Jan. 12, 1937. W. J. HITCHCOCK 2,067,607

THERMIONIC CATHODE SPACE CURRENT TUBE

Filed Oct. 12, 1932 2 Sheets-Sheet 1

Fig. 1.

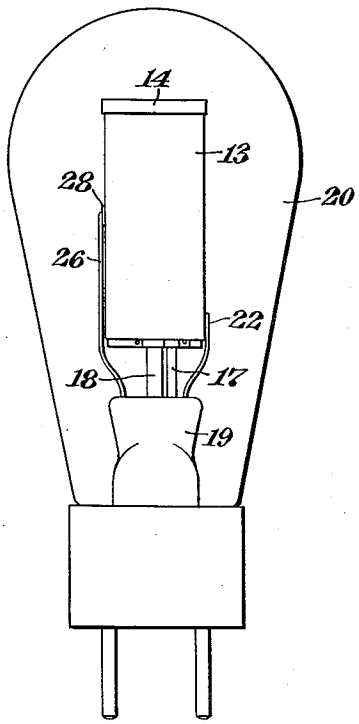


Fig. 2.

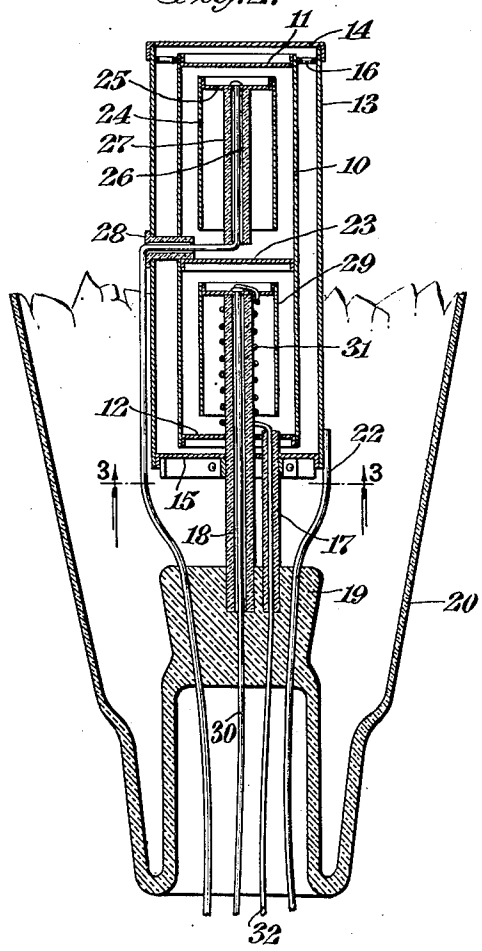


Fig. 4.

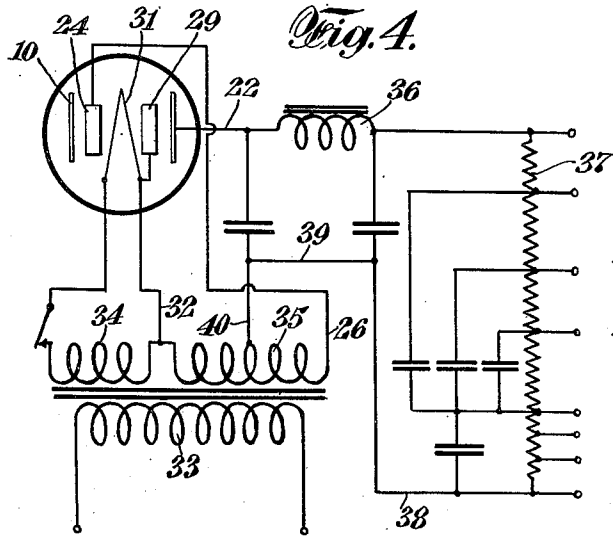
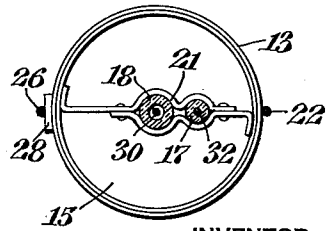


Fig. 3.



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Fig. 5.

