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ELECTRIC DISCHARGE TUBE

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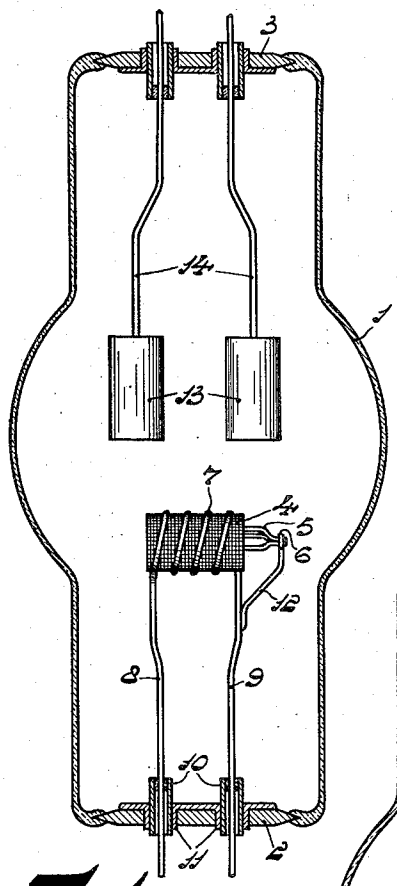

Fig. 1.

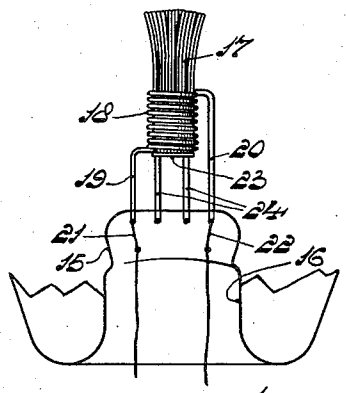

Fig. 3.

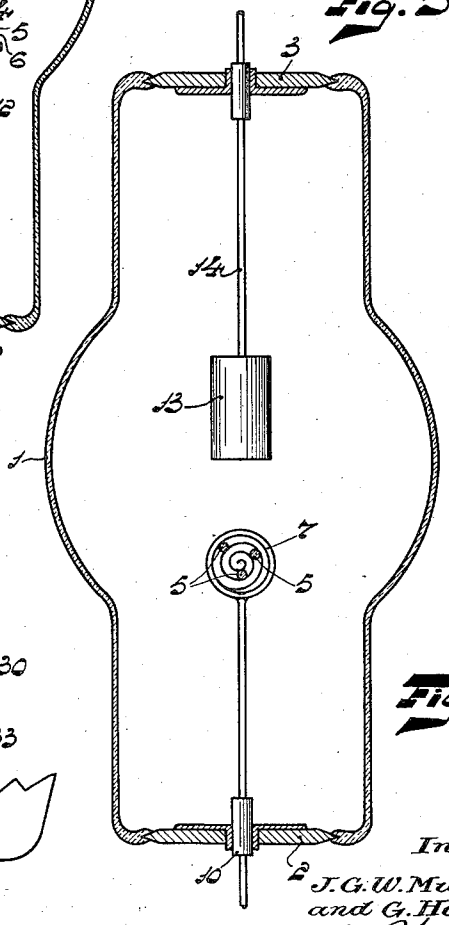

Fig. 2.

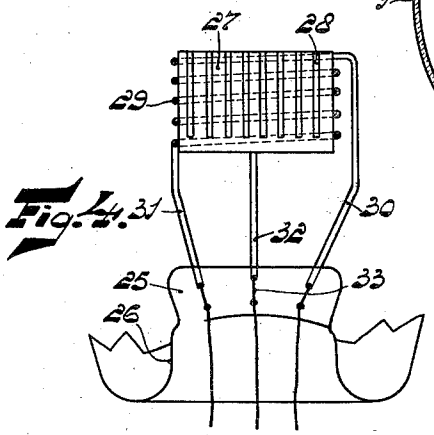

Fig. 4.

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ELECTRIC DISCHARGE TUBE

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15 Claims. (Cl. 250—27.5)

This invention relates to electron discharge tubes having a gas filling, and particularly to electron discharge tubes having electron emitting cathodes which are indirectly heated at least in part and in which is incorporated a material having strongly electron emitting properties. In the present application the term "gas filling" includes a filling consisting of a mixture of gas and vapour or one of or more vapours. The invention has for its main object to increase the emission, the efficiency and the life of the electron emitting cathode in such tubes.

