Feb. 22, 1949. P. W. STUTSMAN 2,462,142

COLD-CATHODE GAS TUBE WITH STARTING ELECTRODE

Filed June 14, 1947

FIG. 1

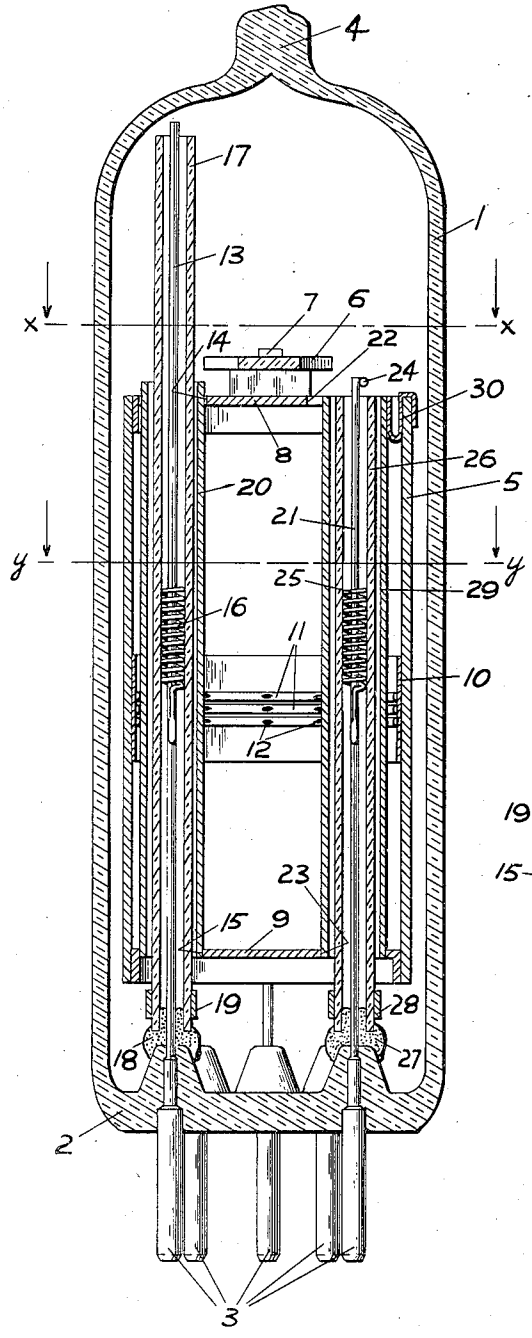
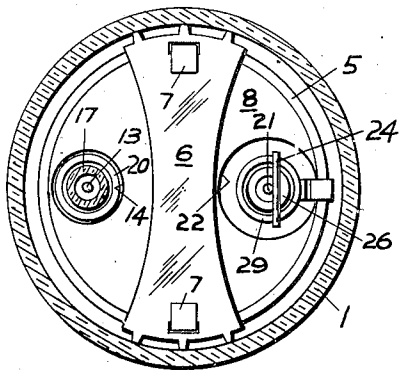


FIG. 2



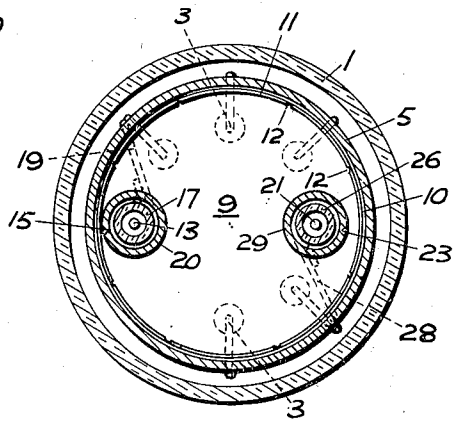


FIG. 3

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COLD-CATHODE GAS TUBE WITH STARTING ELECTRODE

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10 Claims. (Cl. 250—27.5)

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This invention relates to electron-discharge devices, and more particularly to a controllable cold-cathode gas discharge tube.

