Sept. 15, 1953 L. R. LANDREY ET AL 2,652,510

GAS DISCHARGE DEVICE

Filed Oct. 3, 1951

Fig. 1

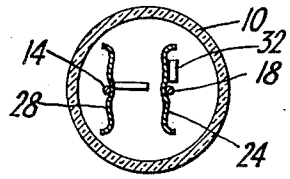


Fig. 3

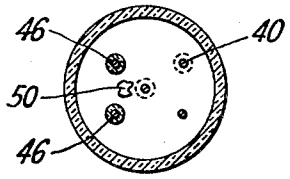


Fig. 2

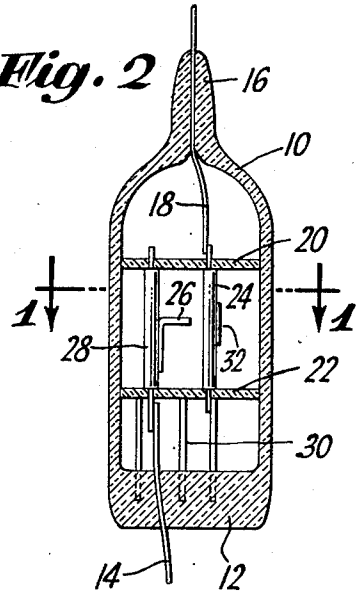
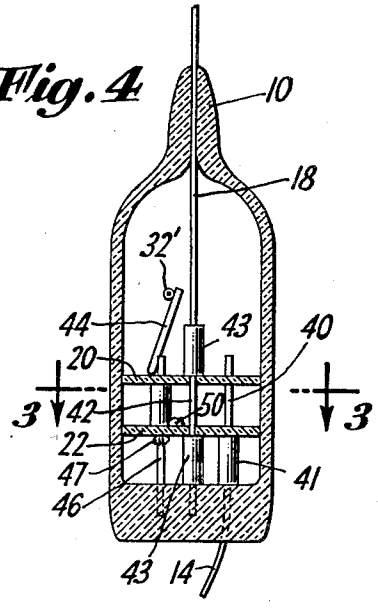


Fig. 4



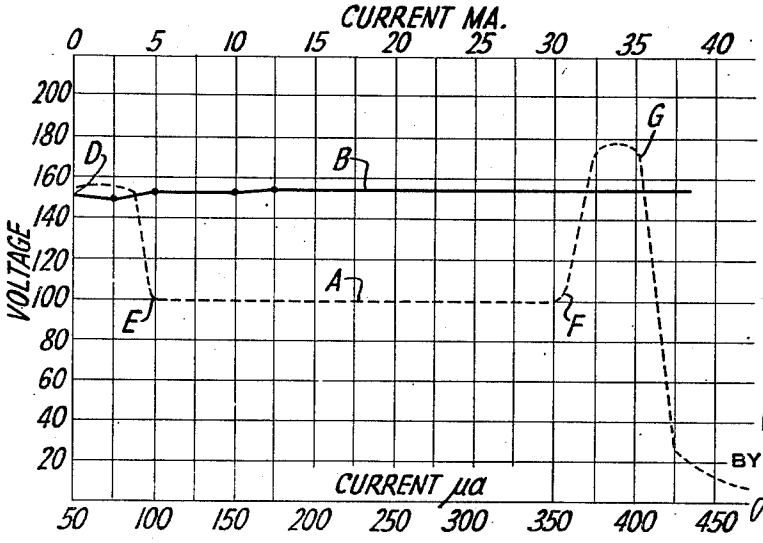


Fig. 5

INVENTOR
LEO R. LANDREY
ALFRED MAZZEI
BY J. Albert Hallquist
ATTORNEY

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GAS DISCHARGE DEVICE

Leo Raymond Landrey, Lynbrook, and Alfred Mazzei, Richmond Hill, N. Y., assignors, by mesne assignments, to the United States of America as represented by the United States Atomic Energy Commission

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10 Claims. (Cl. 313—54)

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The present invention relates to electron discharge tubes and more particularly to cold cathode gas-filled electron discharge devices, particularly adapted for voltage regulator operation.

An object of the present invention is the provision of a gas-filled voltage regulator tube adapted for stable operation at low current values.

Another object of the present invention is to improve the uniformity of operation of voltage regulator devices.

Still another object of the present invention is to increase the reliability, at low operating currents, operation of voltage regulator devices.

Still another object of the present invention is to facilitate the manufacture of cold cathode gas filled discharge devices.

The foregoing objects and others which may appear from the following detailed description are attained in accordance with an aspect of the present invention by providing a cold cathode gas-filled electron discharge device having a uniformly processed cathode surface, of an area no larger than that which will be wholly covered by the glow discharge at the maximum rated current so that the discharge is prevented from shifting about over the cathode surface to seek out the most active part of the cathode surface. The variations in activity of different cathode spots tended, in prior art tubes of which we are aware, to cause changes in cathode potential drop with each shift.

