binding action of the insulator is not as important. However, the advantage of the protective agent remains, since it is necessary in any case to protect the filament against erosion due to released gases, which causes a disintegration of the filament at the hotter portions and destroys its usefulness.

Any insulator may be employed with a metal that is not readily volatilized but is chemically active, such as chromium, and it has been found that porcelain or isolantite, when used with a tungsten filament protected by chromium, gives satisfactory results. The slag formed is the result of a reaction between the chromium and the silica of the insulating material and presents a hard greenish glazed surface to the filament and bonds with the insulator.

It will be seen from the foregoing that the inventive idea contemplates the use of a filament in combination with a material which acts as a keeper or fixer which neutralizes the gases injurious to the filament. The use of a tungsten filament with a chromium coating is an example of the condition sought, since the chromium fixing agent takes up the injurious gases and is converted to an oxide which is irreducible in the environment within the envelope of the radio tube or other device to which the invention may be applied. Although it is believed that the injurious element is water vapor, it is to be understood that erosion of the filament may be due to carbonaceous gases in which the material employed will form permanent carbides with the same beneficial results.

The present invention, therefore, provides a heater unit for a thermionic device, such as a radio tube, in which the heater element, which is preferably in the form of a tungsten filament, is protected against the erosive action caused by the attack of gases. Although coatings composed of various substances may be employed and changes and modifications may be made in the proportions thereof, it is to be understood that the present invention contemplates a simple and effective prevention of filament erosion and that the same may be accomplished in various ways without departing from the spirit and scope of the invention as set forth in the appended claims.

What is claimed is:

1. A heater unit for an electron emission device comprising an insulative sleeve enclosing a refractory wire and a layer of chromium oxide on the wall of the insulator and between the insulator and the refractory wire.

2. A heater element for an electron emission device comprising a refractory wire, a tubular insulator surrounding said wire, the inner wall of said insulator being permeated with a medium to protect the filament against erosion caused by the release of gases.

3. An electrical device comprising a sealed envelope, an insulator within said envelope having an electron emission material thereon, a heater element for elevating the temperature of said insulator and a material disposed on the wall of said insulator adjacent to said element for neutralizing gases detrimental to the life of said element.

4. A thermionic device having an indirectly heated cathode comprising a heater element, an insulator enclosing said element and a layer of a compound on the wall of the insulator adjacent to said element to protect said element from gases liberated from said insulator.

5. A thermionic device having an indirectly heated cathode comprising a heater element, a porous insulator surrounding said element and a stable compound on the inner surface of the insulator to prevent gases from attacking the filament.

In testimony whereof, I have hereunto subscribed my name this 8th day of May, 1928.

JOHN HUMPHREYS RAMAGE.