The principal object of this invention is to devise a double-gap cold-cathode gas discharge tube which is capable of carrying a rather high plate current and yet which is rather small in size.

Another object is to devise a grid-controlled cold-cathode gas tube which may be used to operate various types of control devices, for example, relays, which require rather high currents for their operation.

A further object is to devise a cold-cathode gas tube which may be used to replace hot-cathode gas tubes, thus eliminating and saving the current consumption required for heating the cathodes of such hot-cathode tubes.

The foregoing and other objects of the invention will be best understood from the following description of an exemplification thereof, reference being had to the accompanying drawing, wherein:

Fig. 1 is a central vertical cross-section of a tube embodying the invention;

Fig. 2 is a horizontal cross-section on line x—x of Fig. 1; and

Fig. 3 is a horizontal cross-section on line y—y of Fig. 1.

Referring now to the drawing, the device comprises a vitreous envelope 1, containing a suitable ionizable gaseous atmosphere, preferably ninety-nine per cent neon and one per cent argon, at a pressure of about forty millimeters of mercury. In the embodiment shown, the external diameter of envelope 1 is approximately ¾ of an inch. A flat button-type base 2 of similar material is fused to one end of said envelope for supporting various electrodes within said envelope, and a plurality of conductors 3 are sealed in said base 2 for supporting and conveying energy to said electrodes. The other end of said envelope is closed by the material of the envelope itself and by a tipped-off exhause tubulation 4. In the embodiment shown, the overall length of the device, from the lower end of leads 3 to the top of tubulation 4, is approximately 2⅜ inches.

Inside envelope 1 is a hollow metallic member or cathode 5, which is supported at its lower end by means of several of the leads 3 which are firmly attached to said cathode, and is maintained in position at its upper end by means of an insulating spacer 6, to which said cathode is secured by means of a pair of tabs 7 which are integral with said cathode and extend through holes in said spacer, these tabs being bent over on the top surface of said spacer to firmly engage the same. Cathode 5 is tubular and relatively large so that it substantially fills the interior of the envelope 1, and is closed at its upper and lower ends by upper and lower metallic disks 8 and 9, respectively, which are rigidly secured to the cathode inner surface at their outer edges, as by welding for example. Fixed within said cathode, near the central region thereof, is an annular metallic member 10 which supports, on its inner surface, hollow iron wire members 11 which contain therein an electron-emissive material (not shown). Means for readily releasing said electron-emissive material is provided by regularly spaced apertures 12.

A wire anode member 13 is fastened to one of the leads 3 at its lower end and passes upwardly, substantially vertically, through the interior of cathode 5 near the inner wall thereof, to a point a substantial distance above the upper cathode disk 8, as shown. To allow for this passage, a pair of coaxial circular apertures 14 and 15, respectively, are provided in the upper and lower cathode disks, upper aperture 14 having a slightly larger diameter than lower aperture 15. Anode 13 has a helical metal spring member 16 surrounding it, the ends of member 16 being fixed to said anode. Member 16 serves as a positioning means to maintain anode 13 centered in a vitreous sleeve 17, and also to permit expansion and contraction of member 13 without undue strain on said sleeve 17. The upper end of sleeve 17 terminates somewhat below the upper end of anode member 13, and the lower end of said sleeve is fastened to the base 2 by means of a suitable cement 18. However, the sleeve 17 can be fused to the base 2 directly. In order to assist in maintaining sleeve 17 in position, a horizontally-extending metal bracket 19 is tightly looped around said sleeve near the lower end thereof and is firmly attached to one of the leads 3.

A metallic sleeve 20, preferably made of the same material as cathode 5, coaxially surrounds sleeve 17 but is spaced therefrom, and if desired, a helical spring member (not shown) similar to spring 16 may be provided to center sleeve 20 with respect to sleeve 17, so that anode 13, sleeve 17, and sleeve 20 are all coaxial. The lower end of sleeve 20 preferably terminates in the same horizontal plane as the lower surface of cathode disk 9, the outer diameter of sleeve 20 being substantially the same as the diameter of aperture 15 and said sleeve being rigidly secured, as by welding, in said aperture and being thereby mechanically and electrically connected to the cathode.

