Feb. 18, 1947. W. W. WATROUS, JR 2,415,980

ELECTRONIC DISCHARGE DEVICE

Filed March 9, 1943

Fig. 2.

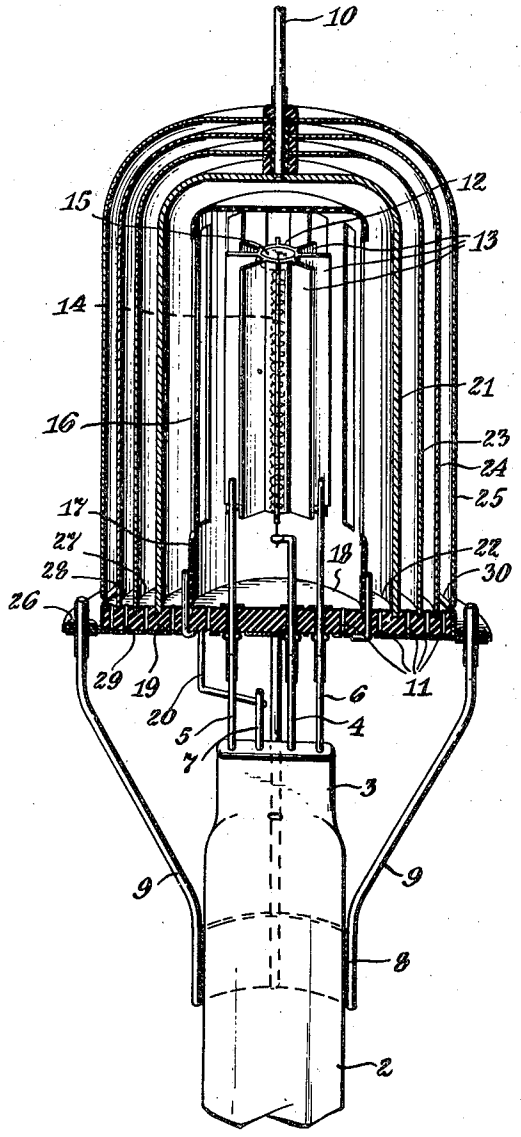
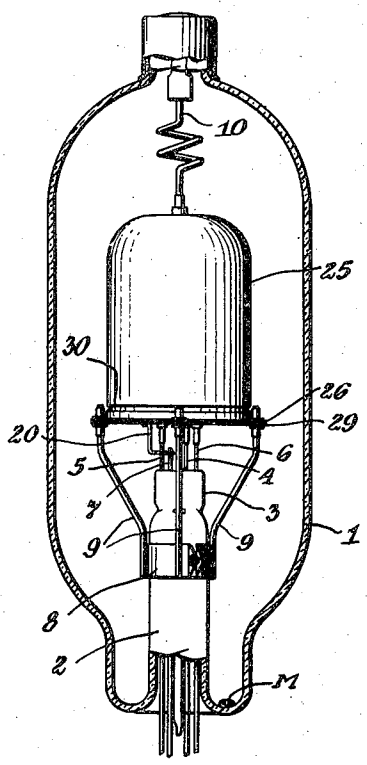


Fig. 1.



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ELECTRONIC DISCHARGE DEVICE

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4 Claims. (Cl. 250—27.5)

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This invention relates to electronic discharge devices, and more particularly to such devices which operate with an ionizing discharge in gas or vapor.

It has been known to provide discharge tubes of this type with heat-shielding means which do not form part of the electrodes proper but serve mainly to improve the efficiency of the thermionic operation or to prevent an undue rise in the temperature of accessory parts such as the seals.

For instance, in order to obtain a high ratio of emissive cathode area to heating energy, it is customary to heat-shield the cathode in some manner. To this end, the cathode is usually enclosed by one or several heat shields, thus screening the cathode thermally from the other electrodes and parts of the tube structure. There are also self-screening cathode constructions in which the heated emissive surfaces lie within a pot-shaped hollow structure which is open towards the anode only at a relatively small surface area in order to obtain approximate "black body" emission.

