Oct. 3, 1933. C. G. FOUND 1,929,369

ELECTRICAL DISCHARGE DEVICE

Filed Sept. 30, 1931

Fig. 1.

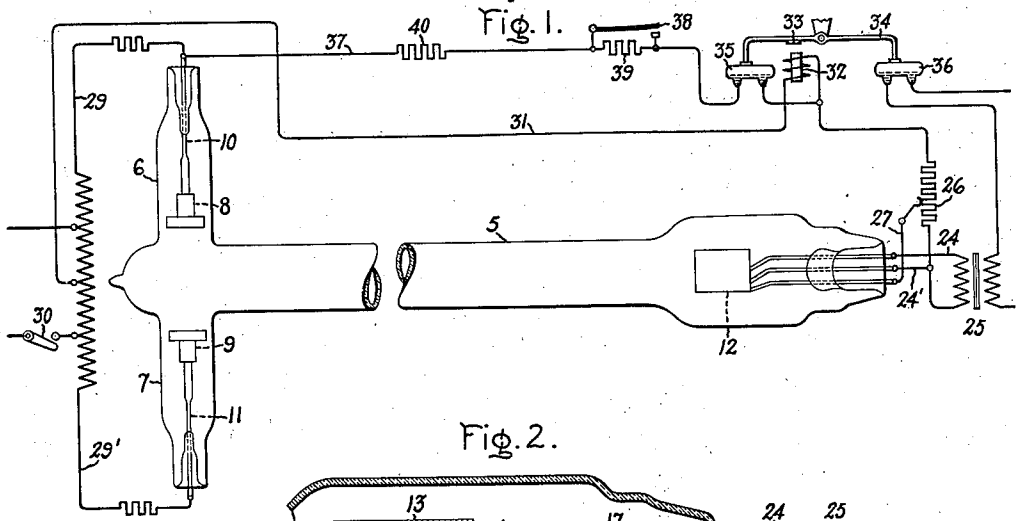


Fig. 2.

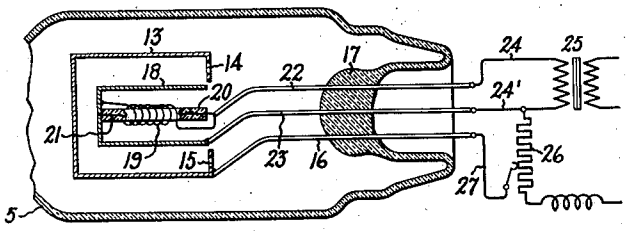
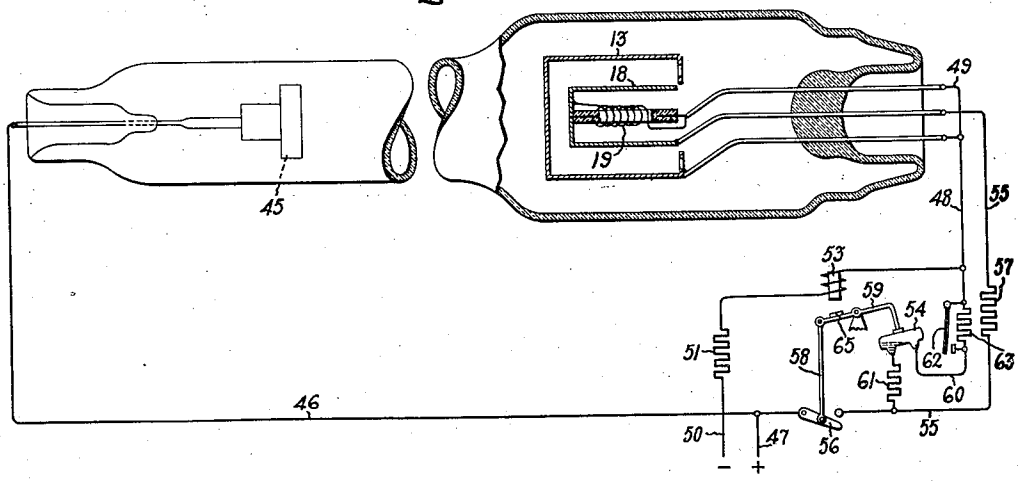


Fig. 3.