The upper end of sleeve 20 passes freely through aperture 14, due to the increased diameter of said aperture as compared to that of aperture 15, and said upper end terminates slightly above the upper surface of cathode disk 8.

Positioned within, and extending through, cathode 5 is a third vertically-extending wire electrode 21, which will be referred to hereinafter as the starting electrode or control electrode. Electrode 21 is fastened to one of the leads 3 at its lower end and passes upwardly, substantially vertically, through the hollow interior of tubular cathode 5 near the inner wall thereof, but further from said wall than is anode member 13, to a point slightly above the upper cathode disk 8. As shown in Fig. 2, anode member 13 and grid member 21 are located diametrically opposite each other. To allow for the passage of electrode member 21 through cathode 5, a pair of coaxial circular apertures 22 and 23, respectively, are provided in the upper and lower cathode disks, upper aperture 22 having a substantially larger diameter than lower aperture 23, for a reason to be explained hereinafter. Affixed to and extending substantially horizontally at right angles to grid electrode 21 is a wire member 24, said member being a part of said grid electrode. Electrode 21 has a helical metal spring member 25 surrounding it, the ends of member 25 being fixed to said electrode. Member 25 serves as a positioning means to maintain grid 21 centered in a vitreous sleeve 26, and also to permit expansion and contraction of electrode 21 without undue strain on said sleeve 26. The upper end of sleeve 26 terminates in substantially the same horizontal plane with the upper surface of cathode disk 8, and the lower end of said sleeve is fastened to the base 2 by means of a suitable cement 27. However, the sleeve can be fused to the base directly. Horizontally-extending metal bracket 28 is tightly looped around sleeve 26 near the lower end thereof and is firmly attached to one of the leads 3, thus functioning to assist in maintaining sleeve 26 in position. A metallic sleeve 29, preferably made of the same material as cathode 5 and sleeve 20, coaxially surrounds sleeve 26 but is spaced therefrom and, if desired, a helical spring member (not shown) similar to spring 25 may be provided to center sleeve 29 with respect to sleeve 26, so that grid electrode 21, sleeve 26, and sleeve 29 are all coaxial. The lower end of sleeve 29 preferably terminates in the same horizontal plane as the lower surface of cathode disk 9, the outer diameter of said sleeve being substantially the same as the diameter of aperture 23 and said sleeve being rigidly secured, as by welding, in said aperture and being thereby mechanically and electrically connected to the cathode. The upper end of sleeve 29 passes freely through aperture 22, due to the large diameter of said aperture relative to that of aperture 23, and said upper end terminates in substantially the same horizontal plane as the upper end of sleeve 26 and the upper surface of cathode disk 8. In order to maintain the upper end of sleeve 29 centered in aperture 22, a metallic tab 30 has an inner vertical portion which is welded to the outer surface of said sleeve at its upper end, said tab being looped over the upper end of cathode 5 and having an outer vertical portion which is welded to the outer surface of said cathode as shown.

Spacer 6 is shaped as shown in Fig. 2, so that no portion of either of the apertures 14 or 22 will be covered thereby.

In manufacture, a relatively small amount of electron-emissive material is evolved from the wires 11 containing such material onto the inner wall or active surface of the cathode 5, the balance of the activating material being evolved during the operation of the device by bombardment from the positive ions present in the discharge. For a more detailed disclosure of this feature, reference is made to my copending application Ser. No. 647,463, filed February 14, 1946, now Patent No. 2,435,246, dated February 3, 1948.

The metallic sleeves 20 and 29 are provided in the present invention in order to increase the effective or active area of the cathode; such sleeves are a part of the cathode.

