May 23, 1939. H. E. MENDENHALL 2,159,747

GLOW DISCHARGE DEVICE

Filed Oct. 3, 1935

FIG. 1

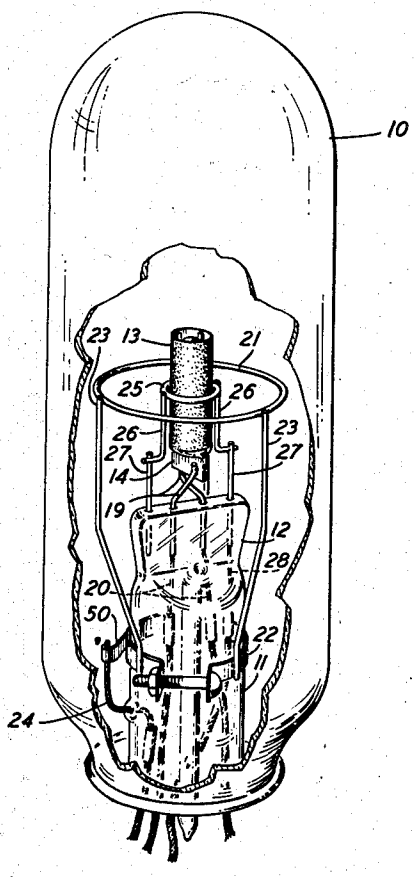


FIG. 2

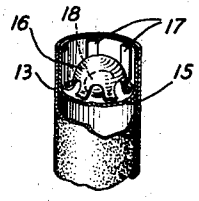


FIG. 3

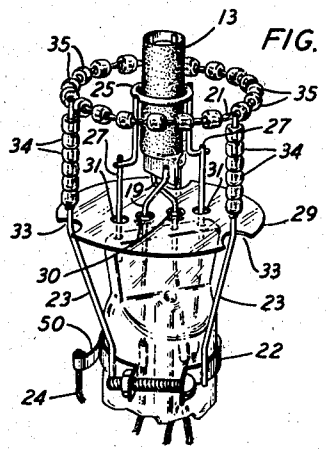
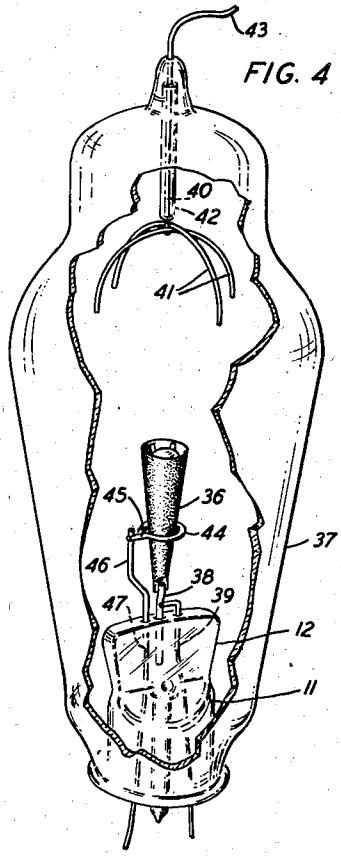


FIG. 4



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GLOW DISCHARGE DEVICE

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5 Claims. (Cl. 250—27.5)

This invention relates to glow discharge devices and more particularly to such devices of the cold cathode type wherein the initiation of a discharge between two electrodes is controllable by a third electrode.

One object of this invention is to reduce the potential necessary between the cathode and an auxiliary or control electrode in glow discharge devices to cause the initiation of a discharge between the cathode and another electrode, such as a work anode.

Another object of this invention is to increase the rectification ratio of glow discharge devices.

In one illustrative embodiment of this invention, a glow discharge device comprises an enclosing vessel having a filling of an inert gas, such as argon or neon or a mixture of gases therein, a cold cathode, a work anode, and an auxiliary or control electrode. The cathode may be a straight or tapered metallic cylinder having a coating of a thermionic material, such as barium and strontium carbonates, on its outer surface. preferably the anode-cathode spacing is relatively great so that at the pressure employed a high work gap striking potential may be utilized.

In accordance with one feature of this invention, the auxiliary or control electrode, which may be coated with thermionic material, is in the form of a wire ring encircling and closely spaced with respect to the cathode. This construction provides relatively large coaxial surfaces of the cathode and control electrode so that a uniform and low breakdown potential is obtained. Furthermore, this construction prevents substantial entrapment of ions between the cathode and control electrode and thereby insures low transfer current and the rapid establishment of a discharge between the cathode and anode upon the application of the critical striking potential to the auxiliary or control electrode.