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ELECTRICAL DISCHARGE DEVICE

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7 Claims. (Cl. 176—124)

The present invention relates to thermionic discharge devices, such, for example, as luminescent glow lamps and in particular to an improvement in electrode structure for such devices.

It is the main object of my invention to provide an improved electrode construction which is capable of efficient operation at an elevated temperature.

It has been found that it is highly advantageous to construct electrodes of the thermionic type in the form of a hollow body, the interior surface of the hollow body being provided with a coating of thermionically active material. Such electrodes are ordinarily provided with a heater which may be operated continuously while the electrode is functioning, or which may be operated only initially to heat the electrode to an emitting temperature. When the heater is operated continuously the electrode is apt to overheat during otherwise normal operation as additional heat is supplied by the discharge. When the heater is employed only to heat the electrode to an electron emitting temperature, and especially if its operation is to be discontinued after the discharge has started, then the size of the electrode must be decreased in order that it may be adequately heated by the discharge alone. The decrease in size is accompanied by smaller electron emissive capacity. As low electron emission will result in positive ion bombardment, shortened life will result also in this case.

In accordance with my invention these difficulties have been overcome by providing electrical discharge devices with compound thermionic electrodes, or, in other words, with a plurality of interrelated thermionic electrodes, together with means for sub-dividing or properly alotting the current between said cathodes. In a simple form of invention an electrode provided with a heater is surrounded by a second electrode which is unprovided with a heater and these two electrodes are connected to one another by a suitable electrical resistance. The inner cathode being of smaller mass is heated quickly to an efficient emitting temperature by the heater, thereby enabling the discharge to be started. The heat radiated by the inner electrode, as well as the heat radiated by the discharge itself, raises the outer enclosing electrode to an electron-emitting temperature. Suitable electrical means to be described hereinafter divides the current between the electrode elements.

My invention will be described in greater detail in connection with the accompanying drawing which illustrates embodiments of my invention. The novel features of my invention will be set forth with greater particularity in the appended claims.

Fig. 1 is a top view of a glow discharge device, in this case a positive column lamp, containing a plurality of cathodes, or in other words, a compound cathode, embodying my invention; Fig. 2 is a sectional view on a larger scale of the compound cathode of Fig. 1 shown together with suitable electrical connections; Fig. 3 illustrates a lamp having modified circuit connections suitable particularly for a direct current operation.

Referring to the drawing, and in particular to Fig. 1, the device illustrated comprises an elongated tubular container 5 having outwardly extending arms 6, 7 in which are located anodes 8, 9 connected as usual to sealed-in conductors 10, 11. The electrodes 8, 9 may consist of graphite, or of a suitable metal such as nickel, iron, molybdenum, or tungsten. At the opposite end of the envelope is provided a compound cathode 12, shown in detail in Fig. 2. As here illustrated the electrode 12 comprises an outer enclosure, or shell, 13 provided with a plurality of openings, two of which are shown at 14, 15 and supported by a conductor 16 sealed into a stem 17. The inner enclosure or shell 18 is provided on its inside with a resistance heater 19 consisting of tungsten, or other refractory metal. It is supported by a core 20 of refractory material, such as alumina or thoria. It is held in position by a wire 21 which is welded to the shell 18. One end of the heater 19 is connected to the shell 18 and the other end is connected to a conductor 22 also sealed into the stem 17. A projection of the conductor 22 also assists in supporting the core 20. The shell 18 is supported from a wire or conductor 23 also sealed into the stem 17.

The conductors 22 and 23 are connected by wires 24, 24' to the secondary winding of a transformer 25, which furnishes heating energy for the cathode. A resistance 26 is connected between the two cathodes, the connecting conductor 27 being adjustable as indicated to vary the effective value of the resistance.