Another object of the invention is an arrangement in which the heating wire itself contributes to a considerable extent in the electron emission.

Another object of the invention is to provide a cathode having a large electron emitting surface, the outside surface having the highest temperature.

Another object is to prevent the active material volatilized from parts of the cathode from being deposited either on the glass walls, or on the anodes or any other part within the tube.

Incandescent cathodes according to the invention may be used with advantage inter alia in the so-called neon tubes and in discharge tubes for high capacities such as rectifiers.

In an electric discharge tube according to the invention a cathode is provided which has a large number of cavities and which is surrounded by a heating element. These cavities considerably increase the electron emitting surface of the cathode without, however, substantially enlarging the heat radiating surface of the cathode. Consequently, the total electron emission of the cathode may be made very large and the specific electron emission, that is the emission per unit of energy required to heat the cathode to the operating temperature reaches high values. The heating element which is placed outside the cathode may be made to take part in the electron emission to a great extent. Disintegration and volatilization of the active cathode material will be very slight because the substance broken off or volatilized from certain surface portions of the cavities will again deposit on other parts of this surface. Furthermore, the heating element when surrounding with its windings the main body of the cathode, may form a screen so that parts of the active material volatilized in the inner parts of the cathode are not permitted to pass through the cathode. In the narrow cavities of the cathode the electric field will be as a rule very weak or entirely suppressed, which facilitates the emission of electrons.

The cathode body is preferably provided with numerous internal cavities. The electron emitting substance which is not located at the outer surface of the cathode body but, in the interior of this body, only contributes to the emission of electrons but not to the radiation of heat.

An advantageous construction is obtained by providing a cathode comprising a network of metal wires. Such arrangement is very compact especially when using a network consisting of a plurality of layers. For this purpose the cathode may consist of a sheet of gauze rolled up in the form of a cylinder or of a plurality of concentric cylinders of gauze. In many cases it is advisable to provide between the individual layers of the network, conductors to space the layers at a definite distance from each other, whereby these conductors may at the same time serve as current conductors for the cathode.

Another suitable construction consists in making the cathode body from a bundle of wires which, at least for part of their length, are slightly spaced apart from each other.

The invention will be more clearly understood by referring to the accompanying drawing which represents schematically, by way of example, some embodiments of the invention.

Figure 1 is a side elevation, and

Figure 2 an end elevation of an electron discharge tube with a cathode formed of rolled up sheets of gauze;

Figure 3 is an elevation of the stem of a discharge tube with a cathode consisting of a bundle of wires;

Figure 4 is an elevation of the stem of a discharge tube with a cathode consisting of a solid body having deep cavities.

The discharge tube represented in Figures 1 and 2 has a wall 1 of glass, quartz or similar material to which are sealed two metal discs 2 and 3 which are conveniently made of ferrochromium. The disc 2 carries the incandescible cathode and the disc 3 carries the two anodes 13 of the discharge tube.

The cathode consists of a rolled-up sheet of metal gauze 4 the different layers of which are spaced apart by conducting rods 5. These rods project to the right outside of the rolled up cathode body and are bent towards each other and interconnected by a collar 6. The rolled-up network 4 is surrounded by a helically wound wire 7 whose ends form a current lead-in wires 8 and 9. These lead-in wires are hermetically secured to the upper ends of thin tubes 10, for example of ferrochromium, and the cylindrical surfaces of which are sealed by means of interposed glass bushings 11 into apertures provided in the disc 2. As indicated in Fig. 1, there is space provided between the current lead-in wires and the tubes 10, so that said wires are connected to the said tubes only at the top thereof. This method of leading-out the current supply wires renders it possible to carry very heavy currents through the supply wires without exces-

sively heating the sealing-in points. The ends of the rods 5 are connected by means of a wire 12 to the lead-in wire 9.

The network 4 is coated with a substance having high electron-emitting properties. For instance the network may be immersed in a solution of hydrates of one or more alkaline earth metals. These hydrates are subsequently converted into oxides by heating. The conductor 7, which constitutes the heater of the cathode, is also coated with an electron emitting substance. Between the wire 7 and the network there is provided a sufficient quantity of insulating material consisting, for example, of alkaline earth oxide, in order to prevent a short circuit between the turns of the heater 7. The electron emitting substance in the interior of the rolled-up cathode body does not contribute to the radiation of heat so that the cathode requires only a small heating energy although the emission of electrons can be raised to a very high value. In fact, the electron emitting surface of the cathode is very large. For example, it is possible to manufacture in this manner without any inconvenience a cathode which provides an emission current of several hundred of amperes. Part of this current is supplied to the interior of the cathode by the conductor 12 and the rods 5. It appears that the electron emission is also facilitated by the very weak electric field in the narrow cavities and by the mutual action of the walls of the cavities, which in this case consist of the wires of the network. Due to this construction a positive ion, upon entering a narrow cavity, can expel several electrons therefrom.

