Oct. 1, 1935. J. W. MARDEN ET AL 2,016,152

ELECTRON DISCHARGE DEVICE WITH INDIRECTLY HEATED CATHODE

Filed July 12, 1928

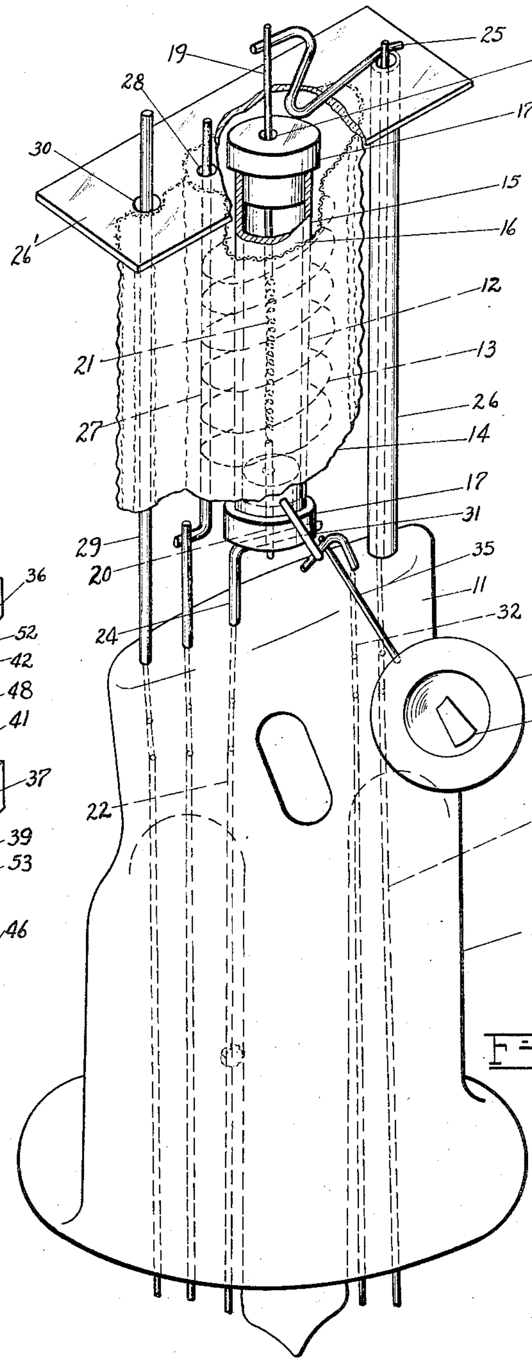

FIG. 1.

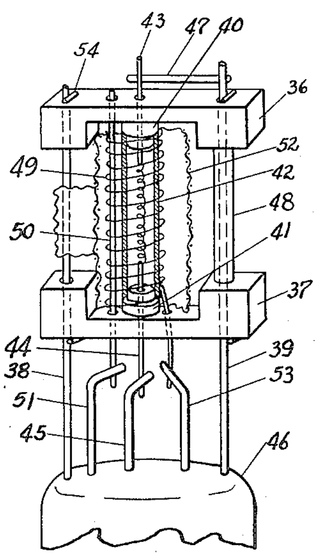

FIG. 2.

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Patented Oct. 1, 1935

2,016,152

UNITED STATES PATENT OFFICE

2,016,152

ELECTRON DISCHARGE DEVICE WITH INDIRECTLY HEATED CATHODE

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Application July 12, 1928, Serial No. 292,116

16 Claims. (Cl. 250—27.5)

This invention relates to an electron discharge device and more particularly to such device of the type in which the cathode is heated indirectly by a heating element disposed adjacent thereto.

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 disposed therein. The heating element of such cathode usually consists of a tungsten filament contained within an apertured insulating member about which the hollow metal cylinder is positioned. A coating of thermionically active material, such as the oxides of the alkaline earth metals, is provided on the exterior surface of the metal cylinder. This coated cylinder constitutes an equi-potential cathode.

