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GASEOUS DISCHARGE DEVICE

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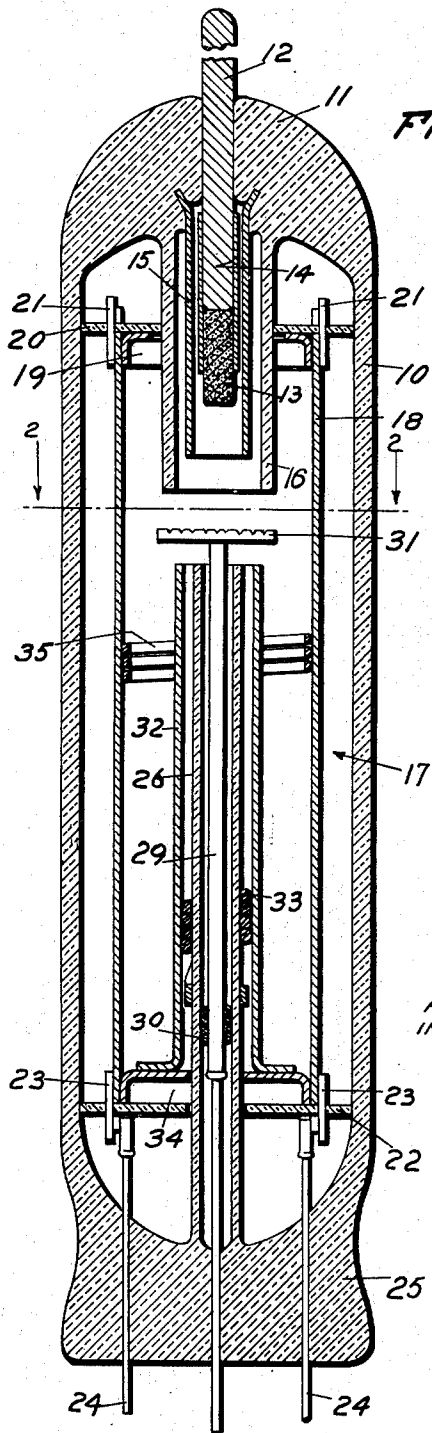


FIG. 1

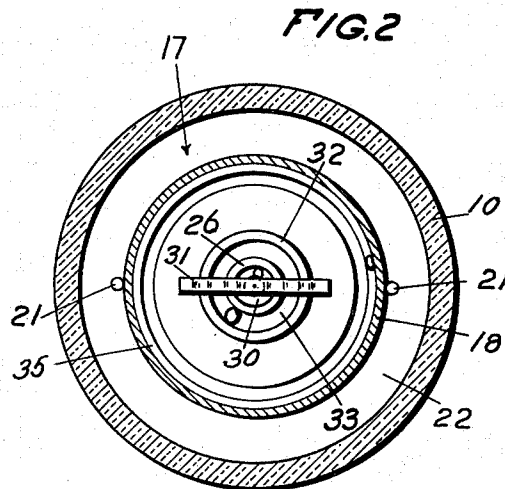


FIG. 2

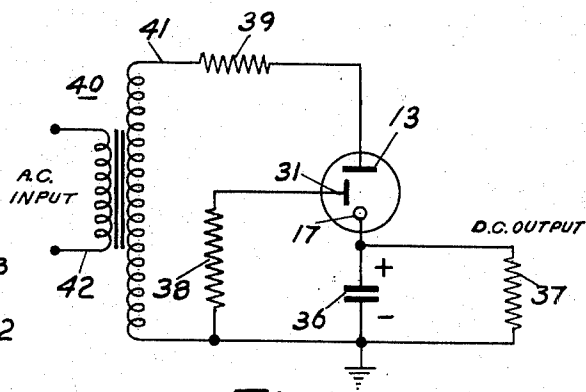


FIG. 3

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GASEOUS DISCHARGE DEVICE

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This application relates to gaseous discharge devices and more particularly to structures suitable for subminiature tubes of relatively large current capacity.

In the design of cold cathode tubes, the problem of producing sufficient cathode area in a small tube, for example, of the sub-miniature type, has materially limited the average and peak current capacities of these devices. In addition the use of large cathodes creates a serious problem of shielding the cathode from the anode to prevent inverse current discharges and loss of grid control for forward discharges.