These methods of heat-shielding the cathode, while effective in conserving heating energy, have the serious disadvantage of so enclosing the active emitting area as to make only a fraction of this area available for effective emission. In other words, in the known types of heat-shielded cathode designs, the actually useful emission falls far short of the theoretically available magnitude.

It is an object of the invention to provide a thermionic discharge device, in particular for operation with an ionizing atmosphere, in which the ratio of active cathode emission to heating energy is improved over unshielded electrode structures to a degree similar to the shielding effect of the above-mentioned known devices but without incurring the drawback peculiar to heat-shielded cathodes.

Another object, allied to the foregoing, is to increase the actually effective surface area of the cathode in a gaseous discharge device beyond that heretofore utilizable, and preferably up to the obtainable maximum value, while preventing the loss in economy or efficiency incurred in the known unshielded structures. In another aspect but also related to the above-mentioned object, the invention aims at eliminating between cathode and anode all obstructions not necessitated by the discharge or discharge control proper while at the same time increasing the efficiency ratio.

Further objects of the invention relate to the constructional and manufacturing aspects of discharge tubes of the above-mentioned type and

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consist in providing an electrode structure, suitable for preventing ionization outside the discharge space proper and containing a large-surface cathode with freely-open emissive surface areas, in which the cathode has a simplified construction as compared with the known screened or black-body type cathode structures.

According to the invention and in view of the objects aforestated, an electronic discharge device is provided with electrode elements and associated parts designed as follows. The cathode of the device is formed of a structure composed essentially of a cylindrical body, preferably hollow to receive a heating element, and a plurality of radiating members projecting radially from the cylindrical body and serving to enlarge the effective outer surface of the cathode structure. This cathode structure is concentrically surrounded by a substantially cylindrical anode, with or without one or several interposed grid electrodes, so that the anode encloses the cathode to a sufficiently complete extent to prevent outside ionization. This anode, in turn, is surrounded by heat-shielding means placed between the anode and the sealed envelope of the tube to prevent the radiation of heat from the anode towards the envelope. Hence, the heat developed in or by the cathode is largely confined to the discharge space, while the cathode has an emissive outer surface freely open towards the anode and not obstructed by the shielding means.

Details of the invention will be apparent from the following description of the embodiment exemplified by the drawing in which Fig. 1 shows a side elevation, with the envelope partly broken away, of a discharge tube according to the invention, and Fig. 2 a longitudinal cross-section perspective view of the electrode assembly of the same tube on a larger scale.

In the specific embodiment of the invention illustrated in said drawing, there is shown a discharge tube having an envelope 1 of glass or other suitable material provided with a reentrant stem 2 merging into a press 3. A number of wires, numbered 4 through 7, pass through the press and form sealed lead-in wires and generally holders for the electrodes as will be set forth in a later place. A clamp-collar 8 is shown mounted on the stem and provided with upwardly extending support rods or wires for purposes hereinafter explained. Another holder and lead wire 10 passes through the top portion of the envelope 1. A gaseous atmosphere is intended to be present in the envelope, such as mercury vapor, argon, xenon, krypton and the like, so by way of

illustration a drop of mercury is provided at M to obtain the desired vaporous atmosphere within the envelope. That is, when the envelope is partially evacuated to assume the desired low pressure, the evaporating mercury in this instance provides the ionizing atmosphere required for the thermionic discharge between the electrodes.

