Feb. 20, 1934. F. S. McCULLOUGH 1,948,122

THERMIONIC TUBE

Original Filed March 2, 1925

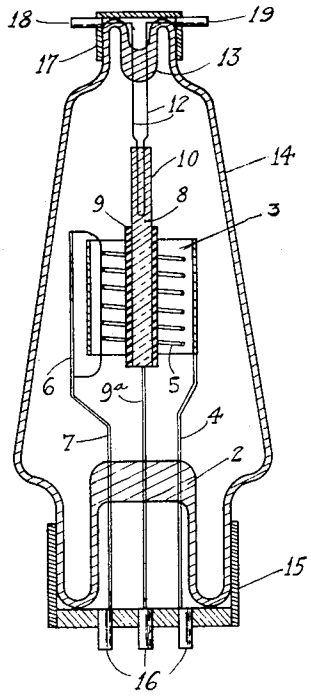


Fig. 1.

Fig. 2.

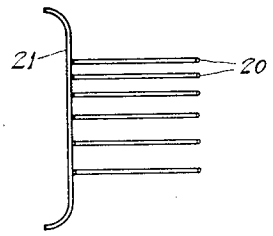
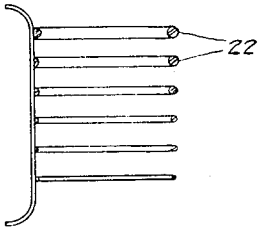


Fig. 3.



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THERMIONIC TUBE

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Continuation of applications Serial No. 12,477, March 2, 1925, Serial No. 16,711, March 19, 1925, and Serial No. 30,182, May 14, 1925. This application December 29, 1931. Serial No. 583,687

28 Claims. (Cl. 250—27.5)

This invention is for electron tubes of the type commonly used in radio communication and commonly referred to as radio tubes. The present invention relates particularly to tubes capable of operation on alternating or pulsating currents and in which the hum ordinarily produced by such pulsating currents is entirely eliminated.

Various attempts have been made to indirectly heat an electron emitting cathode from a heating element energized from a source of alternating current, heat being transferred to the cathode either by conduction or by radiation. Such devices, while operable, do not entirely eliminate the hum due to the action of the field around the heating device resulting from the continuing phase reversal of the alternating current therein.

It is a common practice in the electrical industry to heat a member conductively from a heating element energized by an alternating current. This is found, for instance, in the Nernst lamp, in various electrically heated utensils, and to a certain degree in radio tubes using a Wehnelt cathode wherein the electron emitting coating is conductively heated by the filament which the coating encrusts.

The present invention follows the general plan of heating a cathode conductively from a resistance element, but it has for its object to so organize and arrange the several parts as to completely eliminate any noise or distortion resulting from phase reversal or pulsations in the current supplied to the resistance element.

It is well known that in the usual tube having a cathode which is heated by the passage of electric currents directly therethrough, there is a graduation in the electron current between the cathode and the anode along the length of the cathode, by reason of the potential drop across the cathode. In other words, one end of the cathode is positive and the other end negative, so that there is a graduation of current along the entire length of the cathode. This necessarily results in a gradient for the electron current along the cathode.

In a vacuum tube of the kind herein shown the cathode is uni-potential. It is heated by means of a heater which is entirely separate from and independent of the cathode and from which heat is transferred from the heater to the cathode. There is, therefore, no potential drop across any part of the cathode, but there is a temperature gradient which results in a graduated electron emission along the cathode.

This application is a continuance of my applications Serial No. 12,477, filed March 2, 1925, Serial No. 16,711, filed March 19, 1925, and Serial No. 30,182, filed May 14, 1925.

One object of the present invention is to so arrange the grid as to overcome the gradient in the electron current along the length of the cathode.

In my application I show a grid whose metallic surface, or whose effective surface, is graduated according to the graduation in the electron current along the cathode. Such variation may result either by reason of a temperature gradient along a cathode in the case of an equal potential cathode, or by reason of a potential gradient along the cathode.

A feature of the present invention is the provision of a grid capable of effecting the greatest control where the electron current is the greatest, and less control where the electron current is less.

I show two methods by which the desired results may be obtained, one wherein the spacing of the turns of the grid is graduated and the other wherein the size of the metal used as a grid is graduated.

The invention may be readily understood by reference to the accompanying drawing, in which:

Fig. 1 shows a section through a thermionic tube of my invention;

Fig. 2 is a view of the grid having the spacing of the turns graduated; and

Fig. 3 shows a grid in which the metal is of a graduated size.

While I have specifically illustrated a small tube especially designed for radio receiving circuits, the invention is not to be considered as confined to receiving tubes, or to be restricted to the specific arrangement and assembly of parts illustrated.