Other aspects of the present invention provide for means for adequately degassing and processing such a limited cathode surface by providing auxiliary heating means within the gas filled envelope in thermal conducting relationship with the cathode so that the cathode can be adequately heated.

A more complete understanding of the present invention will be had by reference to the following detailed description which is accompanied by a drawing in which:

Fig. 1 is a transverse sectional view of an embodiment of the present invention taken along line 1—1 of Figure 2, while;

Fig. 2 is a longitudinal section of the tube shown in Figure 1.

Fig. 3 is a view similar to Figure 1 but illustrating a modification of the present invention, while;

Fig. 4 is a longitudinal cross-section of the embodiment of Figure 3, and;

Fig. 5 is a chart of a group of curves diagrammatically illustrating some of the operating principles of the invention.

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The structures shown in Figures 1 and 2 includes a hermetically sealed vitreous envelope 10 closed at one end by a glass header 12 through which a number of lead-in conductors 14 pass and closed at the other end by a seal-off tip 16 through which a lead-in conductor 18 is sealed. The tube is provided with a pair of internal spacer discs or wafers 20 and 22 of insulating material such as mica. The spacer discs 20 and 22 support in proper relative position an anode 24 and a cathode 26. Anode 24 comprises a metal plate, preferably corrugated to increase its rigidity, welded to an extension of lead-in wire 18 which passes through appropriate apertures in spacer discs 20 and 22. Cathode 26 comprises a small L-shaped wire or rod welded or otherwise secured to a supporting plate 28. Plate 28 is corrugated similarly to anode plate 24 and is similarly held in position between spacer washers 20 and 22 by an extension of lead-in conductor 14 passing through appropriate apertures in discs 20 and 22 and welded or otherwise secured to the plate 28. Auxiliary mounting tabs at each end of plates 24 and 28 passing through spacers 20 and 22 may be provided if desired but are not here shown as being necessary to an understanding of the present invention. In order to maintain the proper spacing between header 12 and the lower insulating spacer 22, a number of dummy conductors 30 may be sealed into header 12 of such length and so disposed as to bear against the lower surface of spacer 22 and prevent it from tipping or shifting in position. The cathode rod is preferably constructed of pure nickel and the end facing anode 24 is ground and polished so that it is smooth and flat. Cathode supporting plate 28 is preferably constructed of metal having a higher work function than nickel, or if constructed of nickel or steel, may be carbonized or painted with a colloidal suspension of graphite in order to provide a surface with an effective high work function. Metals other than nickel which may be used for cathode supporting plate 28 and which may not require coating with colloidal graphite or carbonizing are platinum, gold, arsenic and osmium. Either a solid metal or a thin plating over a baser metal may be employed.

Anode 24 may be constructed of nickel. It is provided with a getter capsule 32 welded or otherwise secured to the rear-surface of anode 24 with respect to the cathode so directed that

as the getter is flashed the material vaporized from the getter is deposited on the glass wall of the tube away from the active discharge area of the tube.

The envelope **10** is filled with a helium-argon gas mixture at a low pressure. Due to the small effective area of cathode **26**, that represented by the polished end of the L-shaped wire, substantially all of the glow discharge taking place in the tube during operation takes place between the end of the cathode rod **26** and anode **24**. The cathode spot substantially entirely covers the end of the cathode rod at the rated maximum current of the tube and is effectively prevented from wandering about over the surface of the cathode rod or progressing to the cathode supporting plate, since for the cathode spot to move away from the end of rod **26** the ionization path must increase substantially. Furthermore if overload should cause the discharge to move to plate **28** it will not remain there except at grossly excessive values of current because of the effective high work function of the surface of plate **28**. This construction should be contrasted with previously known apparently similar structures which are designed to use a pointed rod only for starting and have the large cathode area activated by the use of metal having a low work function.

Tubes constructed according to the embodiment described above and utilizing a cathode rod 0.15 inch in diameter have maintained a rated voltage of 150 volts plus or minus 1½ volts over the major part of the microampere range for long periods of time without change.