The electrode assembly, according to Fig. 2, includes a cathode structure composed of a hollow cylinder 12 and radially-projecting members 13 which, in the illustrated embodiment, consist of flat fins extending in axial and radial planes relative to the cylinder axis. The cathode structure is mounted on the leads 5 and 6. A heater 14, here shown as formed by a coiled heating resistor, is arranged inside the hollow cathode cylinder 12 and mounted at its lower end on lead 4 and at its upper end carried at the center of a plug 15 fixed in the top end of cathode cylinder 12. This lead 4, the heating resistor 14 and circuit through plug 15, cathode 12 and its lead 5, serve to supply the cathode with heating energy, while the discharge current is supplied through cathode lead 5.

A control or grid electrode formed by a slotted or foraminous cage 16 of substantially cylindrical shape may be provided to surround the cathode structure concentrically and extend axially at both ends beyond the cathode. The upper end of the grid electrode is dome shaped and closed while the lower end is open. This lower end, however, extends downwardly beyond the cathode preferably as a non-foraminous collar or base 17 and mounted at its marginal basal rim in a circular groove 18 for the purpose formed in the upper face of a disc-like insulator 19. The grid is connected by wire 20 to lead-in wire 7 through the press which together form the grid lead. It is especially noted that this grid, when used as part of the tube structure becomes very hot, and is not only made of a material which will withstand the intense heat of the order of 750° C., but a material preferably non-conductive at usual temperatures which becomes conductive at the high temperature of operation of the device. Examples of such materials are glass and porcelain.

The anode 21 consists of a conductive, preferably metallic, body of substantially cylindrical shape having a closed dome-shaped top portion attached to the holder and lead wire 10. The anode encloses the cathode and grid completely in the peripheral direction as well as at the dome-shaped end, and extends downwardly beyond the cathode to prevent uncontrolled ionization. The basal marginal rim of the anode, like the grid, is mounted in a circular groove 22 for the purpose also formed in the upper face of said disc-like insulator 19. The device may be made, if desired, without a grid and used as a rectifier.

A heat-shielding assembly, composed of three nested shield members 23, 24 and 25 of substantially cylindrical shape, is placed around the anode. The shield members have their upper ends closed so said members not only engirdle the entire peripheral surface of the anode but also cover its upper, dome-shaped end portion. The shield members are spaced from each other, the inner shield 23 being preferably also spaced from the anode, and have heat-reflective surfaces to deter the radiation of heat from passing to the anode towards the envelope of the tube. The shield members may consist of metal and should have bright reflecting surfaces. Heat-resistant metals such as nickel or Nichrome (nickel-chromium alloy) are applicable for this purpose, the alloy having the advantage of a lower heat conductivity. The basal ends of the heat shield members extend to the disc-like insulator 19, the outer one 25 overlapping the edge of the insulator and at the bottom thereof flaring outward to form a flange 26. The inner two heat shield members have their marginal ends situated in circular grooves 27, 28 in the upper face of the insulator. All of said grooves 18, 22, 27 and 28 are concentric as is also the outer periphery of the insulator. The number of shield members, of course, may differ from the one chosen in the illustrated embodiment. It will also be understood that shield members of other shape may be chosen, for instance, a single sheet can be wrapped around the anode in such a manner that its several convolutions give the effect of the described series of concentric shielding members.

Reverting to Fig. 2, it will be noted that the electrodes are also heat-shielded towards the stem portion of the envelope. This shielding is accomplished in part by said disc-like insulator and in part by a metallic plate 29 underlying the insulator to form a closure covering the under side of the insulator except where openings are required for lead-in wires and for exhaust purposes. Said plate extends outwardly as far as the outer edge of flange 26 which is juxtaposed on the margin of said plate and secured thereto. The outer shield member 25 has an inwardly directed peripheral rib 30 next the top of insulator 19 thereby holding the insulator and plate in juxtaposed position. Bracing support for the disc-like insulator and plate is obtained by the support rods 9 from clamp-collar 8 on the stem 2. Said rods extend through the plate and flange 26 and welded or otherwise secured thereto, as by use of eyelets on said rods.