In the drawing 2 designates a usual stem structure for a tube, 3 is a cylindrical plate supported thereon, 4 is the usual plate lead wire, 5 is the grid, 6 is the grid support, and 7 is the grid lead.

Centered within the grid is a porcelain or other suitable body 8. This body is materially longer than the grid and plate, so that its upper end extends well above the plate and grid. Around that portion of the body 8 which is surrounded by the grid and plate, is a metal shell 9 on which may be a low temperature emitting substance, of any preferred nature. A lead wire 9a may lead from this shell to the bottom of the

tube. This will take the place of the two filament leads usually coming from the bottom of the tube, and will serve to connect the shell, which is the cathode, in circuit with the plate or "B" battery.

In the upper portion of the body 8, above the part that is surrounded by the shell, is a looped heating resistance 10 having its terminals at the same end of the body whereby the magnetic field around the resistance is partially self-neutralized. The lowermost end of this resistance preferably terminates above the grid, so that the resistance does not extend—at least to any appreciable distance—into the zone of influence of the grid or control.

The heating resistance 10 is connected with wires 12 preferably coming in through a second stem 13 in the top of the envelope 14.

The finished tube comprises the envelope 14, a suitable or standard base 15, with contact pins 16. At the top of the tube is a cap 17 provided with contact pins 18 and 19 adapted to provide for a quick detachable connection of the resistance leads 12 in a lighting or other supply circuit.

In operation, the alternating or other current energizes the resistance element 10, which is preferably of a nature capable of being highly heated by the passage of current therethrough. This heat is conducted through the body 8 to the shell 9, heating it to a temperature sufficient to sustain electron emission.

By reason of the resistance element 10 being entirely above the control and plate elements, the field variation around such resistance element is entirely or substantially above the field of the control element and the space between the plate or anode and the cathode. Consequently, any alternating or varying field around the resistance element will have no effect on the current flow across the space between the anode and the cathode.

By taking the energizing or alternating current leads 12 out of the top of the tube, while the leads from the anode, cathode, and control electrodes pass out the bottom, inductance from the alternating current leads to the electrode leads may be eliminated. Furthermore, it enables the tube to be inserted in standard sockets of present receiving apparatus, without modification thereof.

The upper end of the shell 9 will become more highly heated than the lower end of the shell. Consequently, there will be a greater electron emission from the upper end of the shell than from the lower end of the shell, and this emission will be graduated throughout the length of the shell or cathode.

The particular construction shown possesses a great advantage, by reason of the heating element 10 being substantially above the electrodes of the tube, and consequently so located that it may be heated by alternating currents without generating a field in the space between the electrodes detrimental to the action of the tube.

In order to overcome the gradient in the electron emission along the cathode 9, it not beng possible to compensate for this by any biasing of the grid with respect to the cathode, as is possible in the usual form of tube, I propose to so arrange the grid that it will exert its control proportionately to and in accordance with the gradient in the electron stream. This is preferably done by increasing the open area of the grid toward the cooler end of the cathode. This will result in the grid having a greater metallic area at the upper end of the cathode where the electron stream is greatest and in having a smaller metallic area at the lower end of the cathode where the emission is the lowest. This spacing of the grid is preferably graduated approximately in accordance with the gradient of emission or with the temperature gradient of the cathode.

I have shown in Fig. 2 the grid as consisting of a helix 20 secured to the grid supporting member 21 with the upper convolutions of the helix more closely spaced than the lower convolutions, with the spacing gradually increased toward the lower end. From the foregoing, it will be readily seen that the upper end of the grid will have a greater control effect where the electron stream is the greatest, while the lower end in the field of lower electron flow will have a less and proportionate control.

The grid may be in the form of a coil 22 shown in Fig. 3, the metal turns of which are of larger diameter at one end than at the other, while the pitch of the coil may be constant, the decrease in the diameter of the wire being gradual.

The heavier end of the grid has a greater mass, or greater metallic surface, than the other end, and has a greater control effect than the other end, and this propensity is graduated along the grid.

In the type of tube shown, the heater is well above the greater portion of the length of the cathode, whereby there is an appreciable temperature drop along the cathode, the upper end being hotter than the lower. The grid is accordingly arranged with its heavier end toward the hotter end of the cathode, and its controlling effect graduated substantially in accordance with the emission gradient along the cathode.

I have illustrated but two forms of graduated grid, but it will be apparent that the same result may be achieved with grids of different construction but presenting a graduated controlling surface. The specific construction shown and described is to be considered as merely illustrative of an embodiment of the invention, to the construction of which I am not confined.

