May 3, 1932. E. A. LEDERER 1,856,258

ELECTRON DISCHARGE DEVICE WITH CÆSIATED CATHODE

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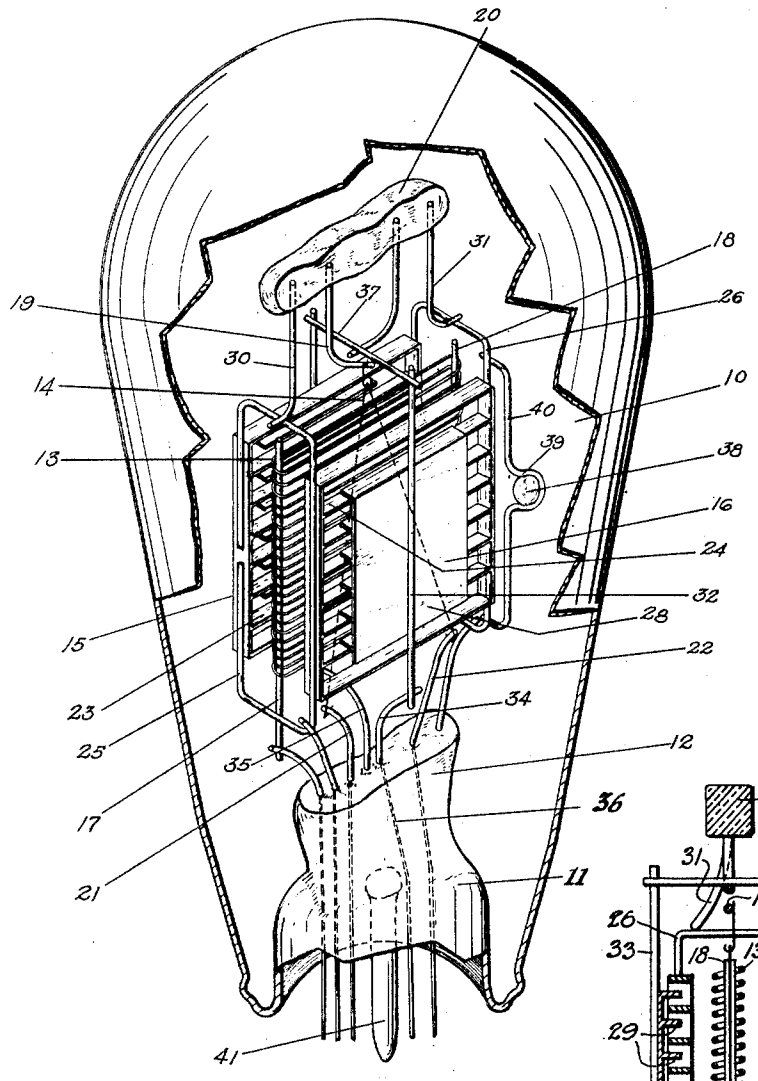


FIG. 1.

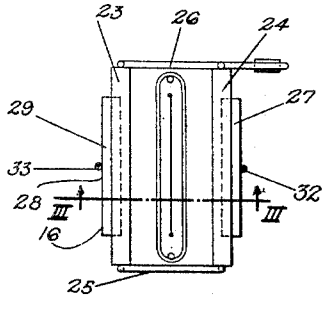


FIG. 2.

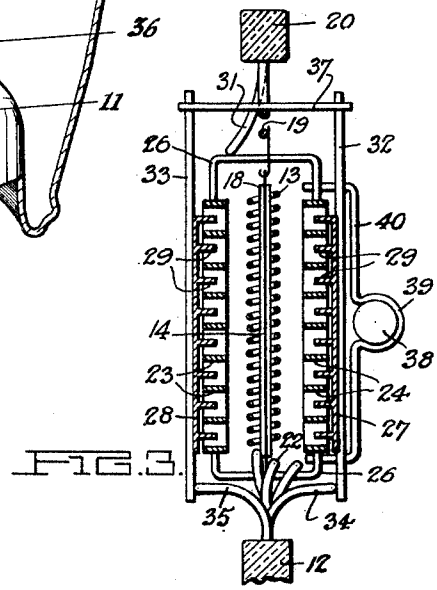


FIG. 3.

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UNITED STATES PATENT OFFICE

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ELECTRON DISCHARGE DEVICE WITH CÆSIATED CATHODE

Application filed December 1, 1927. Serial No. 236,977.