Applicant has produced a device utilized, by way of example, in a rectifier which has a large cathode surface such that large peak and average currents may be drawn from this cathode. To do this applicant has made a hollow cathode substantially filling the entire envelope of the device and has positioned the anode inside this cathode. In addition the area of the cathode has been further increased by placing a second cylinder inside the first for a portion of the length thereof, both cylinders being coated with electron emissive material. This necessitates the positioning of the anode structure inside a hollow cathode and, to prevent inverse discharges between the anode and cathode for relatively high voltages, applicant provides for the anode to be shielded by electrostatic and dielectric shielding structures.

Since this anode shielding substantially reduces the potential gradient between the anode and cathode, applicant provides a novel means of starting the discharge between the anode and cathode during the application of positive potentials to the anode and negative potentials to the cathode. This starting means comprises an auxiliary electrode positioned between the anode and cathode, such that the dielectric and electrostatic shields surrounding the anode do not lie between the auxiliary electrode and the anode or the auxiliary electrode and the cathode. Applicant provides electron emissive material on the auxiliary electrode so that a relatively low potential gradient produced in the gap between the anode and the auxiliary electrode, or the cathode and auxiliary electrode, will produce a discharge, thereby supplying electrons and positive ions in the gaseous medium so that a relatively low potential gradient between the anode and cathode will transfer the discharge from the auxiliary electrode and anode or cathode to the cathode and the anode. One species of this device will now be described in detail, reference

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being had to the accompanying drawings wherein:

Fig. 1 is a longitudinal cross-sectional view of a device embodying applicant's invention taken along line 1-1 of Fig. 2;

Fig. 2 is a transverse cross-sectional view of the device shown in Fig. 1 taken along line 2-2 of Fig. 1; and

Fig. 3 is an illustrative example of a circuit wherein this device may be used.

Referring now to Fig. 1, there is shown an envelope 10 comprising a substantially tubular member which may be of, for example, glass. The upper end of the tubular envelope 10 is fused together as at 11 and has extending therethrough a metallic conducting member 12, said conducting member being substantially coaxial with the tubular envelope 10. Attached to the lower or inside end of the conducting member 12 is a carbon rod 13 whose diameter is substantially equal to that of conducting member 12, said diameter being, for example, approximately one-tenth the diameter of the tubular envelope 10. The carbon member is held to the conductor member 12 by a short metallic sleeve 14 extending over the lower end of conductor 12 and a portion of the carbon rod 13. The lower end of the rod 13 is positioned about one-fifth of the length of envelope 10 down from the glass seal 11.

Surrounding sleeve 14, carbon rod 13 and the lower end of conducting member 12 is an electrostatic shield comprising a metallic cylinder 15 slightly larger in diameter than sleeve 14. Cylinder 15 is rigidly positioned by having the upper end imbedded in glass seal 11. Cylinder 15 does not touch the anode assembly 12, 13 and 14 and extends downward from glass seal 11 beyond the lower end of carbon button 13 for a distance approximately equal to its own diameter.

Surrounding shield 15 is a dielectric member 16 comprising a glass tube whose upper end is fused to the glass seal 11 and which extends downwardly therefrom coaxial with carbon button 13, metallic rod 12 and shield 15 for a distance somewhat less than the diameter of shield 15 below the lower end of shield 15.

Surrounding the glass tube 16 is a cathode structure 17 comprising a cylinder 18 coaxial therewith and whose diameter is approximately twice the diameter of glass tube 16. The cylinder 18 extends from a point substantially above the lower end of carbon button 13 downwardly to a point adjacent the lower end of envelope 10. The upper end of cylinder 18 is substantially closed by an end plate 19 having an aperture

therein sufficient to allow the passage of the glass tube 16 therethrough. Above end plate 19 is positioned a mica spacer 20 in the form of a ring, the outer edge of which rests against the inside of envelope 10 and the inside hole of which surrounds and is in close proximity to the outside of the glass tube 16. The mica spacer 20 is attached to cylinder 18 by metallic tabs 21 welded to cylinder 18 and extending through apertures in the mica spacer 20. The lower end of cylinder 18 is maintained in position by resting against a mica spacer 22 substantially similar to spacer 20. Extending through spacer 22 are tabs 23 which are welded to cylinder 18 and to lead-in wires 24 which extend through a glass press 25 sealing the lower end of envelope 10.