Having described my invention, what I claim as new and desire to secure by United States Letters Patent is:

1. An electron tube, having a metal cathode, a grid around said cathode, a plate around said grid, a heat conducting body extending into said cathode and in intimate contact therewith, and a resistance element for said heat conducting body for heating the same, said resistance element being positioned beyond the extremities of said grid and plate whereby an alternating current may be passed through said resistance element without creating a field between the several electrodes detrimental to the desired action of the tube.

2. An electron tube having a plate, a grid, a metal cathode, a resistance element, a body extending within the cathode for transferring heat from the resistance element to the cathode, said resistance element being located in the heat transferring body outside the cathode so that the effect of an inductive field thereabout will be negligible between the plate and the cathode.

3. An electron tube having a plate electrode, a control electrode, and a metallic cathode, a body through which heat is transferred to the

cathode, and a looped resistance element having its terminals extending out of one end of said body for supplying heat to said body to heat the cathode and positioned above the upper extremities of said metallic cathode and said plate electrode.

4. An electron tube having a plate, a grid and a metal cathode, a body member through which heat is to be transferred to the cathode, a looped resistance element extending through orifices in the body member for supplying heat to said body to heat the cathode, said resistance element terminating short of said cathode, said resistance element having both its terminals at the same end of said body member, and terminal connections extending from the opposite end of said cathode, grid and plate for external connections.

5. An electron tube having a metal cathode member, a grid encircling said cathode member, a plate encircling said grid, a body of electrical insulating material extending into said cathode member and having a projected end portion extending outside the grid and plate, a looped electrical resistance element extending through orifices in said body of insulating material for heating the same, said resistance element terminating short of said cathode, terminals for the cathode member, the grid and the plate extending out of the bottom of the tube, and terminals for the resistance element extending out of the top of the tube.

6. A vacuum tube including an envelope, a tubular metallic cathode within said envelope, a grid surrounding said cathode, a plate surrounding said grid, a resistance element in juxta-position to said cathode for heating the same, a base for said envelope, plate grid and cathode connector terminals positioned in said base, a connector cap on the opposite end of said envelope, connector terminals in said cap, conductor leads extending away from said resistance element in one direction and connected with the terminals in said cap, and cathode, plate, and grid leads extending away in the other direction to the connector terminals in said base.

7. A heating cathode structure for audion tubes including a member of refractory material, a metal shell over one end of said member of refractory material, and an electric heating element extending into the other end of said member of refractory material above the said metal shell so that an inductive field about the resistance element will substantially avoid passing through said shell.

8. An electron tube of the character described including an envelope, an upper and a lower cap for said envelope, terminals secured to said caps for external connections, a grid, a plate and a cathode located within said envelope, connections extending in one direction from said grid, plate and cathode to the terminals of one of said caps, a looped resistance element for heating said cathode, and connections from said looped resistance element extending in the other direction to the terminals of the other of said caps.

9. An electron discharge tube of the character described including an envelope, a base for said envelope having terminal contacts, terminal contacts for the other end of said envelope, a plate, a grid and a cathode located within the said envelope, a heat conducting member extending within said cathode, a looped resistance for heating the said heat conducting member terminating without said cathode, conductors extending in one direction from said plate, grid and cathode to the terminals of said base member, and conductors from said resistance element extending in the other direction to the other said terminal contacts at the other end of said envelope.

10. A device of the character described including an envelope, terminals for external connection located at both ends of said envelope, a plate, a grid and a cathode located within said envelope and supported thereby, conductors extending from said plate, grid and cathode to the terminals at one end of said envelope, a heat conducting body extending into said cathode, a looped resistance element extending through rectilinear orifices in said body and having its terminals at one end thereof, said resistance element terminating short of said cathode, and conductors extending from said looped resistance element to the terminals at the other end of said envelope.

11. A device of the character described including a glass envelope, terminals located at both ends of said glass envelope, a cathode within said envelope and supported thereby, a grid within said envelope around said cathode and supported by said envelope, a plate around said grid and supported by said envelope, electrical conductors extending from said plate, grid and cathode to the terminals at one end of said envelope, a member extending within said cathode, a looped heating element extending through substantially parallel orifices in said member, said resistant member being located entirely beyond said cathode, and electrical conductors extending from said heating element to the terminal contacts at the opposite end of said envelope.

12. In a thermionic device, an elongated cathode, a grid in proximity to only one end thereof, and heater means in proximity to the other end only thereof.

13. In a thermionic device, an extended cathode adapted to be heated, a body having large heat inertia in proximity to only one end of said cathode, and a grid in proximity to the other end only thereof.