This invention relates to an electron discharge device in which the cathode is heated indirectly by a heating element disposed adjacent thereto and more particularly to such a device in which thermal emission is imparted to the cathode by the presence of an alkali metal vapor, such as cæsium, rubidium or the like.

It has been found that the alkali metals under proper conditions greatly increase the electron emission of a refractory metal cathode, such as a tungsten cathode, in a therminoic device so that high electron emissivity is imparted thereto at a temperature so low that in the absence of such alkali metal vapor no substantial emission would occur. This phenomenon is explained on the theory that a film of the alkali metal forms continuously on the refractory metal body, which film resists evaporation at temperatures much in excess of the vaporization temperature of the alkali metal, when the refractory cathode consists of a suitable metal such as tungsten or molybdenum.

The formation of the alkali metal film, preferably cæsium, is greatly facilitated by the presence of an electro-negative gas on the surface of the refractory body. Oxygen has been most successfully used in this connection and when an oxide or an oxygen film is produced on the surface of the tungsten or molybdenum body it renders this body capable of holding on to or causing the alkali metal atoms to adhere thereto more strongly than does the plain surface of the tungsten or molybdenum electrode.

A device of this nature adapted to have the cathode heated by the direct passage of current therethrough is disclosed in copending applications of Marden and Lederer, Serial Nos. 228,994 and 228,995 both filed October 27, 1927.

One of the objects of the present invention is to produce a tube employing a cæsiated cathode in which the cathode may be heated by an auxiliary heating element disposed adjacent thereto.

A further object is to produce an electron discharge device employing an indirectly heated cathode adapted to be heated by high frequency induction currents independently of the other electrodes, to facilitate the manufacture of the device.

A further object is to produce an electron discharge device employing an alkali metal and an indirectly heated cathode in which the cathode, anode and the source of alkali metal may be heated independently.

A further object is to produce an indirectly heated cathode tube of such construction as to facilitate the oxidation of the surface of the cathode to cause an alkali metal to adhere thereto.

Other objects and advantages will hereinafter appear.

Heretofore in the manufacture of electron discharge devices in which the cathode is designed to be heated through the agency of alternating current, it has been the usual practice to construct the cathode in the form of a hollow metal cylinder and to heat the same by conduction from an electrically insulated heating element. The heating element of such cathode usually consists of a tungsten filament which is supported within an aperture in a cylindrical insulator about which the hollow metal cylinder, coated with a thermionically active material, such as the oxides of the alkaline earth metals, is positioned. This coated cylinder constitutes an equi-potential cathode and may be provided with a terminal separate from those of the heating element.

It is not possible to employ such construction when using a cæsiated cathode due to the high temperature required to oxidize the tungsten cathode to cause the alkali metal to adhere thereto. This temperature is in the neighborhood of 2000° C. to 2500° C. Moreover, it is difficult, if not impossible, to obtain tungsten foil for forming such cylindrical cathodes in sufficiently large surfaces and of a thickness of less than .001 inches, such as would be required for such a cathode. It is obvious, also, due to the high chemical activity of cæsium vapor, that none of the known insulating materials would remain inert in the presence of cæsium vapor, particularly when heated.

Therefore, in accordance with my inven-

tion, I construct an electron discharge device having a cathode provided with a heating element disposed adjacent thereto so as to heat the cathode by radiation during operation without the use of an interposed insulating member and I so construct and arrange the cathode that it may be heated during manufacture independently of such heating element to the required temperature to effect the oxidation of the surface thereof, to cause the alkali metal to adhere thereto.

The cathode may be composed of fine tungsten wire wound helically into grid form of any convenient shape such as cylindrical or rectangular. I prefer to form the cathode of rectangular shape so as to permit the use of an inverted V or M shape heating element. Tungsten wire can be obtained of any desired size and should be sufficiently fine to permit the cathode to be heated to the required electron emitting temperature without the consumption of excessive energy by the heating element. A power consumption of from 2 to 5 watts in the heating element is readily obtained, with a cathode of this form, which is not possible when employing a cylinder of tungsten foil as the cathode.

The heating element may also be composed of a tungsten filament disposed within the helically wound cathode. This construction permits the cathode to be heated by high frequency induction current to a sufficiently high temperature to oxidize the same after it has been incorporated into the envelope of the device while maintaining the heating element cold and consequently unoxidized. The alkali metal when generated within the device, adheres to the oxidized cathode surface but does not readily adhere to the unoxidized heating element. This is important in order to prevent electron emission from the heating element, when heated by alternating current, from passing through a grid shaped cathode and producing A. C. hum in the output circuit.

