

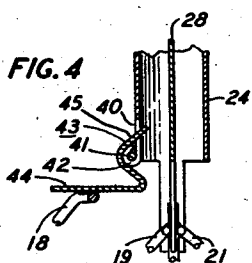
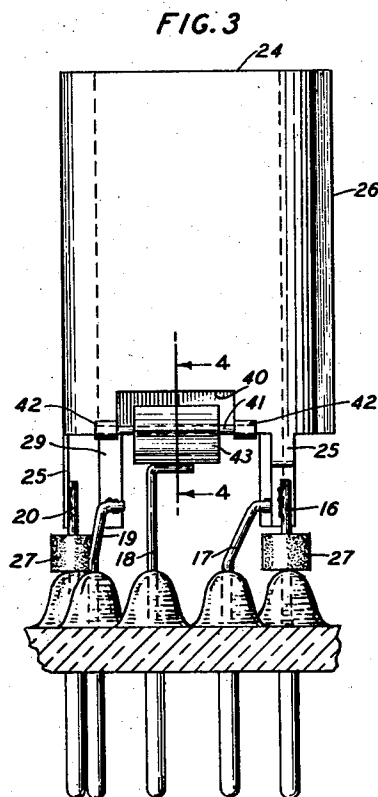
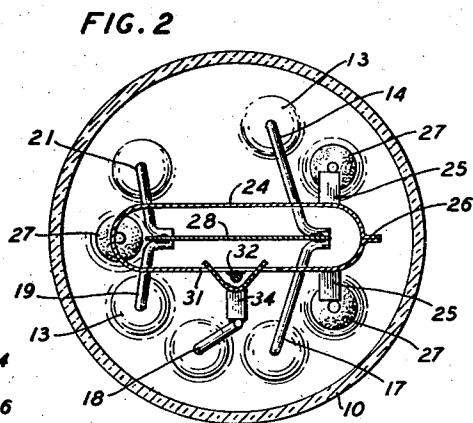
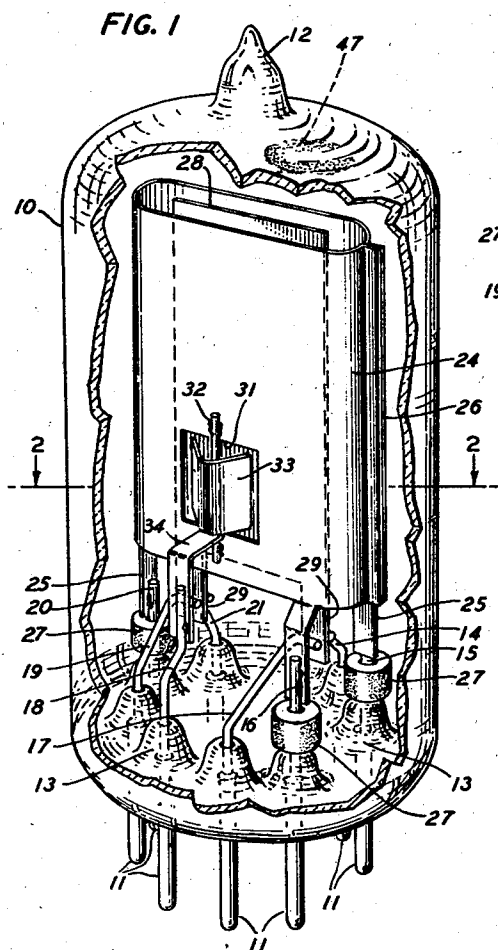
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GLOW DISCHARGE VOLTAGE CONTROL DEVICE

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GLOW DISCHARGE VOLTAGE CONTROL
DEVICE

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14 Claims. (Cl. 313-217)

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This invention relates to gaseous discharge devices and, more particularly, to such devices employing starter electrodes.

In such devices, for example those used as voltage regulator tubes, a maximum value of starter breakdown voltage that may be impressed between the starter anode and cathode is imposed by the circuit conditions to be met and also by the gas pressure of the tube. The gas pressure is further controlled by considerations of the cathode area, as lower pressures, while decreasing the starter breakdown voltage, would require an increased cathode area. The starter voltage should also not be subject to variations either caused by deviations in the manufacture of the tube or by drift of the voltage during the life of the tube.

In addition to a low starter breakdown voltage, it is also desirable that the transfer current be a minimum. The transfer current is the minimum current that can flow in the starter circuit to cause transfer of the glow to the main anode at a given main anode potential. Generally, these two effects of low starter voltage and low transfer current have been incompatible.

One object of this invention is to improve the performance of gaseous discharge devices.

A further object of this invention is to improve the starter gap characteristics of such devices.

Another object of this invention is to realize a low breakdown voltage between the starter anode and starter cathode.

A still further object of this invention is to reduce the variations in the starter voltage due either to manufacture or the operation of the device.

