July 21, 1936. F. S. McCULLOUGH 2,048,133

THERMIONIC TUBE AND CIRCUIT EMBODYING THE SAME

Filed April 18, 1929

Fig. 1.

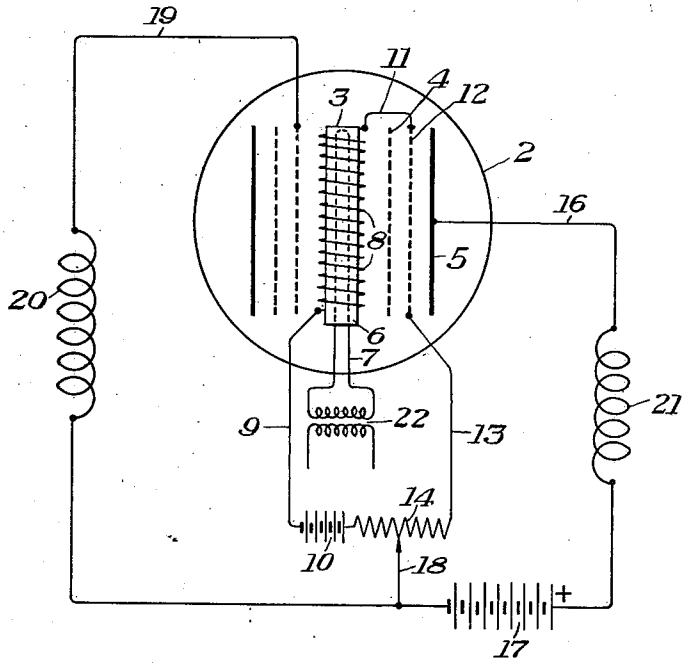
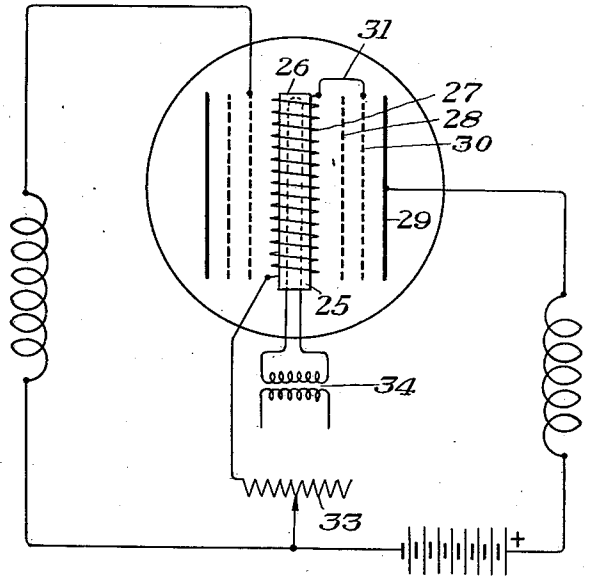


Fig. 2.



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by his attorneys

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THERMIONIC TUBE AND CIRCUIT EMBODYING THE SAME

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Application April 18, 1929, Serial No. 356,089

10 Claims. (Cl. 250—27)

This invention relates to space discharge devices, and more particularly to space discharge devices of the hot cathode type wherein a heater is used for heating the cathode. The invention constitutes an improvement on the tube shown in my co-pending application Serial No. 79,353, filed January 5, 1926, Patent No. 1,853,281, April 12, 1932.

In the usual thermionic tube of the indirectly heated cathode type, the cathode is in the form of a metal cylinder, and within this cylinder is a rod of porcelain or quartz having embedded therein a loose heater wire. Tubes of the directly heated cathode type wherein the cathode is in the form of a filament, have a potential gradient along the filament, by reason of the application of the opposite poles of the source of heating current to the opposite ends of the filament. A tube of the indirectly heated type, as above described, does not have such a potential gradient along the cathode, due to the fact that the heating current flows through the heater wire. The cathode of such a tube is commonly referred to as being an equipotential cathode.

In certain types of radio apparatus, it is desirable to have a potential gradient, or non-equipotential cathode characteristic.

In my said application, there is shown one way of securing a potential drop between one end of the cylindrical cathode and the other end, but due to the relatively low resistance of the cathode material, this potential drop is relatively slight. The present invention provides a tube of the indirectly heated cathode type wherein a substantial potential drop between one end of the cathode and the other can be obtained, and the amount of potential drop can be accurately determined in the manufacture of the tube.