The inner surface of the cathode 13 and the outer surface of the cathode 18 are provided in the usual manner with a coating of alkaline earth oxide or other thermionically active material, for example, barium oxide. The container 5 is evacuated and then is charged with a gas or vapor, such as neon, or mercury vapor, or a mixture of gases such as a mixture of neon and argon, or neon and krypton, or mercury and argon. The gaseous pressure at operating temperature ordi-

narily is of the order of one to ten millimeters of mercury but may be varied with the conditions and results desired.

The main electrodes receive energy from a main transformer, which is connected to the anodes by the conductors 29, 29' and to the cathode 12 by a conductor 31, in series with an impedance device 32. When the cathode 18 becomes heated to an electron-emitting temperature by energizing the auxiliary transformer 25, and the main circuit is energized by closing the switch 30, then the lamp may be started by any known method.

A suitable and preferred starting circuit has been illustrated in connection with Fig. 1. The impedance device 32 assumes the form of a magnet coil, the armature 33 of which is connected to a lever 34 which supports two mercury switches 35, 36. In the circuit 37 completed by the switch 35 is a thermostatic switch 38 having a resistance heater 39, and the circuit 37 also contains a resistance 40. When the transformer is energized, the heater 39 becomes energized resulting after an interval of a few seconds in the closure of the thermostatic switch 38. The resulting flow of current through the circuits 31—37 energizes the magnet 32 sufficiently to pull down its armature 33, opening the switch 35, causing an inductive kick to be impressed on the lamp electrodes and starting the arc discharge in the gas or vapor. At the same time the mercury switch 36 is opened, and the auxiliary transformer 25 is deenergized, a separate heating current for the cathode no longer being necessary. In some cases the switch 36 may be omitted, the separate heating of the cathode then being continued even after the lamp has started.

The potential drop at the cathode under the conditions described is confined to a zone having a thickness of the order of the electronic mean free path close to the active surface of the cathode. Since the electronic mean free path is small compared to the distance between the cathodes 13 and 18, the energy evolved from the discharge due to the cathode fall at the cathode 18 is delivered in the space between 13 and 18 and as a consequence the temperature of the outer cathode 13 is raised to an electron-emitting temperature both by radiation from the heated cathode 18 and by the dissipation of the energy of the discharge due to the cathode fall.

When the outer electrode 13 assumes a sufficiently high temperature to emit electrons the space current divides between 18 and 13 in a ratio determined by the value of the resistance 26. For example, with a resistance of 22 ohms and a total space current of 3.5 amperes, current of 0.5 amperes flows to the cathode 18 and a current of 3.0 amperes flows to the cathode 13. By increasing the resistance 26 a smaller current flows to the cathode 18 and vice versa.

As a consequence of the described construction and the division of the current both members of the compound cathode operate at a favorable temperature since the energy due to the cathode fall of potential is distributed between the two cathode members. If the current were not properly divided or if a simple hollow cathode were used overheating might be caused by the heat from the cathode fall space being added to the heat delivered by the heater 19. This would be especially noticeable when operating with such gases as neon and helium in which the cathode fall of potential is high.