In accordance with another feature of this invention, the anode is a wire ring or arcuate member disposed outside of the control electrode and having a relatively small surface so that, if the device is operated on alternating current, the current from the anode to the cathode on the inverse cycle is relatively small and hence a high rectification ratio is obtained.

In accordance with still another feature of this invention, one end of the cathode is closed by a dish-shaped member having an alkaline earth metal, such as barium or a mixture of barium and magnesium, therein. This material may be utilized as a getter and flashed during the evacuation treatment of the device. Alternatively it may be used to replenish the barium supply on the cathode, being heated during the operation of the device and depositing on the outer surface of the cathode by migration.

The invention and the various features thereof will be understood more clearly and fully from the following detailed description with reference to the accompanying drawing in which:

Fig. 1 is a perspective view of a glow discharge device illustrative of one embodiment of this invention, a portion of the enclosing vessel being broken away to show the electrode structure more clearly;

Fig. 2 is a detail view, partly in cross-section of the upper end of the cathode in the device shown in Fig. 1;

Fig. 3 is a perspective view illustrating a modification of the embodiment of this invention shown in Fig. 1; and

Fig. 4 is another perspective view of another illustrative embodiment of this invention wherein the cathode is a tapered cylinder or cone.

Referring now to the drawing, the glow discharge device shown in Fig. 1 comprises an enclosing vessel 10 having a stem 11 at one end terminating in a press 12. The vessel 10 has a filling of a rare gas or a mixture of rare gases, such as argon or neon at a pressure of the order of ten to forty millimeters of mercury. A cold type cathode is supported from the press 12 and includes a cylindrical metallic shell 13 the lower end of which is pressed together to form a flat flange 14 and the outer surface of which is coated with a thermionic material, such as barium and strontium carbonates. The upper end of the cathode shell 13 is closed by a dish-shaped member 15 having therein a substantially hemispherical cup 16 which is secured to the dish-shaped member 15 and slightly spaced from the base thereof by tabs 17. Disposed within the dished member 15 is a pellet 18 of an alkaline earth metal, such as magnesium or barium or a mixture of magnesium and barium. The alkaline earth metal may be heated during the evacuation treatment of the device and utilized as a getter for fixing residual gases within the enclosing vessel 10. Alternatively, if the earth metal is barium it may be heated during the operation of the device, by heat from the cathode, so that it migrates upon the outer surface of the shell 13 and replenishes the supply of barium in the thermionic coating.

The cathode assembly is supported by a pair of bent metallic rods or wires 19 embedded in the press 12 and suitably secured to the flange 14,

one or both of the rods or wires 19 having a leading-in conductor 20 connected thereto.

Disposed about the cathode shell 13 and coaxial therewith is a work anode 21 which is supported from a split metallic band or collar 22 clamped about the stem 11, by a plurality of metallic rods or wires 23. The work anode 21 preferably is formed of circular wire of small gauge in order to present a relatively small surface to the cathode 13 so that, if the device is operated on alternating current, the current from the anode to the cathode during the inverse cycles is small and a high rectification ratio is obtained. The spacing between the cathode 13 and anode 21 preferably is relatively great so that at the gas pressure employed a high work gap potential, for example of the order of ten times the ionization potential of the gas in the vessel 10, may be employed and a large output obtained. Such a potential may be applied to the anode 21 through a leading-in conductor 24 sealed in the side of the stem 11 and connected to a metallic tab 50 secured to or integral with the band or collar 22.

As is known in the art, a discharge between a cathode and an anode in a glow discharge device may be initiated by applying a suitable potential to a third electrode, commonly termed an ignition anode or control electrode, whereby a discharge occurs between the cathode and this third electrode and subsequently ionization of the gas between the cathode and the work anode results. It is desirable, for efficient operation, that the potential between the cathode and the ignition anode or control electrode requisite for the initiation of a discharge therebetween be small and also that a large portion of the cathode become activated substantially simultaneously. These and other desiderata are attained in accordance with this invention by an ignition anode or control electrode of a particular construction described hereinafter.

As shown in Fig. 1, the cathode shell 13 is encircled by an annular ignition anode or control electrode 25 which is supported from the stem 11 by L-shaped rods or wires 26 carried by other rods or wires 27 embedded in the press 12, one of the rods or wires 27 having a leading-in conductor 28 connected thereto. The electrode 25 preferably is formed of circular wire, for example of ten to forty mils diameter, and is substantially coplanar with the work anode 21. Preferably it is coaxial with the cathode sleve 13 so that an annular ignition gap of uniform width is obtained. The electrode 25 may be spaced from the shell 13 a distance of the order of 0.1 to 1 millimeter. Inasmuch as the ignition anode or control electrode 25 encircles the cathode 13 and is uniformly spaced therefrom, it will be apparent that a large portion of the cathode 13 will be activated substantially simultaneously. Furthermore, the form of the electrode 25 prevents substantial entrapment of ions in the gap between this electrode and the cathode, so that rapid establishment of a discharge between the cathode 13 and work anode 21 occurs upon the application of the critical or ionization potential to the ignition anode or control electrode 25.