A still further object of this invention is to attain a low transfer current.

These objects are accomplished in accordance with one feature of the present invention by providing a starter anode which produces a concentrated field on the starter cathode. Specifically, it is a feature of this invention that a starter anode partially encompass a thin or small starter cathode.

In accordance with another feature of this invention, the concentrated field is produced over a wide area of varying distances between the two starter electrodes, whereby breakdown may occur in the concentrated field at the optimum distance for the gas or pressure employed. Specifically, it is a feature of this invention that the starter cathode and auxiliary anode have non-parallel surfaces.

In accordance with a further feature of this

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invention, the starter cathode is directly in the main anode field.

In one specific embodiment of this invention, a gaseous discharge device comprises a flattened cylindrical cathode surrounding a central plate anode, the cathode having a rectangular cut-out portion in one surface parallel to the anode, a vertical wire auxiliary cathode across the opening, and a separate substantially V-shaped auxiliary anode partially surrounding the wire auxiliary cathode. The auxiliary anode is positioned mainly external to the cylindrical main cathode to allow the main anode to have an unobstructed view of the auxiliary cathode.

In another specific embodiment of the invention, the main cathode has a cut-out portion on one lower edge, an auxiliary wire cathode is positioned across the edge and perpendicular to the axis of the cylindrical cathode, and a bent anode of Z-shape cross-section is mounted adjacent to the wire cathode external to the cylindrical main cathode.

A complete understanding of the invention and the various desirable features thereof may be gained from consideration of the following detailed description and the accompanying drawings in which:

Fig. 1 is a perspective view of a gaseous discharge device illustrating one embodiment of this invention, a portion of the glass envelope having been broken away to show the internal elements of the device;

Fig. 2 is a plan view of the device shown in Fig. 1, taken along the line 2-2;

Fig. 3 is an elevational view of the electrode mount of another embodiment of this invention; and

Fig. 4 is a detail sectional view along line 4-4 of Fig. 3, showing the auxiliary anode and cathode.

Referring now to the drawing, the glow discharge device illustrated in Fig. 1 comprises an enclosing vessel 10 with base pins 11 sealed in the base and an exhaust tubulation 12 at its top. The pins 11 are connected in seals 13 to conductors 14, 15, 16, 17, 18, 19, 20, and 21. A flattened cylindrical cathode 24 is connected to conductors 15, 16, and 20 through tabs 25 extending from the bottom of the cathode. The cathode may advantageously be formed of molybdenum and in one piece, the end seam 26 being closed as by arc welding. However, a two-piece cathode may be employed using welded or staked seams. Insulators 27, as of alumina, are placed around the conductors 15, 16, and 20 just beneath the tabs

25 to prevent arcing at the seals during the high current aging treatment of the device.

A plane anode 28 is placed at the median plane of the flattened cylindrical cathode 24. Tabs 29 formed integral with the anode are connected to the leads 14, 17, 19, and 21 to support the anode. One conductor is connected to each side of the tabs 29 to overcome bimetallic action during processing or use between the lead-in wires, which may advantageously be of nickel, and the anode tabs, which may advantageously be of molybdenum, as is taught in the application of M. A. Townsend, Serial No. 104,264, filed July 12, 1949.

The cathode 24 has on one side near the base a rectangular cut-out portion 31, across which a wire auxiliary cathode 32 is placed, as by welding its ends to the outer surface of the cathode 24. A platinum foil flux may advantageously be employed for the welding. A substantially V-shaped auxiliary anode 33 partially surrounds the wire cathode 32 in the portion 31, the cathode 32 being spaced adjacent the bottom of the V. The anode 33 is mounted outside the cathode 24 by a tab 34 integral therewith which is connected to the conductor 18.

Referring now to Fig. 3, another embodiment of this invention is disclosed wherein the cathode 24 has a cut-out portion 40 on one lower edge. A wire auxiliary cathode 41 is placed across the edge and is secured to the main cathode 24 as by extensions 42 crimped around the ends of the wire cathode. A Z-shaped auxiliary anode 43 having a flat portion 44 and a substantially V-shaped portion 45 partially surrounds the wire cathode 41, as best seen in Fig. 4. The cathode 41 is advantageously spaced adjacent the bottom of the V-shaped portion 45.

A spot of radium bromide 47 is placed on the inner wall of the envelope 10. There also may advantageously be formed on the interior of the glass wall a coating of electrode metal deposited there during the aging process, as taught by the above-mentioned application to M. A. Townsend, to attain maximum stability in operation, the metal performing a gettering action and imprisoning contaminants in the glass that might otherwise evolve during operation and deleteriously effect the operation of the device.