In the manufacture of cathodes of this type, difficulty has been experienced due to interaction of the tungsten filament with the insulating material within which it is contained and to the fusion of the insulating material on to the tungsten, resulting in early burnout of the heating element. One method which has been proposed for eliminating this difficulty is to construct the insulator of a material which does not readily react with the filament and which is sufficiently refractory so as not to become fused at the temperature to which it is subjected during manufacture and operation, as is fully set forth in application of John W. Marden and Frank W. Driggs, Serial No. 233,543, filed November 16, 1927 and entitled "Insulating material for vacuum electric devices".

The method which is used to a very large extent and which we prefer for producing the thermionically active coating on the exterior surface of the cathode is to first coat the cylindrical cathode in a quick drying binder, such as nitrocellulose in amyl acetate, with the carbonates of the alkali earth metals. The carbonates are stable in the atmosphere and may be stored for indefinite periods without detrimental effects. After the cathode has been assembled within the evacuated device, the carbonate coating is converted to the oxides of the alkaline earth metals by heating the cathode to a high temperature. It has not been found advisable to effect this conversion of the carbonates to the oxide prior to assembly of the cathode within the evacuated device since the oxides apparently become contaminated in the atmosphere and the electron emission of the cathode is impaired. Heretofore this heating of the metal cylinder has been accomplished by passing a heavy current through the heating element to raise the same to an abnormally high temperature, but such procedure is objectionable since at this high temperature the reaction of the tungsten heater element with the insulator is accelerated. The insulator also fuses onto the tungsten during this high heat treatment and upon cooling of the cathode assembly a portion of the tungsten adheres to the insulator and is chipped off from the filament, due to the difference in contraction between the insulator and the filament. The filament, moreover, is gradually worn away by the alternate heating and cooling thereof in contact with the porcelain body when the tube is brought into and out of operation, so that the filament burns out prematurely and the life of the device is relatively short.

Another objection to the use of a cathode employing a refractory insulator between the heating element and the cathode, is the time interval required to bring the cathode up to the desired temperature. The refractory insulating materials available for this purpose are also good heat insulators and consequently an excessively long time interval is required for transmission of the heat from the heating element to the cathode surface when the tube is first brought into operation. This necessitates operating the heating element at a high temperature for a long period of time in order to effect a decomposition of the carbonate coating during manufacture of the device and is a source of considerable annoyance during operation of a radio receiving set employing such tubes since the time required to bring the cathode up to operating temperature after switching on the set may amount to nearly a minute.

One of the objects of the present invention is to provide a cathode construction for a tube capable of being heated by alternating current, in which insulating material between the cathode and the heating element may be dispensed with.

Another object is to provide a cathode construction adapted to be heated by an adjacently disposed heating element in which substantially all of the heat generated in the heating element will be radiated to the cathode.

A further object is to produce an indirectly heated cathode type of tube in which the electrodes will be shielded from electrons emitted from all portions of the heating element.

A still further object is to prevent undesired discharges between the current conducting leads and supports for the heating element of an indirectly heated cathode tube and the electrodes of the device.

Other objects and advantages will hereinafter appear.

In accordance with the present invention I construct a cathode in the form of a hollow metallic member, such as a tube or thimble having a coating of thermionically active material on the exterior thereof and a heating element contained therein for heating the cathode by radiation to an electron emitting temperature. The heating element may be energized by alternating current and preferably consists of a coil of refractory metal, such as tungsten, of relatively large diameter. The coil is disposed axially within the metallic tube and the ends thereof are welded or otherwise secured to support wires of relatively large size, which extend to the exterior of the metallic tube. The ends of the metal tube are entirely closed by insulating members through which the supports for the filament extend and which prevent the escape of electrons emitted by the heating element to the exterior of the tube so that they do not exert any erratic action on the discharge between the electrodes due to the alternating heating current.

The tubular cathode is surrounded by a control electrode, which in turn is contained within an anode or plate electrode. In the construction of indirectly heated cathode tubes of this type, the cathode is of relatively large diameter and considerable heat is radiated therefrom so that the grid electrode may be heated to a sufficiently high temperature to emit electrons which have a detrimental influence upon the operation of the tube.