Extending upwardly from glass press 25 through mica spacer 22 is a glass tube 26 which is coaxial with envelope 10 and the carbon button 13. The diameter of glass tube 26 is approximately equal to the diameter of the sleeve 14 and the upper end of tube 26 is positioned somewhat below the lower end of the tubular shield 16; for example, approximately the diameter of the tubular shield 16 separates the ends of the aforementioned tubes.

Extending upwardly through tube 26 and glass press 25 is a lead-in rod 27 which is positioned concentrically inside glass tube 26 by means of a spacer 29 comprising several turns of wire helically wrapped around member 29. Rod 29 extends slightly beyond the end of tube 26 and terminates in electrode 31 comprising electron emissive material. Electrode 31 is shown here, by way of example, as a short piece of straight wire welded to the end of rod 29 and at right angles thereto. The wire is hollow and contains electron emissive material such as barium carbonate which is exposed through the upper side of the wire through nicks cut therein. The length of the wire electrode 31 is slightly greater than the diameter of glass shield 16.

Surrounding glass tube 26 is a metallic cylinder 32 whose diameter is approximately twice the diameter of glass rod 26, the relative coaxial position of members 26 and 32 being maintained by a spacer 33 similar to spacer 20 but whose turns are somewhat larger in diameter. The lower end of cylinder 32 is attached as by welding to an end plate 34 which closes the lower end of cylinder 18.

Inside cylinder 18 at approximately the midpoint thereof, said midpoint being substantially below the upper end of cylinders 26 and 32, is positioned several turns of wire 35 of the same type used for electrode 31.

After the tube has been assembled but before the gaseous filling has been admitted, the wire turns 35 are heated in a vacuum, for example, by R. F. induction heating whereby the electron emissive core of wire 35 is evaporated. This electron emissive material then condenses on the inner surface of cylinder 18 and the outer surface of cylinder 32 as well as upper and lower end plates 19 and 34 such that these surfaces become an active part of the cathode, thereby producing a cold cathode having an extremely large emitting surface and hence a high peak and average current capacity.

Since the carbon button 13 is shielded by the metallic tube 15 and the dielectric tube 16 from direct exposure to any cathode surface, the potential gradient in the gaseous medium between the cathode and the anode button 13 is relatively low for high voltage differences therebetween. In

order to allow the tube to conduct readily for relatively low forward voltages between the anode and the cathode, auxiliary electrode 31 is positioned directly below the anode button 13. Since the shield members 15 and 16 are not positioned between anode button 13 and the electrode 31, a relatively low potential between these two electrodes will produce a sufficiently high potential gradient to ionize the space therebetween so that by an appropriate circuit the tube may be fired.

Referring now to Fig. 3, there is shown, by way of example, a circuit using the discharge device illustrated in Figs. 1 and 2. The cathode 17 is connected to ground through a condenser 36 of, for example, 4 microfarads across which is attached the output load 37 shown here, by way of example, as a resistor of 50,000 ohms. The auxiliary electrode 31 is connected to ground through a current-limiting resistor 38 of, for example, 10 megohms. The anode 13 is connected through a peak current-limiting resistor 39 of, for example, 2,500 ohms, to a source of alternating current which is to be rectified. This source, as shown here, is a transformer 40 whose secondary 41 is connected from ground to resistor 39 and whose primary 42 is connected to a source of alternating potential.