The starter gap is formed by the wire auxiliary cathode 32 or 41 and the substantially V-shaped portion of the auxiliary anode 33 or 45. Because the radius of curvature of the open V of the starter anode is larger than the radius of the wire cathode, a concentrated field is produced on the small wire cathode, which is located within the V near the apex. This concentrated field allows a reduction in the starter voltage required to break down the starter gap. In accordance with a feature of this invention, the encompassing electrode may vary in form from a sharp pointed V to an even flat curve. The concentrated field will be provided by the encompassing of the small cathode and by the focussing effect of the larger radius. Further, in accordance with a feature of this invention, the distance from the surface of the encompassing electrode to that of the wire cathode will vary provided that the centers of the radii of the two surfaces are different. While these conditions are most advantageously met by a wire cathode and a substantially V-shaped anode, it is apparent that modifications can be devised within the scope of the invention.

As the auxiliary starter anode, which encompasses the auxiliary wire cathode, is positioned to one side of the auxiliary cathode opposite the

main anode, there is an unobstructed main anode field on the starter gap and the starter cathode which allows a low transfer current. Thus, by means of this starter gap geometry, the two desiderata of low breakdown voltage and low transfer current are obtained in an efficient and facile manner. Further, as is apparent from the drawings, the starter gap and other elements are expeditiously and easily fabricated and assembled in the completed device.

The breakdown of the starter gap will occur within the wide area of the concentrated field at the optimum distance between the two electrodes. This optimum distance is the minimum distance for an electron to travel in the field between the two electrodes to provide sufficient ionizing collisions to cause breakdown. At a shorter distance, insufficient collisions will occur, so that the optimum distance generally is not from the apex of the V to the wire cathode. The distance is thus dependent on collisions and, therefore, on the mean free path of the gas employed. By the geometry of the starter gap in accordance with my invention, the concentrated field extends over about two-thirds of the circumference of the starter cathode, whereby path lengths between the two electrodes at the outer edges of the concentrated field may be three times as long as at the apex. A wide range of distances are therefore provided from which the gap can choose its optimum.

After breakdown, the cathode fall surrounds the wire cathode completely. Current which is initially drawn from the surface portions of the auxiliary cathode having the lower work functions because of imperceptible surface variations is drawn from the whole surface of the electrode through the starter circuit. Sufficient ions are produced by this starter current in the glow area to provide transfer to the main anode.

At the instant of transfer, the starter circuit current has attained the transfer current value. Because the glow area around the starter cathode is directly in the main anode field, as explained above, a low value of starter current is also obtained. After the transfer to the main anode, the main circuit demands for the current to be supplied rapidly cause saturation of the starter cathode, causing the glow to spread along the length of the auxiliary cathode to the main cathode.

In one specific illustrative embodiment constructed in accordance with this invention, the cathode 24 is formed from .010 inch sheet molybdenum, although tantalum, columbium, or other similar refractory metals may be used, and is a flattened tube $\frac{1}{8}$ by $\frac{1}{2}$ inch in cross-section and $\frac{3}{4}$ inch high. The cathode is prepared and cleansed by an acid etching process followed by a heat treatment in wet hydrogen at 1400° C. for thirty minutes, though it may be cleansed by other processes known to those skilled in the art. The outside surface is then calorized, as with a coating of aluminum powder, or other material known in the art, to inhibit glow from that part of the cathode. The starter cathode 32 or 41 is a length of .020 molybdenum wire, though other refractory metals may be employed, bridged across the cut-out portion 31 or 40 of the main cathode, the wire being approximately $\frac{3}{8}$ inch long.

The main anode is a plane sheet of .010 inch molybdenum, though other materials as mentioned above may be advantageously employed, and may advantageously be spaced approximate-

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ly .057 inch from the cathode inner surface. The V-shaped anode 33, as shown in Fig. 1, may be $\frac{1}{8}$ inch high and have an angle of about seventy degrees. The V-shaped portion 45, as shown in Fig. 4, may similarly be approximately $\frac{1}{8}$ inch long and have an angle of approximately seventy degrees. Both anodes are also cleansed prior to incorporation in the device by the method above mentioned or other known in the art.

The wire auxiliary cathode is spaced .010 inch from the bottom of the V. This geometry further improves the manufacture of these devices as the breakdown of the starter gap is not critical with spacing over a range of $\pm .005$ inch.

With the cathode dimensions noted above, argon in the pressure range of 20 to 30 millimeters of mercury will give the proper order of sustaining voltage, though other gaseous fillings at other pressures may be employed, as will be appreciated by those skilled in the art.

The two embodiments, as shown in Figs. 1 and 3, have essentially the same electrical characteristics and advantages due to the particular starter gap geometry and configuration in combination with the other elements of the device. One specific illustrative embodiment constructed in accordance with these illustrative dimensions had an operating current range of 5 to 40 milliamperes, a sustaining voltage at 20 milliamperes of approximately 100 volts, a starter breakdown voltage of 125 volts, and a transfer current of 25 microamperes at a main anode voltage of 110 volts, with a gas filling of argon at 23 ± 1 millimeter of mercury.

