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HOT CATHODE ELECTRON TUBE WHICH REQUIRES
NO EXTERNAL CATHODE HEATING CIRCUIT
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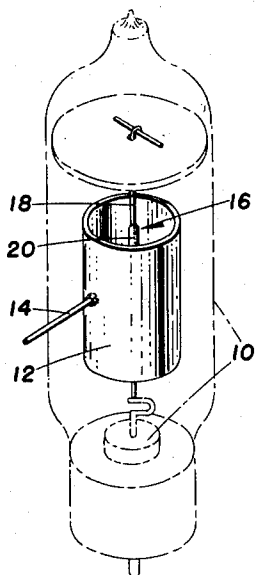


FIG. 1

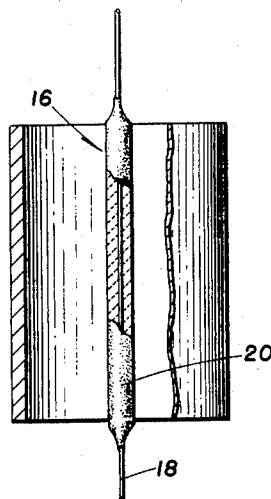


FIG. 2

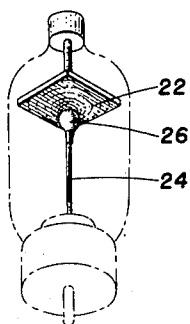


FIG. 4

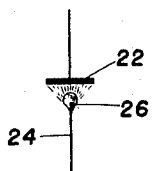


FIG. 4a

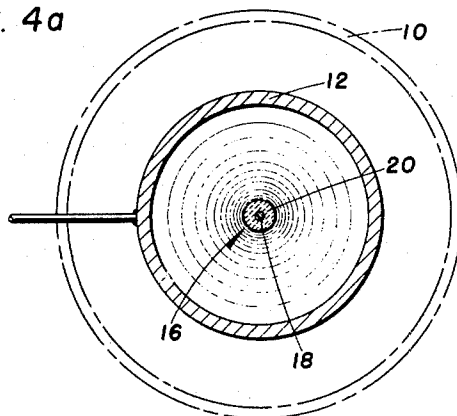


FIG. 3

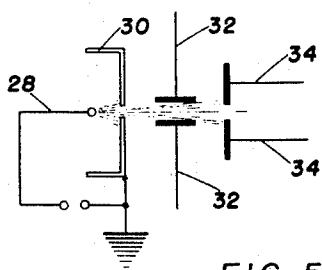


FIG. 5

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HOT CATHODE ELECTRON TUBE WHICH RE-
QUIRES NO EXTERNAL CATHODE HEAT-
ING CIRCUIT

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7 Claims. (Cl. 313—337)

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The present invention relates to an improved high vacuum hot cathode electron tube.

In rectifier circuits operating from a radio frequency power source, for supplying direct power to a load at voltages of less than 1000 to more than 20,000 volts, the cathode of the rectifier tube must be electrically insulated from ground potential if the negative side of the output circuit is to be grounded, in the conventional way. Moreover, voltage multiplying rectifier circuits, used to obtain extremely high voltages, require two or more rectifier tubes to obtain the multiplying effect, and the cathodes of each of these tubes must be electrically insulated from each other in addition to being insulated from ground.

When conventional hot cathode high voltage rectifier tubes are employed in these circuits, a separate power source must be provided to heat each cathode, and when the power to heat each said cathode is derived from a common source of power, the circuit elements provided to heat them must be electrically coupled to the said power source and must all be insulated from each other to withstand a potential at least equal to that of said source. These requirements impose severe problems in the design and construction of voltage multiplying rectifier circuits operating from a source of radio frequency energy.

One of the principal objects of the present invention, therefore, is to provide an electron tube of the hot cathode type which will eliminate the external cathode heating circuit elements and the accompanying problems above mentioned. More specifically, an important object of the invention is to provide a high vacuum, hot cathode electron tube which requires no external cathode heating circuit.

Another object of the invention is to provide an electron tube having a novel coated cathode.