The possibility of electron emission from the heating element affecting the operation of the device is still further reduced by operating the tungsten filament at a temperature well below that of which tungsten emits electrons but above the temperature at which cæsium metal will form thereon, that is, above about 650° K. If desired, the cathode may be maintained at a negative potential with regard to the heating element to repel any electron emission emanating from the heating element.

The alkali metal may be introduced into the device in the desired manner, but preferably from a pellet or capsule of an alkali metal compound and a reducing agent so positioned within the envelope that it may be heated by high frequency induction currents, without heating up the other elements of the device.

In order that the invention may be more fully understood, reference will be had to the accompanying drawings, in which:

Fig. 1 illustrates, partly in section, an electron discharge device having an indirectly heated cathode and employing an alkali metal vapor for imparting electron emission thereto;

Fig. 2 is an end view of the plate and control electrode structure shown in Fig. 1; and,

Fig. 3 is a sectional view of the electrode structure taken on the line III—III of Fig. 2.

The discharge device shown in the figure comprises a bulb 10 having a flare tube 11 provided with the usual press 12. Extending from the press are a plurality of support members for securing the several electrodes in position as will be more clearly hereinafter described.

The electrode assembly includes a cathode 13, heating element 14 therefor, grid or control electrode 15 and anode 16.

The cathode 13 is in the form of a grid or fine tungsten wire wound helically about support wires 17 and 18 so as to form an oblong opening therein in which the heating element 14 is disposed. The heating element is in the form of an inverted V-shape tungsten filament having the loop portion thereof supported by a wire 19 carried by an insulating bead 20 disposed above the electrode assembly. The terminal ends of the heating element are secured to leading-in wires 21 and 22 sealed in the press 12 for conducting current to the heating element.

The control electrode 15 includes two sets 23 and 24 of horizontally disposed slats or vanes disposed on opposite sides of the cathode and connected to support members 25 and 26 arranged so as to form a lattice like enclosure for the cathode.

The anode 16 consists of a pair of plate members 27 and 28, also having a number of vanes 29 projecting laterally therefrom between the vanes of the control electrode so that the vanes of the plate and those of the control electrode are disposed in spaced overlapping relation.

By reason of this construction, the cathode is protected from positive ion bombardment due to the electric field produced between the vanes of the respective electrodes. The support wires 25 and 26 for the control electrode are braced at the upper ends by rigid wires 30 and 31 secured in the bead 20. The anode plates 27 and 28 are secured to support wires 32 and 33 joined to wire supports 34 and 35 sealed in the press. Support wire 34 is welded to leading-in conductor 36 for supplying current to the anode. Support wires 32 and 33 are braced at the upper end by a bridge member 37.

In order to provide a supply of alkali metal in the device, a pellet 38, which may be composed of a compound of an alkali metal and

a reducing agent such as, for instance, cæsium permanganate and silicon, is supported by bending a portion of the metallic strip 40 about the pellet. The metallic strip 40 is secured to the support wire 26 in such manner that it forms a closed electrically conductive loop therewith, whereby the strip 40 may be readily heated by high frequency induction current to decompose the alkali metal compound cotained in the pellet 38 and liberate the alkali metal.

It will be noted that the closed electrical loop is disposed at right angles to the plane of the anode plates 27 and 28 and control electrode members 23 and 24 and that the loop formed by each turn of the grid-shaped cathode is disposed in a plane at right angles to both the anode and control electrode and the closed loop in which the pellet 38 is contained so that each of these members may be heated independently by high frequency induction current without inducing heating currents in the other members. Thus, for instance, the cathode may be heated by placing a high frequency induction coil about the bulb with its axis concentric with the axis of the bulb, whereas, the anode plates and the grid may be heated by arranging the high frequency induction coil with its axis normal to the anode plates. The getter capsule 38 is heated by arranging the axis of the heating coil substantially normal to the axis of the bulb and also 90° disposed from the position employed in heating the anode and grid electrodes. The importance of this will appear more fully hereinafter.