14. An electron tube having a metal cathode, a grid around said cathode, a plate around said grid, a member extending into said cathode and in contact therewith, the extremities of said metal cathode extending substantially above and below the extremities of said plate and a looped resistance element extending through orifices in said member, said resistant member being located entirely beyond said cathode, said resistance element being positioned with respect to said grid and plate that there is substantially no overlapping of its inductive field with the space between the plate, grid and cathode.

15. An audion tube including an anode, a cathode having an electron emitting surface, looped means for applying heat to one end of said cathode so that one end thereof becomes hotter than the other thereby producing a varying space charge between said anode and cathode, and a grid of graduated size between said cathode and anode adapted to exert a graduated control along the cathode.

16. A thermionic tube having an anode, a cathode, looped heater means located at one end of said cathode for conductively heating the same, and a grid mounted between said anode and cathode and of a decreasing mass from one

end thereof to the other, arranged to exert a graduated control along the cathode corresponding to the natural gradient of the electron current flow along the cathode between the cathode and anode due to the gradient temperatures along the cathode.

17. A thermionic tube having an anode, a uni-potential cathode, a looped heating wire located at one end of the cathode for heating the same by transmitting heat along said cathode, and a grid formed of wire the diameter of which gradually decreases from one end thereof to the other adapted to exert a greater control at the end of the cathode nearest the heating means.

18. A thermionic tube having an anode, a cathode, a looped heater for the cathode located substantially above the anode and designed to apply heat to one end of the cathode, means for conveying heat from the heater to the cathode so that there is a temperature gradient along the length of the cathode, a grid of graduated size extending along the cathode out of contact therewith and having its effective control graduated along its length with the more effective portion at the end of the cathode nearest the heater.

19. A thermionic tube having an anode, a cathode, and a grid mounted in an envelope and means located above the anode for applying heat to the cathode at one end thereof producing a variable electron current flow along the cathode, portions of said grid being variably spaced to compensate for the variation in the electron current between the cathode and the anode along the length of the cathode due to the gradient of the heat along the cathode.

20. A thermionic tube having an anode, a cathode, a heating wire terminating at one end of said cathode for conductively heating the cathode, and an intervening grid of graduated effective area arranged to exert a graduated control along the cathode corresponding to the natural gradient in the electron current flow along the cathode due to the gradient temperatures along the same.

21. A thermionic tube having an anode, a uni-potential cathode, heating means terminating at the end of the cathode adjacent thereto for heating the same, and a grid having its parts arranged in graduated spaced relation to exert a greater control at the end of the cathode nearer the heating means than at the end of the cathode further from the heating means.

22. A thermionic tube having an anode, a cathode, means including a heating wire terminating near one end of the cathode outside the electron emitting surface of the cathode for heating the same, and a grid interposed between the anode and the cathode having a graduated open area which increases toward the end of the cathode away from the heating means, and an envelope for said anode, cathode and grid.

23. In a vacuum tube having an anode, a cathode, a heater, means for transferring heat from the heater to one end of the cathode, thereby heating the cathode to variable temperatures and causing a variable emitting action of the cathode surface, a grid between the anode and the cathode having the open area thereof graduated inversely to the temperature gradient of the cathode.

24. In a vacuum tube having an anode, a cathode, a heater extending from the anode and the cathode, means for transferring heat from the heater to one end of the cathode thereby producing a gradient temperature along the cathode, a grid between the anode and the cathode having the open area thereof graduated inversely to the temperature gradient of the cathode.

25. In a thermionic tube having an anode and a cathode, a heater for the cathode extending away from the anode and the cathode, means for conveying heat from the heater to the cathode so that there is a temperature gradient along the length of the cathode, and a grid extending along the cathode out of contact therewith having its effective control area graduated along its length with the more effective portion at the end of the cathode nearer the heater.

26. An audion tube including an anode, a cathode, means for applying heat to said cathode at one end thereof so that one end thereof becomes hotter than the other thereby producing a varying space charge between said anode and cathode, and a graduated grid between said cathode and anode adapted to exert a graduated control along the cathode.

27. An audion tube including an anode, a cathode, means including a heater wire adapted to be energized by alternating current for applying heat to said cathode at one end thereof so that one end thereof becomes hotter than the other, thereby producing a varying space charge between said anode and cathode, and a graduated grid between said cathode and anode adapted to exert a graduated control along the cathode.

28. An electron tube having a plate electrode, a control electrode, and a metallic cathode, a body through which heat is transferred to the cathode, leads from said cathode plate and said control electrode extending in one direction, and a resistance element in the body of said cathode for supplying heat to said body to heat the cathode, leads from said resistance element extending in a direction opposite to said cathode plate and control electrode leads, and having both of its terminals at the same end of the body and at the end opposite to the terminals of said cathode plate and control electrode.

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