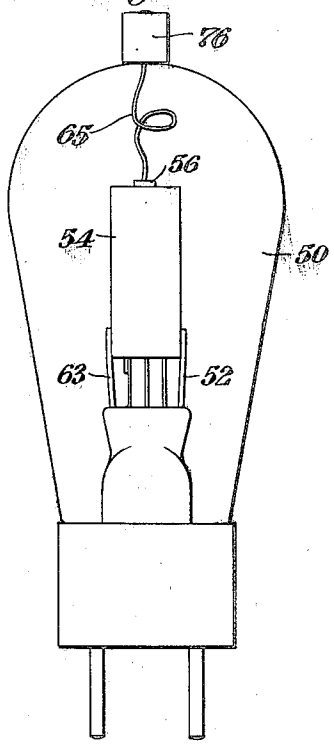


Fig. 6.

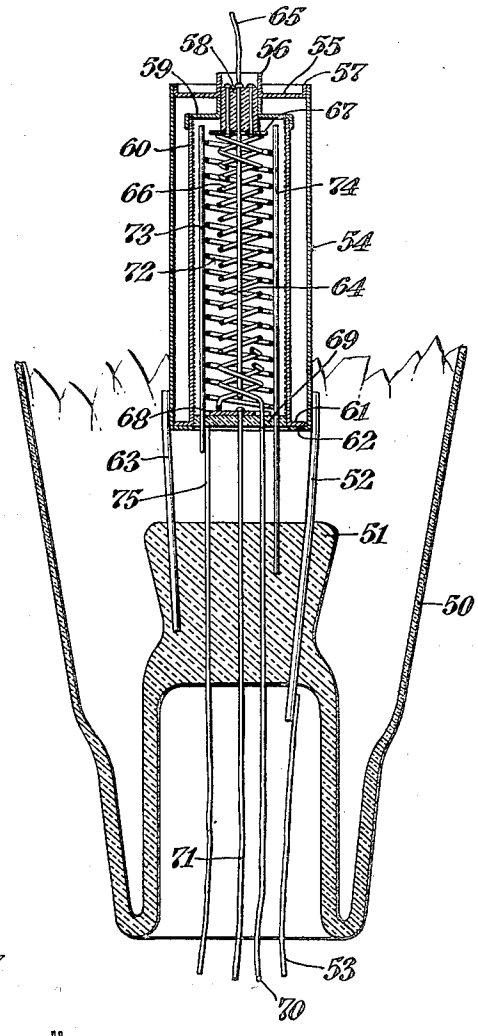
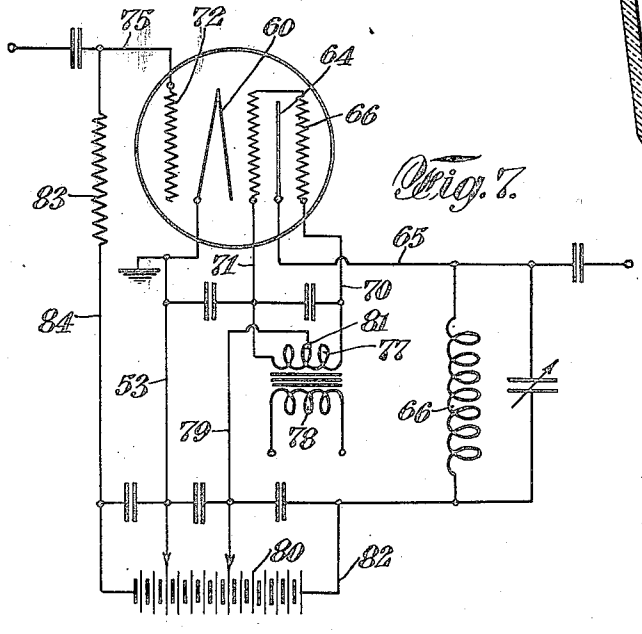


Fig. 7.



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UNITED STATES PATENT OFFICE

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THERMIONIC CATHODE SPACE CURRENT TUBE

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Application October 12, 1932, Serial No. 637,433

7 Claims. (Cl. 250—27.5)

The present invention relates to hot cathode space current devices such as thermionic vacuum tubes and the like.