In order to prevent the heating of the control electrode to such temperature, it has been proposed to construct the plate or anode of the device of perforated metal or wire mesh which permits the escape of the heat from within the electrode assembly. Some of the electrons traveling from the cathode to the plate electrode pass through the meshes in this electrode and produce in the space outside of the anode a quantity of free electrons, which, unless precautions are taken, enable a discharge to pass between the anode and the current conducting leads for the heater element of the cathode. Since these leads are alternately charged negatively and positively an intermittent discharge may take place from such lead to the anode. This discharge affects the plate current of the device in such manner as to produce a hum when such tube is employed in a radio receiving apparatus. In order to prevent this discharge between the anode and the heater leads, the leads are shielded from the anode by dielectric insulating members.

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

Figure 1 is a perspective view of a mount for an electron discharge device embodying the present invention; and

Figure 2 is a perspective view of a modified form of mount for such tube.

The device shown in Figure 1 comprises the usual flare tube 10 having a press 11 upon which the electrode assembly is supported. The electrode assembly comprises a cathode 12, a grid 13 and a plate or anode 14.

The cathode 12 consists of a hollow metal shell 15 having a coating 16 of electron emitting material thereon, such as a mixture of barium and strontium oxides. However, if desired, the cathode may be of the caesiated type in which a layer of caesium metal is held to the cathode cylinder by an interposed atomic layer of oxygen or oxidized metal. In such case the cylinder should be composed of a metal, such as tungsten or molybdenum, upon which the electro-negative oxygen gas layer may be readily formed and maintained. Such a cathode may be heated by either alternating current or direct current with only a low current consumption. The ends of the metallic shell 15 are closed by small insulating plugs 17 having an aperture 18 centrally thereof through which heavy support wires 19 and 20 pass. A coiled tungsten filament 21 is secured between the support wires 19 and 20 and forms a heating element for raising the metal shell 15 to a sufficient temperature to produce thermal electron emission from the coating thereon. The supports 19 and 20 extend beyond the insulating members 17 within the hollow shell an appreciable distance and hence do not attain a high temperature within the insulator, due to heat conducted from the heating element 21. The heating element 21 is entirely encased within the metal tube 15 so that any electrons emitted therefrom cannot escape to the exterior and, therefore, cannot detrimentally affect the discharge between the cathode and the anode of the device. The cathode and heating element comprise a small muffle furnace in which substantially all of the heat generated by the heating element must be utilized in heating the metal shell.

The only possible losses of heat are by conduction through the supports 19 and 20 and by radiation from the insulating plugs 17. With this construction, the time interval required to bring the cathode up to an electron emitting temperature is very short, the electron emission being obtained almost instantly upon energization of the heating element.

Current for heating the element 21 is supplied by leading-in conductors 22 and 23. Leading-in conductor 22 is provided with a heavy support 24 to which the support wire 20 is welded. The support 24 is relatively short so as to have only a small exposed area within the tube and is disposed beneath the lower insulating plug 17 and serves as a support therefor.

The leading-in conductor 23 extends upwardly from the press throughout the length of the electrode assembly outside of the anode 14 and is connected to the upper heating element support 19 by a metallic member 25. An insulating tube 26 of glass, or other suitable dielectric material, surrounds the portion of the leading-in conductor 23 which extends adjacent the anode and prevents any discharge between the anode and leading-in conductor.

An insulating member 26′ extends across the top of the electrodes and is provided with a number of apertures through which the electrode supports pass and said insulating member, which may be of porcelain, mica or similar dielectric material, serves to maintain the electrodes in definite spaced relation. The insulating sleeve 26 extends the full distance between the press portion and the insulating member 26 so that no portion of the leading-in conductors is exposed. The electrodes are shielded from the member 25 by the insulating member 26. The member 25 is bent so as to hold the insulator 26 against the insulating plug 17.

The grid 13 is supported from the press by a support wire 27 which extends upwardly through the aperture 28 in the insulator 26 and the anode is supported by a wire 29 which also extends through an aperture 30 in the insulator 26.

The active surface of the cathode 12 is supplied with a current conducting lead 31 connected to leading-in wire 32 sealed through the press.

For cleaning up residual gases a getter material 33 may be provided on the getter carrier 34 having a support 35 welded to the leading-in conductor 32.

Due to the shortness of the leading-in conductor 24 for the lower end of the heating element and its location immediately underneath the insulating plug 17, no appreciable discharge can take place between the leading-in conductor and the anode.