The electron emitting substance contained in the interior of the cathode, substantially can not break away from the cathode, so that the cathode has a very long life. It may happen that the emitting substance on the wire 7 breaks away during the operation of the wire so that this heater substantially does not participate in the emission of electrons and the emission is entirely brought about by the electron emitting substance on the network 4.

The discharge tube represented in the Figures 1 and 2 comprises two anodes 13 secured to current supply wires 14 which are led through the disc 3 in the same manner in which the conductors 8 and 9 pass through the disc 2. The electron discharge tube represented is suitable for the rectification of alternating currents and is provided with a suitable gasfilling consisting for example, of argon under a pressure of some millimeters. To the argon may advantageously be added some mercury vapour or the filling may consist entirely of mercury. The pressure of the mercury vapour may be very low, for example a fraction of a millimeter.

The cathode represented in Figure 3 is carried by the pinch 15 of a stem 16. This cathode consists essentially of a bundle of wires 17 which for the greater part of their length are apart from each other and which are held together at their lower ends by a helically wound wire 18 whose ends are connected to current supply conductors 19 and 20 secured in the pinch 15 and connected to current supply wires 21 and 22. The helically wound wire 18 constitutes the heater of the cathode and it is therefore sufficiently insulated from the wires 17, for example, by means of a layer of alkaline earth oxide, which prevents short-circuits between the various turns. The wires 17 are coated with a strongly electron emitting substance for example with one or more alkaline earth oxides while the heating wire 18 may also be coated with an electron acting substance. The emission or operating current is supplied to the wires 17 by means of a ring 23 arranged around the lower end of the bundle of wires and mounted on the pinch 15 by means of three supporting wires 24 (only two being visible). These supporting wires my either be connected to one of the current lead-in wires 19, 20 of the heater 18, or may be provided with separate current supply wires. Figure 4 represents a cathode mounted on the pinch 25 of a stem 26 which may be sealed to the envelope of an electron discharge tube. The cathode in this case comprises a cylindrical body 27, for example of tungsten or nickel, the upper surface of which has a large number of deep and narrow cavities 28, said body being surrounded by a heater 29 which is insulated from the body 27 and which is connected to the current supply conductors 30 and 31. The body 27 is connected to the current supply conductor 32 which is provided with a separate lead-in wire 33. The surfaces of the cavities 28 are coated with a strongly electron emitting substance which can be heated to its emitting temperature by means of the heater 29. In many cases it may be advisable to fill the cavities 28 with a network of metal wires which is entirely coated with a strongly electron emitting substance. In this case the cavities 28 may be made wider than if the cavities are not filled. The emitting substance present in the cavities 28 substantially does not contribute to the radiation of heat so that the cathode has a very high efficiency although the disintegration of the electron emitting substance is very slight.

Cathodes of the kind described are especially useful in the case of gasfilled rectifying tubes for high current, for instance, up to several hundred amperes.

What we claim is:—

1. An electric discharge device comprising a container, a gasfilling and electrodes therein including an anode and a thermionic cathode which is heated at least in part indirectly and contains a material having strong electron emitting properties and consisting of a body having a large number of internal cavities and a heating element surrounding said body and electrically connected thereto, said element having an electron-emissive coating and forming an electron-emissive member of said cathode.

2. An electric discharge device comprising a container, a gasfilling and electrodes therein including an anode and a thermionic cathode which is heated at least in part indirectly and contains a material having strong electron emitting properties and consisting of a bundle of wires which are spaced slightly apart at least for a part of their length and are surrounded by a heating element.

3. An electric discharge device comprising a container, a gasfilling and electrodes therein including an anode and a thermionic cathode which is heated at least in part indirectly and contains a material having strong electron emitting properties and consisting of a network of metal wires rolled into a plurality of layers and surrounded by a heating element.

4. An electric discharge device comprising a container, a gasfilling and electrodes therein including an anode and a thermionic cathode which is heated at least in part indirectly and contains

a material having strong electron emitting properties and consisting of a number of layers of metal network spaced apart by rods, the whole being surrounded by a heating element.