In the modification shown in Fig. 3 adapted for direct current operation, the construction of the compound cathode is the same but modified electrical connections are employed. The anode 45 is connected by a conductor 46 to a positive supply main 47. The cathode member 13 and the heating resistor 19 are connected respectively by the conductors 48 and 49 to the negative main 50 in series with a resistance 51 and the operating coil 53 of a mercury switch 54. The cathode member 18 is connected by a conductor 55 to the positive main 47 in series with a circuit breaker or switch 56 and a resistance 57. The switch 56 is connected by an interlocking link 58 to a pivoted lever 59 of the mercury switch 54. The terminals of the mercury switch 54 are connected respectively by a conductor 60 to the circuit 48 and by a resistance 61 to the circuit 55. The circuit 60 contains a thermostatic switch 62 having a heater 63. When the switch 56 is closed manually, heating current is supplied from the mains 47 and 50 to the resistance heater 19 of the cathode through the conductors 55 and 48. The closing of the switch 56 moves the lever 59, which normally is in a tilted position, to its horizontal position on account of the inter-connected link 58. The tube 54 is tilted, causing the contained mercury to assume a horizontal position, bridging the wires 60 and 61 and causing the heater 63 of the thermostatic switch 62 to be connected to the supply mains 47, 50. After a short time interval, the heater 63 causes the thermostatic switch 62 to move inwardly and to short-circuit the heater, thereby permitting a relatively large current to flow through the local circuit, including the resistance 61, the mercury switch 54, the switch 62, the coil 53 and the resistance 51. This large increase of current through the coil 53 causes the armature 65 to be pulled upwardly still further, i. e. beyond its horizontal position, tilting the tube 54 still more until its righthand end (as shown) contains all of the mercury, thereby opening the mercury bridge across the conductors 61 and 60. This movement of the armature 65 also pulls the switch 56 upwardly, away from its horizontal circuit-making position. The coil 53, also the heating circuit through member 19, are thus deenergized insofar as current in the local circuit is concerned. The deenergization of coil 53 causes an inductive kick to be superimposed on the supply voltage impressed on the lamp from the positive side of the line through the conductors 47 and 46, and from the negative side through conductors 50, 48, etc. This inductive kick causes a discharge to pass through the gas or vapor between the electrodes 45 and 18. From the electrode 18 the current passes through the heater 19 through the conductors 49 and 48 to the negative supply main 50.

Since the cathode element 13 is connected to the conductor 49 it causes the element 13 to be negative to the element 18. By proper design of the heater 19 the current divides between the elements 13 and 18 in the same manner as described above in connection with Figs. 1 and 2.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. A compound thermionic cathode comprising a plurality of members which are located in heat-interchanging relation to one another and means for apportioning and controlling a load current in predetermined ratio between said members.

2. A thermionic cathode comprising a main hollow body, a second hollow body of materially smaller dimension located in heat-interchanging relation to said first-mentioned hollow body,

means for heating said second hollow body, and means for allocating a given load in predetermined ratio between said two bodies.

3. A thermionic electrode comprising a metal shell having an opening leading to the interior, a materially smaller metal shell located within said first-mentioned shell and electrically separated therefrom, an activating material upon both the interior surface of said first-mentioned shell and the exterior surface of said smaller shell, separate current-conveying conductors for said respective shells, and means for dividing a load current between said shells.

4. An electric discharge device comprising a sealed container, a gas therein, cooperating electrodes, including a cathode comprising a main hollow body, a smaller hollow body located therein, a thermionically active material coating both upon the interior surface of said main hollow body and the exterior surface of said smaller hollow body, a heater for said smaller hollow body, and means for proportioning current between the said parts of the cathode.

5. An electric discharge device comprising a container, a gas therein, an anode, a cathode comprising a plurality of members one of which is enclosed by the other, means for heating said cathode to an electron-emitting temperature, and means for apportioning and controlling a load current in predetermined ratio between said members, said means including resistance connected between the members of said cathode.

6. An electric lamp comprising an envelope, a gas therein at a pressure of about one to ten millimeters of mercury, cooperating main electrodes including a compound cathode the members of which have separate conductors sealed into said envelope, a resistance heater for one of the members of said cathode, circuit means for operating a glow discharge between said main electrodes, means for impressing a high voltage impulse on said main electrode to start said glow discharge and a circuit interrupter interlocked with said means for opening the circuit of said cathode heater.

7. A thermionic cathode comprising a main hollow body coated upon an inside surface with thermionically active material, a second hollow body located inside said main body and being coated upon an outside surface with thermionically active material, a resistance heater for said second body, and circuit means for electrically connecting said heater between said bodies.

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