In Figure 2 a modified form of tube is shown in which the entire electrode assembly is supported between two spaced insulators 36 and 37 of similar form. These insulators, which may be composed of porcelain, lavite, or other suitable material, are mounted on support wires 38 and 39 sealed in the press. The insulators are provided centrally with tubular portions 40 and 41 which extend into the hollow metallic shell 42 constituting the cathode. The cathode heating element extends centrally thereof in the same manner as shown in Figure 1 and the supports 43 and 44 extend above and below the insulators 36 and 37, respectively. The support 44 is joined to leading-in conductor 45 sealed in the press 46 and the support 43 is joined to leading-in conductor 39 by means of a bridging member 47. A glass insulator 48 surrounds the exposed portion of the leading-in conductor 39 adjacent the electrode assembly.

The grid electrode 49 is supported by wire 50 passing through apertures in the insulating members 36 and 37 and is joined to a leading-in conductor 51. The grid electrode 49 is connected to the supporting wire 50 by following the method outlined in the Henry S. Coyer Patent 1,305,690 dated June 3, 1919, or the Karel A. Lebbink Patent 1,570,265 dated January 19, 1926. When either one of these two methods is employed in uniting the grid 49 to the support wire 50 some of the metal of the support wire adjacent each grid turn acts as a clamping jaw to firmly hold each turn in position and to electrically connect each turn of said grid with said supporting rod 50. The anode 52 is supported from a leading-in conductor 38. Current for the cathode is supplied by leading-in conductor 53.

The support wires 38 and 39 may be enlarged above and below the insulators 36 and 37, respectively, to retain these members in definite position thereon or in place of such enlargement small metal members 54 may be welded thereto.

It is obvious, of course, that various other modifications of the invention may be devised and it is to be understood that the invention is not limited to the specific construction shown and described.

What is claimed is:

1. An electron discharge device comprising an enclosing glass envelope an electrode assembly composed of a cathode, control electrode and anode, said anode being perforated, current conductors for said electrodes extending through a wall of said envelope, one of said current conductors connecting to one end of said cathode and extending a part of its length adjacent the exterior surface of said anode, and a dielectric insulating member surrounding said externally extending conductor.

2. An electron discharge device comprising an enclosing glass envelope, a stem sealed therein, a tubular cathode mounted above said stem, a heating element within said cathode, a control electrode and an anode disposed about said cathode in concentric relation, insulating members extending across the ends of said electrodes to maintain them in definite spaced relation, said insulating members closing the ends of said tubular cathode, lead wires extending through said stem and electrically connected to said cathode, heater element, anode and control electrode, and means comprising an interposed dielectric shield member for preventing electric discharge from said heater element leads and said anode.

3. An electron discharge device comprising an envelope, a cathode therein, a heating element within said cathode, a perforated anode surrounding said cathode, a pair of insulating spacer members disposed across the ends of said anode and cathode electrodes, a current conductor for supplying alternating current to the heating element, extending longitudinally of said anode, externally thereof between said insulating members, and a dielectric insulator between said current conductor and said anode.

4. An electron discharge device comprising an enclosing glass envelope, a cylindrical perforated anode, a centrally disposed electron emitting hot cathode of the indirectly heated type, an interposed control electrode, a coil type cathode heater element centrally disposed therein, lead-in wires extending through a wall of said envelope and electrically connected to said heater element, and dielectric shields interposed between said lead wires and said anode and said cathode, said cathode being disposed wholly between said shielding members.

5. A cathode assembly comprising a tubular cathode having an outer surface of electron emitting material thereon, a coiled heater element disposed within and spaced from the inner wall of said tubular cathode, supporting plugs of insulating material at the ends of said tubular cathode, said tubular cathode between the opposing limits of said plugs being substantially a closed tubular section to provide a substantially complete shield between the inner and outer ambient mediums of said tubular cathode, said supporting plugs extending into the ends of said tubular cathode and having apertures extending therethrough, current conducting leads extending through said apertures and connected to said coiled heater element, said supporting plugs having shoulders engaging the ends of said tubular cathode, substantially all of the surface area of said coiled heater element between said current conducting leads being substantially free from solid insulating material and the inner wall of said tubular cathode opposite said surface area also being substantially free from solid insulating material.