Figs. 3 and 4 illustrating a modified form of the invention use the same reference character for the same parts. This embodiment obtains the restricted area of cathode over which the discharge may be supported by utilizing a straight cathode rod **40** supported between insulating spacers **20** and **22** spaced apart such distance as to provide a desired clear area of the cathode rod between the spacers. In this form of construction the anode is likewise a straight wire **42** passing through appropriate aligned apertures in the spacers **20** and **22**. In order to prevent a discharge from taking place between the anode and cathode outside of the space between the spacers, ceramic sleeves **41** and **43** are secured respectively over the cathode lead-in wire **14**, the anode lead-in wire **18** adjacent spacer disc **20** and over the portion of anode rod **42** which extends beneath spacer disc **22**. In this form of construction the getter **32'** is supported by a U-shaped loop of wire **44** secured to a dummy lead **46** molded into glass header **12** and passing through spacer discs **20** and **22**. Wire **46** is swaged into wing-like formations below spacer **22** as shown at **47** and above spacer **20** or short pieces of tubing welded in place at those locations in order to support the discs in their proper spaced relationship. The getter is preferably so arranged as to direct the getter flash toward the glass wall of envelope **10** and away from the mica **20** to prevent the possibility of any contamination of the spacer **20** reducing the insulation between the anode member and the cathode member.

In order to provide a constant source of ionization within the tube so that starting conditions are maintained uniform after long periods of inactivity an activation primer **50** may be inserted in the tube. A radio active material, such as cobalt **60** has been found satisfactory.

It will be noted that the structure shown in Figures 3 and 4 utilizes the principle of restricted area of the cathode for improved regulation in the same way as the embodiment shown in Figures 1 and 2. The form of construction used in Figures 3 and 4 is somewhat easier to fabricate than that shown in Figures 1 and 2, but due to the absence of the cathode heating plate **28** of the first modification, more care is required in processing the tube during the exhaust and filling of the envelope with the gas in order to obtain maximum life and stability.

The dotted line curve A in Fig. 5, illustrates a typical voltage-current characteristic of cold cathode gas-filled regulator tubes and is plotted with reference to the upper scales of milliamperes. It will be noted that no regulation is normally obtained between point D, the breakdown voltage of the tube, and point E, the first knee on the curve. The position of point E along the regulation curve is governed by the size of the cathode. The larger the cathode area the higher the minimum value of current at which regulation begins. The substantially horizontal line portion of curve A between point E and point F is the region of normal operation. Point F is reached when the entire cathode area is covered by glow. An abnormal glow with failure of regulation takes place beyond point F at about 30 milliamperes current and as the current is further increased the tube eventually breaks down into an arc-discharge at point G. In most normal gas-filled voltage regulator tubes of which we are aware, point E on the curve is reached at a current value of somewhere near 5 milliamperes and no reliable regulating action can be obtained at lesser values of current. However it is often necessary to provide regulated sources of voltage in situations where a current drain of 5 milliamperes would be grossly excessive.

The regulating characteristic of tubes constructed according to our invention is shown by the solid line curve B of Figure 5. By reference to the lower scale of currents in microamperes in Figure 5, it will be noted that only minor variations in the regulated voltage take place in the region from 50 to 150 microamperes and thereafter substantially no variations in voltage take place over a comparatively wide range of variation of current drain.

While we have shown and particularly described several modifications of our invention it should be clearly understood that our invention is not limited thereto but that modifications within the scope of the appended claims may be made.

What we claim is:

1. A gas discharge voltage regulator tube including within a hermetically sealed envelope containing an ionizable gas, an anode and a cathode, said cathode having an effective area no greater than that of the glow which the tube must support at maximum rated current.

2. A gas discharge device at set forth in claim 1, wherein the effective area of the cathode is restricted by covering areas of said cathode with a material which will not support cathode activity.

3. A gas discharge device as set forth in claim 1, wherein the effective area of the cathode is restricted by covering areas of said cathode with a ceramic insulating material.

4. A gas discharge device as set forth in claim 1, wherein the effective area of the cathode is restricted by covering areas of said cathode with material having a high work function.

5. A gas regulator tube as set forth in claim 1, wherein said cathode is constituted of a section of wire having a polished end surface directed toward said anode.

6. A gas regulator tube as set forth in claim 1, wherein said cathode is constituted of a section of wire having a polished end surface directed toward said anode and supported on a metallic plate so treated as to inhibit cathode activity.

7. A gas regulator tube as set forth in claim 1, wherein said cathode is constituted of an L-shaped section of wire supported on a plate spaced from said anode and having a polished end surface directed towards said anode.

8. A gas discharge voltage regulator tube including within a hermetically sealed envelope containing an ionizable gas, a rod-like anode and a rod-like cathode each passing through a pair of spaced insulating discs so spaced that said cathode has an effective area no greater than that of

the glow which the tube must support with maximum rated current.

9. A gas discharge device as set forth in claim 8, wherein the portions of said anode and cathode outwardly of said spacers are treated to inhibit a gas discharge therebetween.

10. A gas discharge device as set forth in claim 8, a radio active material is attached to one of said discs to facilitate initiation of gas discharge between said cathode and anode.

LEO RAYMOND LANDREY.
ALFRED MAZZEI.

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