A further object of the invention resides in the provision of an electron tube having a coated cathode heated by dissipation of electric power (developed between the tube electrodes by the application of radio frequency energy) in the cathode coating.

And another object is to provide an improved method for energizing a high vacuum, hot cathode electron tube.

Further objects of the invention will appear as the description thereof proceeds.

In the drawings forming a part of this application,

Fig. 1 is a perspective view of an electron tube constructed according to the present invention, the electrodes only being shown in full lines;

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Fig. 2 is an enlarged detail elevation, partly in section, of the electrode arrangement according to the invention, the coated cathode being purposely shown exaggerated in size;

Fig. 3 is a semi-diagrammatic plan, showing particularly the potential lines between the anode and the cathode;

Fig. 4 is a perspective view of a modification of the invention, the electrodes only being shown in full lines;

Fig. 4a is a diagrammatic showing of the tube of Fig. 4; and

Fig. 5 is a diagrammatic view showing still another modification of the invention.

Referring to the drawings in more detail, and first to Figs. 1, 2 and 3 thereof, 10 indicates, in broken lines, the envelope and electrode supporting structure of an electron tube, according to the present invention. It should be understood that the envelope and electrode supporting structure 10 are conventional and therefore need no further description. An anode 12 is mounted axially of the tube and, while shown as being cylindrical, may be of some other configuration, provided, however, that it will be capable of concentrating an electric field about the cathode, as will be described in detail hereinafter. Electrical connection to the anode may be effected through a metallic support 14.

The cathode of the tube is shown generally at 16 and comprises a base wire 18, of tungsten for example, and a relatively thick coating 20, of barium and strontium oxides. The cathode 16 is supported at its upper and lower ends by the supporting structure 10, and preferably extends axially through the anode 12.

In operation, when radio frequency potential is applied to the anode 12 and the cathode 16, in a conventional rectifier circuit (not shown), it produces an intense radio frequency electric field in the cathode coating 20, causing appreciable power to be dissipated in the coating which heats said coating to operating temperature. The cathode 16 is thus heated by the radio frequency potential applied between the anode and cathode and no external cathode heating circuit is required.

The power dissipated per unit volume in the cathode coating 20 is proportional to the product of the frequency of the electric field, the square of the intensity of the field in the coating and the dielectric loss factor. The dielectric loss factor is the product of the power factor of the coating and the dielectric constant of the coating.

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The power required to maintain the cathode 16 at operating temperature is the sum of the power required for electron emission, the power lost by radiation from the hot cathode surface and the power lost by heat flowing out of the cathode structure (base wire 18 and coating 20) to the supporting structure 10. This last mentioned power loss is known as the cathode end loss and is an appreciable part of the total cathode power. The end loss in the tube of the present invention is minimized by constructing the cathode base wire 18 of thin, strong wire. This construction is possible in this said electron tube because the parameters of said base wire 18 are not limited by heating current and heating voltage requirements, as in conventional filamentary cathodes. A suitable base wire 18 for use in an electron tube according to the present invention is one of tungsten having a diameter of about 0.0004 inch or a wire weight of 0.35 mg. per 200 mm. length of wire. This dimension is not critical and wires of larger diameter have been used successfully.

The power dissipated in the cathode coating 20 must supply all the power required to maintain the cathode 16 at operating temperature. In order to dissipate this much power in the cathode coating, the following requirements must be satisfied.

(1) The volume of the cathode coating 20 is very great compared to conventional coated cathodes, to increase the power dissipated in said coating. A suitable weight of coating material on the base wire 18 (0.35 mg. per 200 mm. tungsten) is about 3.5 mg. per 200 mm., or about ten times the coating weight in a conventional tube employing the same size base wire.