The principle underlying the present invention resides in the design or arrangement of the electrodes with a view to improving the thermal efficiency and certain other operating characteristics, as will appear from a description of one or two practical embodiments of the invention.

In all devices in which space currents are maintained by the emission of electrons from a hot cathode, heat and light energy are liberated at the anode through condensation of electrons and by the impact of electrons. An important feature of the present invention is the utilization of much of this liberated energy for the maintenance of the cathode at an efficient electron emission temperature. Another important feature of the invention resides in the construction by which the cathode area may advantageously be increased to such an extent as to greatly reduce the rate of sputtering and deactivation of cathode, one of the important results of this being to make more practical the use of caesiated surfaces or alkaline earth surfaces as hot cathodes. These and other important results, which will be apparent, are obtained by enclosing the anode entirely or substantially entirely by the cathode so that heat and light liberated at the anode by the condensation and impact of electrons may substantially all be supplied by radiation to the surrounding cathode for the maintenance of the proper electron emission temperature, while at the same time enabling the cathode to be constructed of such large area as to greatly improve the emission and minimize sputtering. Such a cathode may have a polished outer surface to reduce radiation, and may furthermore be surrounded by suitable radiation shielding to minimize the loss of heat and light energy through radiation.

The principles of the invention are applicable to many different types of hot cathode space current devices, whether high or low vacuum or gas filled, but will be made sufficiently clear by reference to examples in the form of a thermionic rectifier and a screen grid vacuum tube as used in present-day radio circuits.

In the accompanying drawings—

Figure 1 is a side elevation of a full wave rectifier tube constructed in accordance with my present invention.

Figure 2 is an enlarged central vertical section thereof.

Figure 3 is a transverse section thereof on the line 3—3 of Figure 2.

Figure 4 is a circuit diagram showing the electrical connections of the full wave rectifier tube in a standard power supply for radio receivers.

Figure 5 is a side elevation of a screen grid vacuum tube constructed in accordance with my present invention.

Figure 6 is an enlarged central vertical section thereof.

Figure 7 is a circuit diagram showing the connection of the screen grid tube in a typical high frequency radio receiver circuit.

Referring to Figures 1 to 4 inclusive, the hot cathode may comprise a sheet metal cylinder 10 of nickel, tungsten or the like, having end caps or heads 11, 12 at top and bottom, mounted within a radiation screen 13 which has the cover 14 at the top and the closure 15 at the bottom. The cathode 10 may have a bright outer surface to minimize radiation, and its interior surface may be oxide-coated or caesiated, or otherwise treated for the efficient emission of electrons. It is electrically and mechanically connected with the radiation screen 13 by the metallic spacing ring 16 at the top. The screen 13 is supported at the bottom by a pair of lead-in insulators 17 and 18, of thoria or the like, which are mounted in the glass neck 19 of the bulb 20. Such lead-in insulator tubes 17, 18 pass through suitable perforations in the bottom closure 15 of the screen 13, and are secured thereto by a pair of clamping straps 21, as clearly shown in Figures 2 and 3. A conductor 22, leading from one of the terminals of the rectifier tube and passing through the sealing neck 19 of the bulb, may be connected with the screen 13 and through it by way of the spacing ring 16 to the cathode 10.

When employing two anodes the space within the cathode 10 is divided into upper and lower chambers by the transverse partition 23, which may be of the same material as the cathode 10. A cylindrical anode 24 of tubular metal construction, provided with an upper transverse wall 25, is mounted in the cathode chamber above the partition 23 upon a supporting conductor 26, which is surrounded by a collar 27 of insulation and passes through an insulating bushing 28 which is inserted through registering perforations in the screen 13 and cathode 10. This conductor 26 passes from the insulating bushing 28 downwardly through the neck 19 of

the bulb to one of the anode terminals of the tube. A similar tubular anode 29 is mounted on a supporting conductor 30 which passes through the insulator tube 18 above-mentioned, the conductor 30 being connected with the second anode terminal of the rectifier tube. A heating resistance 31, connected at the top to the conductor 30, is coiled around the insulator tube 18 and brought out by conductor 32 through insulator tube 17 to be connected with another terminal of the rectifier tube. This heater coil 31 may be employed only in starting, or continuously, for the purpose of indirectly heating the cathode 10 by radiation from the anode 29, but will ordinarily not be required after the cathode has been brought up to the emission temperature.