The procedure employed for oxidizing the cathode and rendering the same thermionically active is fully set forth in copending application Serial No. 228, 994 referred to above and consists briefly in exhausting the device thoroughly during which time the plate and grid electrodes are heated to a high temperature by high frequency induction currents to drive out any gas contained therein. The cathode is then oxidized by admitting a quantity of oxygen into the bulb through the exhaust tube 41 at such pressures as to make from 5 to 50 cu. millimeters of oxygen at atmospheric pressure available for the oxidation of the cathode. The oxygen pressure is not critical, however, and the above figures are given merely as a guide. The grid-shaped cathode is flashed in this oxygen atmosphere at from 2000 to 2500° C. for about ½ minute by means of a high frequency induction coil disposed about the bulb. During this high temperature treatment, the heating element 14 remains substantially cool so that it does not become appreciably oxidized.

The oxygen is then removed from the device and the pellet 38 is heated by high frequency induction current to generate the desired alkali metal. When employing a mixture of cæsium permanganate and silicon as the source of alkali metal, it is necessary to heat the mixture to around 900° C. During the heating of this getter, it is desirable that the plate and grid or other metal parts do not become heated to a sufficiently high temperature to drive off any additional gas therefrom which might attack the oxygen layer formed on the cathode. The oxygen liberated during the reduction of the cæsium permanganate is removed by the pumps after which the exhaust tube 41 should be sealed off.

It is necessary to now activate the cathode to impart thereto the electron emissivity of the alkali metal. This activation may be carried out in two steps, the preliminary activation being first effected to render the cathode sufficiently thermionically active to permit seasoning of the tube to be accomplished. This preliminary activation may be carried out by heating the cathode through the auxiliary heating element or by high frequency induction current, with or without potential on the control electrode or on the anode, the cathode temperature being raised somewhat above that at which it is normally designed to operate. The filament temperature is then reduced to normal and a voltage applied between the cathode and the anode of about 200 volts with a negative bias of about 17 volts applied to the grid and the tube operated for about 10 minutes. This treatment ionizes the residual gas and enables it to be cleaned up by the alkali metal. Precaution must be taken during this seasoning to maintain the control electrode negative in order to prevent positive ion bombardment of the cathode which might destroy the cæsium layer deposited thereon.

The final activation is then effected by heating the cathode for about 20 seconds at a temperature somewhat in excess of the normal operating temperature, preferably with no voltage applied between the electrodes. This final activation completes the formation of the cæsium film on the cathode and imparts thereto high electron emitting properties.

In order to prevent electrical leakage between the leading-in wires sealed in the press 12 and the supports sealed in the bead 20, it is desirable to coat the press and the bead with a material which will prevent such leakage. This leakage is due to a deposit of alkali metal on the press and the material which has been found particularly effective for preventing such leakage is petrolatum from which the volatile constituents have been removed as is more fully described in a copending application of Marden and Lederer Serial No. 218,138 filed September 8, 1927, and entitled Prevention of electrical leakage.

I am aware that the invention may be embodied in other specific forms without departing from the spirit or essential attributes

thereof and, therefore, I desire the present embodiment to be construed in all respect as illustrative and not restrictive, reference being had to the appended claims rather than the foregoing description to indicate the scope of the invention.

What is claimed is:

1. A cathode for an electron discharge device comprising a number of turns of fine wire having a cæsiated surface and provided with a heating element having a surface substantially free of cæsium electrically insulated therefrom.

2. A cathode for an electron-discharge device composed of a refractory metal helix having an electro-negative gas layer thereon, a quantity of alkali metal held in contact with said refractory metal surface by said electro-negative gas layer and a heating element having its surface substantially free from electro-negative gases insulated from said refractory metal for heating the same to an electron emitting temperature.

3. A cathode for an electron discharge device composed of a helical refractory metal member having formed thereon a coating of oxygenous material, an alkali metal held in contact with said refractory metal member by said oxygenous material, and a refractory heating element disposed adjacent said refractory metal member for heating the same to an electron emitting temperature, said refractory heating element being substantially unoxidized.

4. An electron discharge device comprising an envelope, a cathode, anode and a vaporizable material contained therein, said cathode and anode being shaped to form electrically closed loops having their axes disposed substantially at right angles to each other and said vaporizable material being supported on a portion of an electrically closed loop having its axis disposed at an angle to the axes of said first mentioned loops.

5. An electron discharge device comprising an enclosing glass envelope, a cathode and at least one cooperating electrode, said cathode electrode being comprised of a helical tungsten filament exteriorly coated at least in part with cæsium and a centrally disposed heater element, said heater element being comprised of refractory metal substantially free of surface adsorbed cæsium.

In testimony whereof I have hereunto subscribed my name this 30th day of November, 1927.

ERNEST A. LEDERER.