A feature of the present invention is the space relation of the grid or starting electrode 24 with respect to the cathode 5 and anode 13. The diameter of aperture 22 and the length of member 24 are made such that the starting electrode is spaced a distance from the effective area of the cathode, substantially equal to the minimum breakdown-potential distance of the device. The minimum breakdown-potential distance is defined herein as that distance at which a discharge will be initiated between two electrodes for a minimum applied potential. However, the anode 13 is spaced a distance from the effective area of the cathode substantially different from the minimum breakdown-potential distance between the starting electrode and the effective area of the cathode, the distance being such with respect to the cathode that the anode can handle large inverse voltages. The provision of the insulating sleeve 17 around anode 13 for almost its entire length insures that the anode 13 is spaced the proper distance from the effective area of the cathode.

The provision of insulating sleeve 26 around grid electrode 21 for almost its entire length insures both that the angular portion 24 of the grid electrode will be spaced the proper distance from the effective area of the cathode and that the initial glow discharge will take place in such a location that the discharge will be rapidly transferred to the anode 13, to thereby establish the main discharge.

In operation of the device, a potential on the order of 200 volts is placed on the anode 13, and a potential on the order of 85–105 volts on grid 21 in order to initiate the discharge. Under these conditions, a glow discharge begins to occur between the member 24 and sleeve 29, or between member 24 and cathode 5 proper. This discharge, present in the space between the sleeve 29 and cathode 5 or cathode disk 8, causes the main discharge between anode 13 and cathode 5 to be initiated, this discharge occurring between the interior of the cathode, where the emissive or active material is located, up through the aperture 22 outside of sleeve 29 or through the aperture 14 outside of sleeve 20, to the exposed upper end of anode 13. It has been found that, under the aforementioned operating voltages, the anode-cathode drop is on the order of 95 volts, while the grid-cathode drop is on the order of 78 volts. It has been found that, with a construction according to this invention, when the main discharge has begun, or when the cathode-grid glow discharge has transferred to the anode, a plate current on the order of 30 milliamperes may be readily handled by a tube having the small overall dimensions defined above.

If desired, the grid or starting electrode portion 24 may have affixed thereto a quantity of

electron-emissive material, as disclosed in my aforesaid copending application. In this case, on the negative cycle, if the device is being used on alternating current, the grid electrode behaves like a cathode and is consequently subjected to positive ion bombardment; this action evolves the active material onto the cathode surface, or may even cause the glow discharge to start on the grid and proceed to the cathode, from whence the main discharge may pick up.

It will be seen, from all of the above, that by the construction of the device of this invention, including the metallic sleeves surrounding the anode and grid electrodes to increase the effective cathode area, I have devised a controllable gas tube which is capable of carrying a rather high plate current and yet which is quite small in overall dimensions, and for which no cathode heating current is needed.

Of course, it is to be understood that this invention is not limited to the particular details as described above, as many equivalents will suggest themselves to those skilled in the art. It is accordingly desired that the appended claims be given a broad interpretation commensurate with the scope of this invention within the art.

What is claimed is:

1. A gaseous-discharge device, comprising an envelope containing an ionizable gas, a relatively large hollow metallic cathode substantially filling the interior of said envelope, a wire anode passing longitudinally through the interior of said cathode to a point a substantial distance beyond one end of the same, an insulating sleeve surrounding said anode substantially throughout its length, a metallic sleeve substantially coextensive with said cathode surrounding said insulating sleeve, said metallic sleeve being directly connected to said cathode, a wire starting electrode passing longitudinally through the interior of said cathode to a point adjacent said one end thereof, and an insulating sleeve surrounding said electrode substantially throughout its length.

2. A gaseous-discharge device, comprising an envelope containing an ionizable gas, a relatively large hollow metallic cathode substantially filling the interior of said envelope, a wire anode passing longitudinally through the interior of said cathode to a point a substantial distance beyond one end of the same, an insulating sleeve surrounding said anode substantially throughout its length, a wire starting electrode passing longitudinally through the interior of said cathode to a point adjacent said one end thereof, an insulating sleeve surrounding said electrode substantially throughout its length, and a metallic sleeve substantially coextensive with said cathode surrounding said last-named insulating sleeve, said metallic sleeve being connected to said cathode.