The circuit diagram in Figure 4 shows the heating coil 31 in the form of a filament electrically connected with the anode 29, which latter is within the tubular cathode 10. The second anode 24 is also shown as being located within the cylindrical cathode 10. The power supply primary coil 33 feeds a secondary transformer coil comprising the heating winding 34 and the plate supply winding 35, which latter is connected at one end by conductor 26 with the anode 24, and at the other end by way of the conductor 32, previously mentioned, to the anode 29. The cathode 10 has the lead-in conductor 22 connected through choke 36, voltage divider 37, conductor 38, 39 and 40 to the midpoint on the winding 35 of the transformer secondary. The filter circuits are standard practice and require no further description.

The operation of the device will be apparent to those skilled in the art. Power delivered from the primary 33 and secondary 34 will heat the anode 29 which radiates heat to cathode 10. The conduction of heat through the metal of the cathode will bring all portions of it up to emitting temperature, so that the thermionic or electron current will flow between cathode and the respective anodes 24, 29 as they alternately become positive with respect to the cathode. The impact and condensation of electrons on the anode surface develop heat and light energy which is radiated to the cathode. Since the anode in such case is necessarily at all times hotter than the cathode, it must of course be understood that the cathode employed is one which emits electrons at a temperature well below that at which any substantial emission would occur from the anodes.

The example of a screen grid radio tube, illustrated in Figures 5, 6 and 7, follows in principle the construction already described in connection with the rectifier tube. A glass or pyrex bulb 50 has leading from its neck 51 a supporting conductor 52, which is connected at the bottom with a lead-in wire 53 extending from one of the tube prongs to the radiation screen 54, which has mounted in its top an annular metallic sheet 55 with inner and outer peripheral flanges 56, 57. In the inner peripheral flange 56 is inserted an insulator 58, on which is mounted the flanged cap 59 of the cathode 60. The cathode 60 is of tubular construction, with an out-turned peripheral flange 61 resting upon an in-turned peripheral flange 62 of the screen 54. By this construction the cathode is electrically connected with the screen 54 and through the latter to the supporting wire 52 and the lead-in 53. A second supporting wire 63 is provided to steady the mounting. The anode or plate electrode in this example is in the form of an axial rod 64 which depends from the insulator 58 at the top, where the plate lead 65 is connected. Surrounding the anode 64 is the screen grid 66, which is in the form of a double helix, extending between an upper metallic disk 67 riveted to the bottom of the insulator 58, and a lower metallic disk 68 mounted upon an insulation plug 69 at the bottom of the cathode. The screen grid in this instance serves as the preliminary heater, and for this purpose it is connected at one end with the lead-in wire 70, which passes through the neck 51 of the bulb. The two sections of the helix may be, for example, electrically connected at the top by the metallic disk 67, above-mentioned. The other end of the screen grid is connected electrically with the metallic disk 68 at the bottom of the cathode, which latter has electrically connected with it the lead wire 71. The leads 70, 71 thus constitute the terminals of the preliminary heater circuit, and at the same time the connection through which the operating potential is applied to the screen grid in the receiver circuit. They are accordingly connected to the proper prongs in the base of the tube. Surrounding the screen grid 66 is the normal or control grid which is in the form of a helix 72, mounted between conductive supporting wires 73, 74 which pass through the insulation plug 69 at the bottom of the cathode. The supporting wire 74 is mounted in the neck 51 of the bulb. The supporting wire 73 has electrically connected with it the lead 75, which passes through the neck 51 and is connected with the proper prong of the tube base.

The plate lead 65, above-mentioned, is shown in Figure 5 as being connected with the usual contact post 76 mounted in the top of the bulb.