In this particular circuit, when the ungrounded end of transformer secondary 41 is driven positive, a discharge will occur between anode 13 and cathode 17 charging the condenser 36 such that the side thereof connected to cathode 17 will be positive with respect to ground. This potential will be partially dissipated through resistor 37 between cycles of the alternating current. The result is that the cathode 17 will be at all times more positive than the electrode 31 which is connected to ground through the resistor 38. This potential between cathode 17 and electrode 31 causes the electrons emanating from the electron emissive matter of electrode 31 to flow from electrode 31 to the cathode 18, thereby producing a keep-alive discharge. This keep-alive discharge creates a large quantity of free electrons in the vicinity of electrode 31, said electrons being readily drawn to the anode 13 upon the application of a relatively low positive voltage to anode 13. When anode 13 is driven negative during the negative portion of the alternating current cycle of the source, the potential of the cathode 18 is shielded from the anode 13 by members 15 and 16 such that a higher peak inverse voltage may be applied between anode 13 and cathode 18 without an inverse current breakdown. Since electrode 31 is at a considerably lower potential than cathode 17, for example, near ground potential, the peak inverse voltage between electrode 31 and the anode button 13 is considerably less than the peak inverse voltage between cathode 18 and anode 13 with the result that breakdown does not occur therebetween.

This completes the description of the particular modification of the invention illustrated herein. However, many modifications thereof will be apparent to persons skilled in the art without departing from the spirit and scope of this invention. For example, the tube may be operated by attaching the electrode 31 to the anode 13 or to the cathode 17, and various sizes and shapes of electrodes as well as different materials may be used without departing from the spirit and scope of this invention. Therefore, applicant does not wish to be limited to the particular details of the species of the invention described herein except as defined by the appended claims.

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What is claimed is:

1. An electron discharge device comprising an envelope containing a gaseous medium, an anode, an auxiliary electrode, and a cathode comprising a first hollow cylindrical member substantially surrounding said anode member and said auxiliary electrode, and a second hollow cylinder positioned inside said first cylinder substantially coaxial therewith and substantially surrounding a portion of said auxiliary electrode, the inside of said first cylinder and the outside of said second cylinder having electron-emissive material coated thereon.

2. An electron discharge device comprising an envelope containing a gaseous medium, an anode comprising a rod, a cathode, and an auxiliary electrode positioned adjacent said anode substantially coaxial therewith, said auxiliary electrode having a metallic support connected thereto, said support being surrounded by an insulating sleeve, the portion of said insulating sleeve adjacent said auxiliary electrode being surrounded by a metallic sleeve in close proximity thereto but insulated from said auxiliary electrode, said auxiliary electrode having an exposed area of electron-emissive material thereon.

3. An electron discharge device comprising an envelope containing a gaseous medium, an anode substantially surrounded by a metallic sleeve and an insulating sleeve, a cathode, and an auxiliary electrode, a supporting portion of said auxiliary electrode being substantially surrounded by an insulating sleeve coaxial therewith, said cathode comprising a first hollow member substantially surrounding said anode member and said sleeves, and a second hollow member having an electron-emissive coating thereon and positioned inside said first member spaced therefrom, said second member having therein said supporting portion of said auxiliary electrode.

4. An electron discharge device comprising an envelope containing a gaseous medium, an anode,

a cathode, and an auxiliary electrode, said cathode comprising a first hollow cylindrical member substantially surrounding said anode member, and a second hollow cylinder positioned inside said first cylinder and substantially coaxial therewith, said second cylinder having therein a support member for said auxiliary electrode, said support member being surrounded by an insulating sleeve and being substantially coaxial with said anode and cathode.

5. An electron discharge device comprising an envelope containing a gaseous medium, an anode, a cathode, and an auxiliary electrode positioned adjacent said anode, said auxiliary electrode having an exposed area of electron-emissive material thereon, said anode comprising a rod, and an insulating sleeve substantially surrounding said rod, said cathode comprising a first hollow cylindrical member substantially surrounding said anode member and said sleeve, and a second hollow cylindrical member positioned inside said first member and substantially coaxial therewith but spaced from said cathode, the inside of said first cylinder and the outside of said second cylinder having electron-emissive material thereon, said second cylinder having therein a support member for said auxiliary electrode, said support member being surrounded by an insulating sleeve and being substantially coaxial with said anode and cathode.

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References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
1,749,611	Schroter	Mar. 4, 1930
1,986,397	Hund	Jan. 1, 1935
2,033,089	Bahls	Mar. 3, 1936
2,206,008	Spencer	June 25, 1940
2,435,246	Stutsman	Feb. 3, 1948
2,462,142	Stutsman	Feb. 22, 1949