(2) The dielectric loss factor, mentioned hereinabove, of the coating is made much greater than in the conventional coated cathode. The electron emitting material in the coating is composed of the same barium and strontium oxide, with or without calcium oxide, that results from decomposing the carbonates of these metals that are applied to cathodes in the initial operations of tube manufacturing. The loss factor of the coating can be greatly increased over that of the conventional tube by only partially decomposing the alkali carbonates to the oxides during processing. Sufficient oxide must be formed to provide the required electron emission, but the portion formed is not critical. Similarly, the desired increase in loss factor can be obtained by the addition, to emission coating mixtures, of materials to increase the dielectric loss.

(3) The alternating electric field at the surface of the cathode is made very intense by operating the tube at comparatively high potentials and by employing an anode having a very much larger surface area than the cathode, spaced only far enough away from the cathode to meet the inverse peak voltage requirements. An anode suitable for a rectifier tube operating in a circuit having a peak alternating potential of 10,000 volts and employing the hereinabove mentioned cathode is a cylinder, as in Figs. 1 and 2, having an inside diameter of about one-half inch, with the cathode placed along the axis of the cylinder. To operate at potentials of about 1,000 volts, a very much smaller diameter cylinder is required, i. e. about one-eighth inch. As pointed out hereinabove, the shape and dimensions of the anode are not critical, but they must be arranged to have a large part of the potential difference between the anode and cathode near

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the cathode surface. For example, in Figs. 4 and 4a the anode is shown as a square flat plate 22 and the cathode as a straight rod 24 extending at right angles, and terminating in close spaced relation, to said plate. The cathode coating in this embodiment consists of a mass of high dielectric loss material 26 on the end of the rod.

(4) The power dissipated in the cathode coating is directly proportional to the frequency of the electric field employed for heating it, and an operating frequency is chosen that is sufficiently high to provide the required power dissipation. A suitable frequency for a tube according to the invention, having a one-half inch cylindrical anode operating at an alternating potential of 10,000 volts peak is about 150 kilocycles per second. The product of frequency and the square of the applied alternating potential determine the heating of the cathode, and either factor may be varied over a wide range for a particular tube if the product does not vary more than plus or minus 30 per cent.

It should be understood that the principles set down herein are not limited to use in rectifier applications; they may be employed in any hot cathode, high vacuum, electron tube in which an intense alternating electric field is present at the surface of the cathode. An example of such an application is a hot cathode high vacuum X-ray tube operating from a radio frequency power source. Another example is shown in Fig. 5, which illustrates, diagrammatically, a cathode 28, an apertured anode 30, and a plurality of electrodes 32, 34 disposed to confront a stream of electrons passing through the anode aperture. The electrodes 32, 34 may be, for example, the accelerating electrodes of an electron gun.

What is claimed is:

1. In an electron tube, an anode, a cathode associated with the anode, said cathode consisting of a base wire and a coating of electron emitting material having a thickness greater than the diameter of said base wire, said anode and cathode being adapted for connection to a source of high frequency electricity for generating an electric field, and means positioning the cathode in close spaced relation to the anode whereby the cathode will be heated by said field.

2. An electron tube as recited in claim 1, wherein the electron emitting material has a high dielectric loss factor.

3. An electron tube as recited in claim 1, wherein the electron emitting material includes partially decomposed carbonates of strontium and barium.

4. A high vacuum, hot cathode, electron tube having an anode, a cathode consisting of a base wire and a coating of electron emitting material having a thickness greater than the diameter of the base wire, said anode and cathode being adapted for connection to a source of high frequency electricity for generating an electric field about the cathode, and means positioning the cathode in close spaced relation to the anode whereby the cathode will be heated by said field.

5. A high vacuum, hot cathode, high voltage rectifier tube having an anode, a cathode, said cathode consisting of a base wire and a coating of electron emitting material having a thickness greater than the diameter of said base wire, said anode and cathode being adapted for connection to a source of high frequency electricity for generating an electric field, and an envelope enclosing the anode and cathode, said cathode being positioned in close spaced relation to the anode

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whereby the cathode will be heated by said field.

6. A high vacuum, hot cathode, high voltage rectifier tube as recited in claim 5, wherein the electron emitting material has a high dielectric loss factor.

7. An electron tube as recited in claim 5, wherein the electron emitting material includes partially decomposed carbonates of strontium and barium.

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