3. A gaseous-discharge device, comprising an envelope containing an ionizable gas, a relatively large hollow metallic cathode substantially filling the interior of said envelope, a wire anode passing longitudinally through the interior of said cathode to a point a substantial distance beyond one end of the same, an insulating sleeve surrounding said anode substantially throughout its length, a metallic sleeve substantially coextensive with said cathode surrounding said insulating sleeve, said metallic sleeve being connected to said cathode, a wire starting electrode passing longitudinally through the interior of said cathode to a point adjacent said one end thereof, an insulating sleeve surrounding said electrode substantially throughout its length, and a metallic

sleeve substantially coextensive with said cathode surrounding said last-named insulating sleeve, said last-named metallic sleeve being connected to said cathode.

4. A gaseous-discharge device, comprising an envelope containing an ionizable gas, a relatively large hollow metallic cathode substantially filling the interior of said envelope, a wire anode passing longitudinally through the interior of said cathode to a point a substantial distance beyond the upper end of the same, an insulating sleeve surrounding said anode substantially throughout its length but leaving the extreme upper end of said anode exposed, a wire starting electrode passing longitudinally through the interior of said cathode to a point adjacent the upper end thereof, an insulating sleeve surrounding said electrode substantially throughout its length but leaving the extreme upper end of said electrode exposed, a metallic sleeve substantially coextensive with said cathode surrounding said last-named insulating sleeve, said metallic sleeve being connected to said cathode, and a transverse conducting member attached to the upper end of said electrode and extending to a point spaced a distance from the effective area of said cathode substantially equal to the minimum breakdown-potential distance of said device.

5. A gaseous-discharge device, comprising an envelope containing an ionizable gas, a relatively large hollow metallic cathode substantially filling the interior of said envelope, a wire anode passing longitudinally through the interior of said cathode to a point a substantial distance beyond the upper end of the same, an insulating sleeve surrounding said anode substantially throughout its length but leaving the extreme upper end of said anode exposed, a metallic sleeve substantially coextensive with said cathode surrounding said insulating sleeve, said metallic sleeve being connected to said cathode, a wire starting electrode passing longitudinally through the interior of said cathode to a point adjacent the upper end thereof, an insulating sleeve surrounding said electrode substantially throughout its length but leaving the extreme upper end of said electrode exposed, a metallic sleeve substantially coextensive with said cathode surrounding said last-named insulating sleeve, said last-named metallic sleeve being connected to said cathode, and a transverse conducting member attached to the upper end of said electrode and extending to a point spaced a distance from the effective area of said cathode substantially equal to the minimum breakdown-potential distance of said device.

6. A gaseous-discharge device, comprising an envelope containing an ionizable gas, a relatively large tubular metallic cathode member substantially filling the interior of said envelope, a pair of metallic disk members secured to and closing the ends of said tubular member, a wire anode passing through said disk members and longitudinally through the interior of said cathode to a point a substantial distance beyond one end of the same, said disk members being provided with a pair of aligned apertures to allow for the passage therethrough of said anode, said apertures having a diameter substantially larger than the diameter of said anode, and a wire starting electrode passing through said disk members and longitudinally through the interior of said cathode to a point adjacent said one end thereof, said disk members being provided with a pair of aligned apertures to allow for the passage there-

through of said electrode, said last-named apertures having a diameter substantially larger than the diameter of said electrode.

7. A gaseous-discharge device, comprising an envelope containing an ionizable gas, a relatively large tubular metallic cathode member substantially filling the interior of said envelope, a pair of metallic disk members secured to and closing the ends of said tubular member, a wire anode passing through said disk members and longitudinally through the interior of said cathode to a point a substantial distance beyond one end of the same, an insulating sleeve surrounding said anode substantially throughout its length, said disk members being provided with a pair of aligned apertures to allow for the passage therethrough of said anode and said sleeve, said apertures having a diameter substantially larger than the diameter of said sleeve, a wire starting electrode passing through said disk members and longitudinally through the interior of said cathode to a point adjacent said one end thereof, and an insulating sleeve surrounding said electrode substantially throughout its length, said disk members being provided with a pair of aligned apertures to allow for the passage therethrough of said electrode and said last-named sleeve, said last-named apertures having a diameter substantially larger than the diameter of said last-named sleeve.