The electrical discharge operation of the tube is similar to that of known discharge devices. In thermal respect, however, it will appear from the foregoing that no heat-shielding is provided at the cathode or between the cathode and anode. Nevertheless, an effect similar to that of shielded cathodes is obtained by having the cathode virtually fully enclosed by the anode, and the anode fully shielded against the envelope so that the heat developed in and by the cathode is substantially confined to the thermally insulated discharge space. This ensures the desired high ratio of active cathode to heating energy. It is also apparent that this result is augmented by the fact that the electron-emitting cathode surfaces are freely open towards the anode. The fins 13 and the intermediate outer surface portions of the cathode cylinder 12 form a plurality of areas, each having a sector-shaped cross section flaring towards the anode, thus offering a maximum surface and opening for the emission of electrons into the discharge space. This increases the available emissive area to a maximum value and thus contributes to achieving a high efficiency value. By virtue of the same design, the construction and manufacture of the cathode is simplified and the coating of the surfaces with highly emissive material, such as barium oxide, greatly facilitated. Utility of the device is enhanced by the feature of a grid which becomes conductive at high temperature of tube operation of the order of 750° C.

Although one specific embodiment of the invention has been shown and described, it is to be understood that other modifications may be

made without departure from the features and scope of the appended claims.

I claim:

1. A discharge device, comprising a sealed envelope, an indirectly heated cathode structure disposed in said envelope, said structure having an elongated cylindrical body and radiating members projecting radially from said body forming an enlarged electron-emissive outer surface of said cathode structure, a substantially cylindrical grid element surrounding said cathode structure and extending axially beyond said cathode structure with a dome portion over one end of the cathode to prevent uncontrolled discharges, said grid being of material normally non-conductive electrically but conductive at high temperatures, an elongated hollow anode surrounding said grid element and extending axially beyond and over the dome end of the latter to prevent ionization outside of the grid-controlled discharge space, and heat-shielding means spaced from said anode within said envelope for reducing the emission of heat from the anode-enclosed discharge space towards said envelope and for obtaining high heat concentration within the anode and on the grid for rendering the grid conductive.

2. A discharge device, comprising a sealed envelope, an indirectly heated cathode structure disposed in said envelope, said structure having an elongated cylindrical body and radiating members projecting radially from said body forming an enlarged electron-emissive outer surface of said cathode structure, a substantially cylindrical grid element surrounding said cathode structure and extending axially beyond said cathode structure with a dome portion over one end of the cathode to prevent uncontrolled discharges, a substantially cylindrical hollow anode surrounding said grid element and extending axially beyond the latter to prevent ionization outside of the grid-controlled discharge space, said grid element having one of its ends closed and formed as a dome-shaped portion at said end and positioned with its dome-shaped portion overlying the dome portion of the grid and said grid being of material normally non-conductive electrically but conductive at high temperatures, a heat-shielding closure disposed at the end of said anode and grid opposite from said dome portions

thereof, and substantially cylindrical heat-shielding means surrounding said anode within said envelope and covering the entire peripheral extension and the dome-shaped end of said anode for reducing the emission of heat from the anode-enclosed discharge space towards said envelope and for obtaining high heat concentration within the anode and on the grid for rendering the grid conductive.

3. A gaseous discharge device, comprising a sealed envelope, an indirectly heated cathode structure disposed in said envelope, said structure having an elongated and hollow cylindrical body and a plurality of fin members projecting radially from said body and extending each along the axial direction of said body thus forming a plurality of outer surface areas each having a sector-shaped cross section with a large free opening directed towards the discharge space, a substantially cylindrical anode having one of its axial ends closed, said anode enclosing said cathode structure peripherally and at said closed ends, the other end of said anode extending beyond said cathode structure to prevent ionization outside of the anode interior, and a plurality of nested heat-reflective shields enclosing said anode within said envelope and being spaced from each other.

4. A discharge device having a cathode, grid and anode wherein the grid is normally non-conductive electrically and of a material conductive at high temperature of operation of the device.

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