In the accompanying drawing, I have shown diagrammatically one embodiment of my invention. Figure 1 represents schematically a multiple electrode tube and a circuit for utilizing the same. Figure 2 is a similar view wherein a non-equipotential cathode is provided without the use of a separate source of current in the closed cathode circuit.

In the drawing, 2 designates an enclosing envelope within which is a cathode structure 3, a grid 4, and a cylindrical plate 5.

The cathode structure 3 comprises a rod 6 of insulating material such as quartz, a ceramic composition or a vitreous composition. Embodied within the rod 6 and extending throughout substantially the entire length thereof is a looped filament or heater wire 7. Wrapped tightly about the rod 6, preferably with the convolutions relatively close together, is a wire 8. This coil of wire 8 forms the cathode, and it may be coated with a substance for increasing the emissivity, such as the compounds of the rare earth metals now commonly used for such purposes.

One end of the coil 8 may be connected through a wire 9 with a source of current 10, while the other end of the coil 8 is connected to a wire 11. Interposed between the grid 4 and the plate 5 there may be provided what may be termed a fourth electrode 12, but which is actually an extension of the cathode and which is preferably in the nature of the grid. The wire 11, as shown in the drawing, connects to the top of this fourth electrode or cathode extension 12. A wire 13 leading from the fourth electrode 12 connects to a high resistance 14, and the other side of the high resistance connects to the source of current 10.

The provision of the fourth electrode 12 is not necessary, and the wire 11 may connect directly to one side of the high resistance 14 in a tube where this fourth electrode is not provided. Leading from the plate of the tube 5 is the usual plate lead wire 16 which connects to the positive side of a source of plate voltage 17. The negative side of the source of plate voltage may connect through an adjustable contact 18 with the cathode through the resistance 14. The grid circuit for the tube is of the customary type comprising a lead wire 19 connected to the grid and connected to the cathode, the circuit generally including an inductance 20. The plate circuit may include a translating device or transformer winding 21, as will be well understood by those skilled in the art.

The heater wire 7 may be energized from any suitable source of current, either direct or alternating. I have indicated an alternating transformer 22 as providing the source of current for energizing the heater wire.

The wire of which the helical cathode 8 is formed may have any desired resistance, a wire having a relatively high resistance being preferred. By the term "high resistance" as herein used and as hereinafter used in the claims, I mean a metallic conductor, the length, cross-sectional area and specific resistance of which are such as to produce in a tube of any given size an appreciable potential gradient along the length of the cathode and of a magnitude sufficient to impart to the tube the characteristics of a tube having a directly heated cathode or a

cathode of the non-equipotential type, as distinguished from tubes heretofore constructed wherein the indirectly heated cathode has substantially equipotential operating characteristics.

In the operation of the tube, there is a closed circuit from one side of the source of current 10 through the cathode coil 8 to the fourth electrode 12 and back to the other side of the current source 10 through the high resistance 14. It is preferable that this closed circuit have a relatively high impedance in order that the current flow therethrough will be relatively small, but this will be sufficient to give a potential drop of a predetermined amount from one end of the coil 8 to the other. The coil will be heated by the conduction of heat through the refractory rod 6 from the heater wire 7, rather than by any heating effected from the source of current 10. By reason of the fact that the cathode 8 is in the form of a coil, its resistance can be of any predetermined value, and can be of a very appreciable value, whereas where the cathode is in the form of a metal cylinder, the resistance must necessarily be relatively low.

By the provision of the fourth electrode 12, and the inclusion of this electrode in series with the cathode and source of current 10, the operating characteristics of the tube can be very accurately controlled, and a circuit and tube is provided which is highly desirable for some types of radio work.

The invention, therefore, provides a tube of the indirectly heated cathode type wherein an appreciable non-equipotential characteristic obtains in the cathode, and which further provides a tube whose operation can be controlled in a very definite manner by the provision of the fourth electrode in series with the cathode and the source of current 10.

The provision of a looped heater wire is preferable where the cathode is in the form of a coil, because the current flow in one side of the heater wire is opposed to the current flow in the other side, and the field set up by the current in one side of the wire is neutralized by the field of the other, with the result that no current is induced in the cathode coil 8 which would set up an A. C. ripple or hum in the output circuit of the tube when the heater is energizing from a source of alternating current or from a source of pulsating direct current.

The arrangement shown in Figure 2 is substantially the same as that shown in Figure 1 with the exception that the source of current 10 is eliminated. In this arrangement 25 designates the heater wire, 26 the rod of insulating for refractory material and 27 is the helical cathode. The cylindrical grid of the tube is designated 28 and 29 is a cylindrical plate, while the cathode extension or fourth electrode 30 is interposed between the grid and the plate, this fourth electrode preferably being spaced relatively close to the plate. One end of the coiled or helical cathode 27 is connected through the wire 31 with the fourth electrode 30. I have adopted, in the drawing, the conventional schematic showing of the cylindrical elements.