5. An electric discharge device comprising a container, a gasfilling and electrodes therein including an anode and a thermionic cathode which is heated at least in part indirectly and contains a material having strong electron emitting properties and consisting of a number of layers of metal network spaced apart by conducting rods connected to a current supply conductor, the whole being surrounded by a heating element.

6. An electric discharge device comprising a container, a gasfilling and electrodes therein including an anode and a thermionic cathode consisting of a rolled up sheet of gauze, the different layers of which are spaced apart by conducting rods, the rolled up network being embraced by a helical wire, the ends of which merge into leading-in wires by which the heating current may be supplied, the heating wires and the network being coated with a substance having strong electron emitting properties.

7. An electric discharge device comprising a container, a gasfilling and electrodes therein including an anode and a thermionic cathode consisting of a rolled up sheet of gauze, the different layers of which are spaced apart by conducting rods, these rods being bent inwardly towards each other outside the rolled up cathode body and being connected together, the rolled up network being embraced by a helical wire, the ends of which merge into leading-in wires by which the heating current may be supplied, the ends of the spacing rods being connected to one of these leading-in wires, the heating wires and the network being coated with a substance containing at least one of the oxides of the alkaline earth metals having strong electron emitting properties.

8. A gasfilled electric discharge device, comprising a container, at least one anode, and a cathode, said cathode comprising a body having an effective surface area greatly exceeding its contour area and having a plurality of cavities therein, a network of metal wires filling said cavities, and a heating element at least partly heating said body.

9. A gasfilled electric discharge device, comprising a container, at least one anode, and a cathode, said cathode comprising a body having an effective surface area greatly exceeding its contour area and having a plurality of cavities therein, a network of metal wires filling said cavities, said metal wire having electron emitting properties, and a heating element at least partly heating said body.

10. As an element of a gas-filled electrical discharge device, a cathode structure comprising two cathode members, one member comprising a substantially cylindrical body having internal spaces and a large surface area and provided over its surface including the surface of the internal spaces, with an electron-emitting substance, and the second cathode member comprising an elongated small-cross-section member coated with an electron-emissive substance, said second member surrounding said first member and being electrically connected therewith.

11. A gas-filled electric discharge tube comprising a container, at least one anode, and a cathode comprising two electron-emissive electrically-interconnected members for thermionically supplying the electron emission of the tube, one of said members comprising a body of substantially cylindrical shape provided with internal spaces to form a large surface area, the entire surface area of said body being coated with a highly electron-emitting substance, the second member being in close and electrically non-contacting spatial relationship with said first member substantially throughout the cylindrical surface thereof, said second member comprising a heating element provided with an electron-emissive oxide coating and at least partly heating said body.

12. As an element of a gas-filled electric discharge device, a cathode structure comprising a body having internal spaces whose surfaces are provided with an electron-emitting substance, said body having a large effective surface area which includes the surface of the internal spaces, and a heating element electrically connected with said body and at least partly heating same, said element being in close and electrically non-contacting spatial relationship with said body substantially throughout the outer surface thereof.

13. A gas-filled electric discharge device comprising a container, at least one anode, and a cathode comprising an electron-emissive member consisting of a body having a plurality of cavities, the entire surface of said body being provided with an electron-emissive substance, and a heating element at least partly heating said body and in close electrically-non-contacting relationship therewith, said heating element being coated with an electron-emissive oxide coating and being electrically connected to said body to form a second electron-emissive member of the cathode.

14. As an element of a gas-filled electric discharge device, a cathode comprising a solid cylindrical body provided with a plurality of cavities to increase its total surface area to several times the contour area of the solid body, a coating of an electron-emissive substance provided over the total area of said body to form a layer of substantially the same surface area, and a heating element electrically connected at one point to said body and closely surrounding same, said heating element at least partly heating said body and being provided with an electron-emissive coating to form an active electron-emissive member of said cathode, said element and body being in electrically non-contacting spatial relationship.

15. An electric discharge device comprising a container, a gas filling, at least one anode, and a thermionic cathode heated at least partly indirectly, said cathode comprising an indirectly-heated and substantially cylindrical body having substantially equal length and diameter, said body being provided with a plurality of cavities having large surface areas coated with an electron-emissive substance, and a heating element comprising a closely-wound cylindrical coil surrounding said body substantially throughout its external surface, said coil being electrically connected to said body and being coated with an electron-emissive substance, said element and body being in close and electrically non-contacting spatial relationship and forming the emitting members of the cathode.

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