In a modification, illustrated in Fig. 3, of the embodiment of the invention described hereinabove, the cathode 13 and ignition anode 25, which are coated with thermionic material, may be maintained in proper space relation by an insulating disc 29, such as a sheet of mica. The insulating disc is secured to the supports 19 for the cathode, as by eyelets 30, and is provided with apertures 31 through which the support wires or rods 27 for the ignition anode 25 extend. It is provided also with peripheral grooves 33 adjacent the supports 23 for the work anode 21. The portions of the supports 23 above the insulating disc 29 may be surrounded by an insulating sleeve, such as a ceramic coating or glass beads 34. Also, portions of the work anode 21 may have thereon a ceramic insulating coating or may be surrounded by glass beads 35, so that a high rectification ratio is obtained. Preferably about half of the work anode 21 is coated with a ceramic insulating material or surrounded by the beads 35. The insulating disc 29 and the beads 34 serve to prevent stray or leakage currents between the cathode 13 and the work anode 21 so that constant and uniform operating characteristics are obtained.

In the embodiment of this invention illustrated in Fig. 4, the cathode includes a hollow tapered cylindrical or conical metallic member 36, the outer surface of which is coated with a thermionic material. The cathode 13 is supported from the stem 11 of the enclosing vessel 37 by a short rigid wire 38 embedded in the press 12. A leading-in conductor 39 is connected to the wire 38. The vessel 37 has a filling of a rare gas, such as argon or neon, therein, or a mixture of rare gases with mercury vapor. The upper end of the cathode may be closed by a dish-shaped member of substantially the same construction shown in Fig. 2 and having therein a pellet of alkaline earth metal.

An anode is disposed in axial alignment with the cathode 36 and includes a metallic rod 40 sealed in the top of the enclosing vessel 37 and carrying a pair of substantially semi-circular wire members 41, which may be disposed at right angles to each other, directed toward the cathode 36 and equally spaced therefrom. The rod 40 is encircled by an insulating sleeve 42 and has secured thereto a leading-in conductor 43.

The ignition anode or control electrode comprises a circular wire ring 44 encircling the cathode 36 and having an integral arm 45 which is secured to a rod or wire 46 embedded in the press 12, the rod or wire 46 having a leading-in conductor 47 connected thereto. The wire ring 44 is coaxial with the cathode 36 and closely thereadjacent so that but a small potential is required to produce a discharge between the cathode 36 and ignition anode 44.

A particular feature of the construction shown in Fig. 4, is that entrapment of ions between the cathode 36 and ignition anode 44 is substantially prevented so that a discharge to the work anode 41 is established with great rapidity upon the application of the critical or ionization potential to the ignition anode or control electrode 44. Furthermore, this construction enables relatively large cathode work-anode spacings so that a high work gap potential may be employed. The work anode 41 has a relatively small area so that a high rectification ratio for the device results.

It will be understood, of course, that although several embodiments of this invention have been shown and described, these embodiments are merely illustrative, and various modifications may be made therein without departing from the scope and spirit of this invention as defined in the appended claims.

What is claimed is:

1. A glow discharge device comprising an en-

closing vessel having therein an ionizable gas, a cathode having an external electron emissive surface, an anode in cooperative relation with said cathode, and an auxiliary electrode including a small area annular member encompassing and in immediate proximity to a portion of said surface remote from both ends of said cathode.

2. A glow discharge device comprising an enclosing vessel having therein an inert gas, a cathode having an elongated cylindrical portion, a coating of electron emissive material on the outer surface of said portion, a wire ring ignition anode encompassing said portion and disposed substantially midway between the ends thereof, and a wire work anode in cooperative relation with said cathode.

3. A glow discharge device comprising an envelope containing an inert gas at low pressure, a cylindrical cathode, an annular control electrode encircling said cathode and coaxial therewith, and an annular anode encircling said control electrode and coaxial and substantially coplanar therewith.

4. A glow discharge device comprising an enclosing vessel having therein an ionizable atmosphere, a cathode, a wire ring control electrode encompassing said cathode, a wire ring anode encompassing said control electrode, and insulating beads on portions of said anode.

5. A glow discharge device comprising an enclosing vessel having therein a filling of gas, a stem, a cathode, an annular control electrode encompassing said cathode, an annular anode encompassing said control electrode, a plurality of members supporting said cathode, control electrode and anode from said stem, insulating means encasing the supporting members for said anode, and an insulating disc extending across said stem and between the supporting members of said cathode and anode.

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