The wire of which the cathode is wound has a high resistance and the turns are relatively close together.

In the operation of the tube there is of course a transfer of energy from the cathode extension or so-called fourth electrode to the plate as well as from the main body of the cathode to the plate. This is by reason of the fact that both of these elements of the tube are connected with the negative side of the source of plate voltage. This transfer of energy results in the setting up of a current flow in the circuit comprising the high resistance cathode winding 27, the wire 31 and the cathode extension 30. Due to the relatively high resistance of the cathode winding there is accordingly produced therealong a non-equipotential characteristic which is desirable. This arrangement has the advantage over the arrangement shown in Figure 1 in that the separate source of direct current voltage 10 is not required.

The coil of insulated turns of wire constituting the cathode of the tube constitutes also an inductance functioning as a choke coil which serves to eliminate or reduce variations in the output of the tube by reason of pulsations or alternations in the current used in heating the cathode.

It will be understood that I have illustrated one embodiment of my invention and that various changes and modifications may be made therein and in the circuit in which the tube is adapted within the contemplation of my invention and under the scope of the following claims.

I claim:

1. In a thermionic tube having an indirectly heated cathode in the form of a helix, a grid and a plate, and a fourth electrode interposed between the grid and the plate, a connection leading from one end of the helical cathode to the said fourth electrode, and means for connecting the other end of the helical cathode and said fourth electrode externally of the tube.

2. In a thermionic tube having an indirectly heated cathode in the form of a coil of high resistance wire, a grid, a plate, a fourth electrode interposed between the plate and the cathode, said fourth electrode constituting in effect an extension of the cathode, and means for connecting the other end of the helical cathode and said fourth electrode externally of the tube.

3. In a thermionic tube of the indirectly heated cathode type wherein there is a cathode heater and a helical cathode surrounding the heater, said helical cathode having the convolutions thereof spaced from one another, a grid electrode, a plate electrode and a fourth electrode adjacent the plate electrode and between the grid and the plate, said fourth electrode having one end thereof connected to one end of the helical cathode, all of said electrodes being enclosed in an evacuated vessel, and means for connecting the other end of the helical cathode and said fourth electrode externally of the tube.

4. The combination with a thermionic tube of the indirectly heated cathode type wherein there is a cathode heater and a helical cathode of high resistance, as herein defined, surrounding the heater, of a source of potential across the opposite ends of the cathode, a high resistance being included in series between the source of current and one end of the cathode.

5. The combination with a thermionic tube of the indirectly heated cathode type wherein there is a cathode heater and a helical cathode surrounding the heater, of a source of potential connected across the opposite ends of the cathode, a high resistance being included in series between the source of current and one end of the cathode, said tube having a plate circuit which connects to the cathode through a connection to an intermediate point of the high resistance.

6. In a thermionic tube, a heater wire, a helical cathode surrounding the heater wire and out of

contact therewith, a grid surrounding the cathode, a plate surrounding the grid, a fourth electrode interposed between the grid and plate and connected to one end of said helical cathode, and means for connecting a source of electric current to the opposite end of said helical cathode.

7. In a thermionic tube, a heater wire, a helical cathode surrounding the heater wire and out of contact therewith, a grid surrounding the cathode, a plate surrounding the grid, and a fourth electrode interposed between the grid and plate and connected to one end of said helical cathode, and means for coupling a source of direct current in series with the helical cathode and said fourth electrode.

8. In a thermionic tube, a plate, a grid, a cathode in the form of a coil having the adjacent convolutions thereof spaced from one another, and a heater for energizing the coil, said coil constituting a choke for eliminating variations in the current flow between the plate and the cathode by reason of the use of alternating currents or pulsating currents in the heater, and means whereby a circuit may be completed across opposite ends of the coil.

9. In a thermionic tube having a plate, a grid and a heater, a choke coil surrounding the heater and constituting the cathode of the tube, and means whereby a circuit may be completed across opposite ends of the coil.

10. An electrode tube having a cathode in the form of an inductance, which cathode also has a high resistance as herein defined, a heater wire inside the cathode and arranged for heating the cathode, said cathode having an extension at one end thereof forming an electrode, which electrode is spaced outside the cathode, and a circuit to which the other end of said cathode is connected.

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