6. A thermionic vacuum tube comprising an envelope, a stem, a pair of parallel rods extending therefrom, an insulating bar having apertures through which said rods project, a stud secured to said bar, a tubular cathode surrounding said stud, and engaging said bar, a conductor extending through said bar and stud, and a connector secured to one of said rods and to said conductor.

7. A thermionic vacuum tube comprising an envelope, a stem therein, a plurality of rods mounted on said stem, an insulating cross bar having a vertically extending stud, a tubular cathode surrounding said stud, a conductor extending through said bar and stud, a connector secured to

one of said rods and to said conductor, and a spiral filament secured to said conductor within the cathode, thereby positioning said filament in the cathode.

8. A thermionic vacuum tube comprising an envelope, a stem therein, a tubular cathode, a stud projecting into and closing each end of said cathode, an insulating bar secured to one of said studs, a plurality of rods mounted on said stem and projecting through said bar, a conductor extending through each of said studs, and means secured to said conductors for securing said studs in position.

9. In a vacuum tube a press, an insulator spaced from said press, a second insulator spaced from said first insulator, a cathode supported and disposed wholly between said insulators, a grid supported between said insulators, a pair of supporting rods sealed in said press and extending through openings in said insulators whereby said insulators are aligned, means to electrically connect said grid with one of said supporting rods, an anode surrounding said grid and means to connect said anode to said second supporting rod.

10. A thermionic vacuum tube comprising a stem, a rod extending upwardly therefrom, an insulating cross-bar having an aperture through which said rod projects, a stud adjacent to said cross-bar, a tubular cathode surrounding said stud, and a conductor extending through said stud and cross-bar, and a connector secured to said rod and said conductor and extending along said cross-bar and being in contact with the same to maintain said cathode in surrounding position with respect to said stud.

11. A thermionic vacuum tube comprising a stem, a plurality of rods supported by said stem, an insulating bar having a plurality of apertures through which said rods project, a tubular cathode, a projection from said bar extending into said cathode whereby the bar is prevented from tilting, and means extending across and in contact with the top of said bar and secured to one of said rods for preventing the withdrawal of said projection from said cathode.

12. A thermionic vacuum tube comprising a stem, a plurality of rods mounted on said stem, an upper insulating bar having a plurality of apertures through which said rods project, a lower insulating bar having apertures through which said rods project, each of said bars having a stud secured thereto, a tubular cathode having its ends surrounding said studs, means spaced from said stem and engaging the lower bar to hold it against said cathode, and means secured to one of the rods projecting through the upper bar for holding it against said cathode.

13. A thermionic vacuum tube comprising a stem, a plurality of rods mounted on said stem, an upper insulating bar having a plurality of apertures through which said rods project, a lower insulating bar having apertures through which said rods project, each of said bars having a stud secured thereto, a tubular cathode having its ends surrounding said studs, a rod supported on the stem, and engaging the lower bar to hold it against said cathode, and means secured to one of the rods projecting through the upper bar for holding it against said cathode.

14. A thermionic vacuum tube comprising a stem, a tubular cathode, having its axis in the same direction as the stem, a vertically extending stud projecting into each end of said cathode, a cross-bar perpendicular to one of said studs, and rigidly secured thereto, an enlarged support rigidly secured to the other stud and extending perpendicular thereto, and a plurality of rods mounted on the stem externally of said cathode for positioning said support and bar.

15. An electron discharge device including a press, an insulator spaced from said press, a second insulator spaced from said first insulator, a tubular cathode disposed wholly between said insulators, an anode and a grid, a pair of supporting rods sealed in said press and extending through openings in said insulators whereby said insulators are aligned, a heating element in said tubular cathode, said insulators engaging the ends of said tubular cathode to maintain said tubular cathode substantially free from vertical and horizontal motion with respect to said insulators.

16. An indirectly heated cathode for an electron discharge device, comprising a cathode tube, a pair of supporting plugs of insulating material, one of the plugs extending into each end of the tube, each of said plugs having an abutment engaging an end of said tube and each plug being formed with a central bore, a pair of lead-in wires, one of the lead-in wires extending into each of said bores, a filament connected at each of its ends to the inner end of one of the lead-in wires, and means outside the corresponding supporting plug to retain the parts assembled.

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