It is to be understood that the above-described arrangements are illustrative of the application of the principles of the invention. Numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention. It is also to be understood that the term "V-shaped" anode or electrode as used herein is meant to define the form of the anode adjacent the cooperating electrode and not to preclude a different general form; it thus includes the substantially V-shaped portions of electrodes that may be generally Z-shaped or otherwise formed.

What is claimed is:

1. A gaseous discharge device comprising an anode, a cathode adjacent said anode and having a cut-out portion in one surface, an auxiliary cathode opposite said portion, and an auxiliary electrode partially encompassing said auxiliary cathode.

2. A glow discharge device comprising an anode, a cathode adjacent said anode and having a cut-out portion therein, a wire extending across said portion, and a substantially V-shaped auxiliary electrode positioned in said portion, said wire being adjacent the bottom of said V.

3. A glow discharge device comprising a main cathode having a cut-out portion therein, an auxiliary cathode extending across said portion, an anode adjacent said main cathode to one side thereof, and an auxiliary anode partially encompassing said auxiliary cathode and positioned to the other side of said main cathode.

4. A glow discharge device comprising an anode, a hollow cathode surrounding said anode and having a cut-out portion in one surface, a wire extending across said portion, and an auxiliary anode partially encompassing said wire.

5. A glow discharge device comprising a central flat anode plate, a hollow cathode surrounding said anode and having a cut-out portion in one

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surface, an auxiliary cathode extending across said portion, and a substantially V-shaped auxiliary anode, said auxiliary cathode being positioned adjacent the bottom of said V-shaped anode.

6. A glow discharge device comprising an anode, a hollow cathode surrounding said anode and having a cut-out portion in one surface, an auxiliary cathode extending across said portion, and a substantially V-shaped auxiliary anode positioned in said portion, said auxiliary cathode being adjacent the bottom of said V and between said auxiliary anode and said anode.

7. A gaseous discharge device comprising a central flat plate anode, a hollow cathode encompassing said anode and having a cut-out portion in one surface thereof, a wire positioned parallel to the axis of said hollow cathode across said portion, said wire being secured to said surface of said cathode, and a V-shaped auxiliary anode positioned mainly external to said cathode but extending into said portion, said wire being adjacent the bottom of said V.

8. A gaseous discharge device comprising a central flat plate anode, a hollow cathode encompassing said anode and having a cut-out portion in one surface thereof, a wire positioned across said portion perpendicular to the axis of said cathode, said wire being secured to said surface of said cathode, and a Z-shaped auxiliary anode having a flat portion and a V-shaped portion, said flat portion being positioned external to said cathode and said V portion extending into said cut-out portion, said wire being adjacent the bottom of said V.

9. A gaseous discharge device comprising a central flat plate anode, a hollow cathode encompassing said anode and having a cut-out portion in one surface thereof, a wire positioned across said portion and secured to said cathode, and a substantially V-shaped electrode extending into said portion and partially encompassing said wire, said wire being between said electrode and said anode.

10. A glow discharge device comprising a planar anode, a cathode adjacent said anode and having a plane surface, an auxiliary cathode attached to said surface, and an auxiliary anode partially encompassing said auxiliary cathode to produce a concentrated field over a major portion of said auxiliary cathode surface.

11. A glow discharge device comprising a cathode having a plane surface, an auxiliary cathode attached to said surface, an anode adjacent said cathode and said auxiliary cathode on one side thereof, and an auxiliary anode on another side of said auxiliary cathode and partially encompassing said auxiliary cathode to produce a concentrated field over a major portion of said auxiliary cathode surface.

12. A glow discharge device in accordance with claim 11 wherein the surface of said auxiliary cathode has a smaller radius of curvature and a different center than said encompassing auxiliary anode.

13. A gaseous discharge device comprising an anode, a cathode adjacent said anode and having a cut-out portion in one surface, an auxiliary cathode opposite said portion, and an auxiliary electrode partially encompassing said auxiliary cathode, the distance between said auxiliary cathode and said auxiliary electrode increasing gradually in two directions from a minimum distance.

14. A glow discharge device comprising a main

cathode having a cut-out portion therein, an auxiliary cathode extending across said portion, an anode adjacent said main cathode to one side thereof, and an auxiliary anode partially encompassing said auxiliary cathode and positioned to the other side of said main cathode, the surfaces of said auxiliary cathode and said partially encompassing auxiliary anode adjacent each other having different radii and centers of curvature.

VIVIAN L. HOLDAWAY.

REFERENCES CITED

The following references are of record in the file of this patent:

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Number	Name	Date
2,094,450	Geffcken et al.	Sept. 28, 1937
2,331,398	Ingram	Oct. 12, 1943