8. A gaseous-discharge device, comprising an envelope containing an ionizable gas, a relatively large tubular metallic cathode member substantially filling the interior of said envelope, a pair of metallic disk members secured to and closing the ends of said tubular member, a wire anode passing through said disk members and longitudinally through the interior of said cathode to a point a substantial distance beyond one end of the same, an insulating sleeve surrounding said anode substantially throughout its length, a metallic sleeve substantially coextensive with said cathode surrounding said insulating sleeve, said disk members being provided with a pair of aligned apertures to allow for the passage therethrough of said anode and said two sleeves, the aperture in the disk member opposite said one end being of substantially the same diameter as said metallic sleeve and said sleeve being secured therein, the aperture in the disk member at said one end having a somewhat larger diameter than that of said metallic sleeve, a wire starting electrode passing through said disk members and longitudinally through the interior of said cathode to a point adjacent said one end thereof, and an insulating sleeve surrounding said electrode substantially throughout its length, said disk members being provided with a pair of aligned apertures to allow for the passage therethrough of said electrode and said last-named sleeve, said last-named apertures having a diameter substantially larger than the diameter of said last-named sleeve.

9. A gaseous-discharge device, comprising an envelope containing an ionizable gas, a relatively large tubular metallic cathode member substantially filling the interior of said envelope, a pair of metallic disk members secured to and closing the ends of said tubular member, a wire anode passing through said disk members and longitudinally through the interior of said cathode to a point a substantial distance beyond one end of the same, an insulating sleeve surrounding said

anode substantially throughout its length, said disk members being provided with a pair of aligned apertures to allow for the passage therethrough of said anode and said sleeve, said apertures having a diameter substantially larger than the diameter of said sleeve, a wire starting electrode passing through said disk members and longitudinally through the interior of said cathode to a point adjacent said one end thereof, an insulating sleeve surrounding said electrode substantially throughout its length, and a metallic sleeve substantially coextensive with said cathode surrounding said last-named insulating sleeve, said disk members being provided with a pair of aligned apertures to allow for the passage therethrough of said electrode and said two last-named sleeves, the electrode aperture in the disk member opposite said one end being of substantially the same diameter as said metallic sleeve and said sleeve being secured therein, the electrode aperture in the disk member at said one end having a diameter substantially larger than that of said metallic sleeve.

10. A gaseous-discharge device, comprising an envelope containing an ionizable gas, a relatively large tubular metallic cathode member substantially filling the interior of said envelope, a pair of metallic disk members secured to and closing the ends of said tubular member, a wire anode passing through said disk members and longitudinally through the interior of said cathode to a point a substantial distance beyond one end of the same, an insulating sleeve surrounding said anode substantially throughout its length, a metallic sleeve substantially coextensive with said cathode surrounding said insulating sleeve, said disk members being provided with a pair of aligned apertures to allow for the passage therethrough of said anode and said two sleeves, the aperture in the disk member opposite said one end being of substantially the same diameter as said metallic sleeve and said sleeve being secured therein, the aperture in the disk member at said one end having a somewhat larger diameter than that of said metallic sleeve, a wire starting electrode passing through said disk members and longitudinally through the interior of said cathode to a point adjacent said one end thereof, an insulating sleeve surrounding said electrode substantially throughout its length, and a metallic sleeve substantially coextensive with said cathode surrounding said last-named insulating sleeve, said disk members being provided with a pair of aligned apertures to allow for the passage therethrough of said electrode and said two last-named sleeves, the electrode aperture in the disk member opposite said one end being of substantially the same diameter as said last-named metallic sleeve and said sleeve being secured therein, the electrode aperture in the disk member at said one end having a diameter substantially larger than that of said last-named metallic sleeve.

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