By reference to Figure 7, the electrical connection of the various parts in the receiving circuit will be apparent. The terminals 70, 71 of the screen grid are connected across a secondary winding 77 of a heating transformer, the primary 78 of which may be switched in at the time of heating up the tube. The heating of the screen grid brings the cathode up to the proper emission temperature, which may thereafter be maintained by the radiation of heat from the anode, as already explained. The cathode 60 is represented diagrammatically in Figure 7 in the form of the usual filament, the screen grid being indicated at 66, the anode at 64, and the control grid at 72. A screen grid lead wire 79 leads from a suitable tap on the power source 80 to a midpoint 81 on the secondary winding 77. The anode lead 65 passes through plate inductance 66 to the high tension lead 82 of the power source, the cathode lead 53 connects at a suitable voltage point with the power source 80, and the control grid lead 75 connects in this instance through a grid resistance 83 and conductor 84 with the negative side of the power source 80.

Insofar as the enclosure of the anode within the cathode is connected, the advantages already pointed out in connection with the rectifier tube pertain also to the screen grid tube. There are in addition important advantages present in the screen grid tube. The electrostatic capacity between the plate and the control grid of the tube is reduced by the small area of the plate or anode. The mutual conductance of the tube is considerably improved by the relatively large emitting surface of the cathode. Caesiated or other cathode surfaces which emit at relatively low temperatures are advantageous in the cathode in the present instance, even though the

cathode always remains negative with respect to the anode or plate electrode.

The examples given are not to be taken as limiting the scope of the invention to the employment of its principles in these particular types of space current devices, since the functions pertaining to the invention are applicable quite generally to many different specific forms of devices in which the operation depends upon the application of heat to a cathode for the purpose of causing the emission of electrons.

The anode and cathode may each be in the form of either a single element or a plurality of elements; that is to say, there may be one single anode or two or more anodes, and one single cathode or two or more cathodes. In any case, however, the entire electron current from the cathode system is directed inwardly to the anode system, in the normal operation of the tube, and the heat developed at the anode is largely conserved and delivered by radiation and conduction outwardly to the surrounding cathode system.

I claim:—

1. A rectifier tube comprising a cathode having a thermionic surface extending around its own emission space and provided with an intermediate partition extending transversely across the enclosed emission space, and an anode in each of the emission spaces separated by said partition.

2. A thermionic tube comprising a substantially closed cathode having an inner surface electron emitting when heated, and an anode and a heater both disposed within said cathode, whereby said cathode may be heated to electron emitting temperature by radiation from within said cathode.

3. A thermionic tube comprising a substantially closed cathode having an inner surface electron emitting when heated, a plurality of spaced anodes disposed within said cathode, an intermediate partition extending transversely across said cathode and between said anodes to separate the latter, and a heater enclosed with an anode within said cathode, whereby said cathode may be heated to electron emitting temperature by radiation from within said cathode, initially from said heater and subsequently by heat radiated from said anodes during the operation of the tube.

4. A thermionic tube comprising a tubular sheet metal thermionic cathode closed at its ends and having an inner surface electron emitting when heated, an anode and a heater both disposed within said cathode, and a radiation screen completely enclosing said cathode, whereby said cathode may be heated to electron emitting temperature by radiation and conduction from within said cathode, initially from said heater and subsequently by heat radiated and conducted from said anode during the operation of the tube.

5. A thermionic tube comprising a tubular sheet metal thermionic cathode closed at its ends and having an inner surface electron emitting when heated, an anode and a heater both disposed within said cathode whereby said cathode may be heated to electron emitting temperature by radiation and conduction from within said cathode initially from said heater and subsequently by heat radiated and conducted from said anode during the normal operation of the tube, and a grid electrode disposed between said cathode and anode and enclosed within said cathode.

6. A thermionic tube comprising a tubular sheet metal thermionic cathode closed at its ends and having an inner surface electron emitting when heated, an anode and a heater both disposed within said cathode, and a radiation screen completely enclosing said cathode, whereby said cathode may be heated to electron emitting temperature by radiation and conduction from within said cathode initially from said heater and subsequently by heat radiated and conducted from said anode during the normal operation of the tube, and a grid electrode disposed between said cathode and anode and enclosed within said cathode.

7. A screen grid thermionic tube comprising a tubular thermionic cathode closed at its ends and having an inner surface electron emitting when heated, a control grid, a filamentary screen grid and an anode, all disposed within said cathode, whereby said cathode may be heated entirely from within to electron emitting temperature by radiation from said screen grid serving as a filamentary heating element when the tube is started, and subsequently by heat radiated from said anode and screen grid during the normal operation of the tube.

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