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ELECTRODE STRUCTURE FOR GLOW DISCHARGE TUBES

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FIG. 1

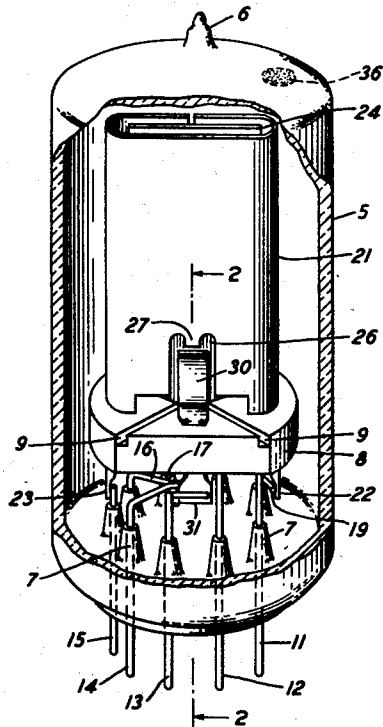


FIG. 2

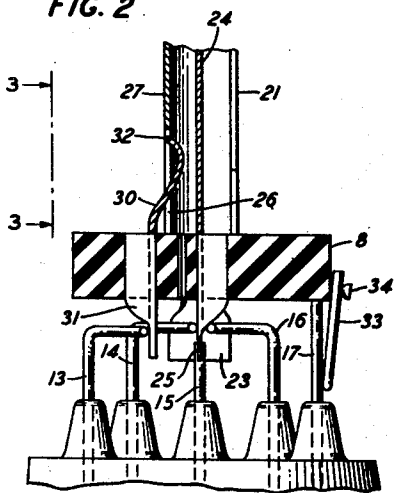
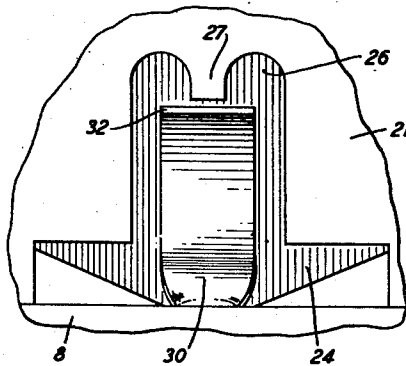


FIG. 3



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ELECTRODE STRUCTURE FOR GLOW
DISCHARGE TUBES

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7 Claims. (Cl. 313-198)

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

In such devices, for example, those used as voltage regulator tubes, there may be a maximum value of starter breakdown voltage that may be required between a starter anode and the cathode because of the circuit conditions to be met. For other reasons, it is further desirable to keep this voltage a minimum. At the same time it is also desirable that the transfer current be kept at a minimum. The transfer current is the minimum current that can flow in the starter circuit to cause a transfer of the glow to the main anode at a given main anode potential.

The normal sequence of operation in devices of this type is the initiation of glow in the gap between the starter anode and the cathode and then an increase of current flow through a series resistor to the gap until the transfer current is reached at which moment the conduction is transferred to the gap between the cathode and the main anode. This transfer current of the device is dependent, among other factors, on the extent to which the operating portion of the starter gap is blocked off or shielded from the view of the main anode. Where the starter gap glow is hidden from the anode by either the starter anode or cathode, a much higher current is carried in the glow without causing transfer, i. e., a higher transfer current is required. This is because it is necessary for a certain amount of glow to be exposed to a certain value of the anode-cathode field for the ionization to occur between the main anode and cathode.

The attainment of these desiderata of low breakdown voltage and low transfer current is complicated by the practical considerations of the importance of the spacings between the electrodes in these devices. Thus, not only are all the dimensions of the electrodes small but the spacings between the electrodes are both small and exact. It is, therefore, desirable to provide a structure in which measurement of the critical spacings may be made easily during the assembly and adjustments also expeditiously made as necessary.

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.

A still further object of this invention is to enable easy determination and correction of the critical spacings during assembly.

These and other objects are accomplished in

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accordance with features of this invention by an auxiliary or starter anode of substantially an S shape with one portion adjacent the main anode, between it and the cathode, the top of the starter anode being flat and adjacent a depending projection from the main cathode. Specifically, it is a feature of this invention that the starter anode project into the main gap and then that the starter anode return back towards the main cathode and be adjacent a starter cathode element integral with the main cathode.

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 cut-out portion in one surface parallel to the anode and a projection depending from the cathode into the portion, and a starter anode having a portion extending into the main gap adjacent the main cathode and then turning back towards the main cathode and having a flat end portion adjacent the flat end of the cathode projection.

A more complete understanding of the invention and the features thereof may be gained from consideration of the following detailed description and the accompanying drawing 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 being broken away to show the internal elements of the device;

Fig. 2 is a partial sectional view along the line 2-2 of Fig. 1, showing the auxiliary anode and support assemblies; and

Fig. 3 is a detailed view along the line 3-3 of Fig. 2, showing the cathode cut-out portion and starter gap.

Referring now to the drawing the glow discharge device illustrated in Fig. 1 comprises an enclosing vessel 5 with an exhaust tubulation 6 at one end. Lead-in conductors 11, 12, 13, 14, 15, 16, 17 and 19 are connected through seals 7 in the base of the vessel 5. A ceramic spacer 8 rests on the leads 11, 12 and 17, the spacer having slots 9 in the upper surface to reduce electrical leakage between the electrodes. A flattened cylindrical cathode 21 has curved base tabs 22 and 23 extending through the spacer 8 and held thereby. The tab 23 is attached to conductor 15 and tab 22 to conductor 19 the end of which is bent over to the tab. A plane anode 24 is placed at the median plane of the flattened cylindrical cathode 21. Its lower end advantageously is tapered, ending in a curved base

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tab 25 which extends through the spacer 8 and is held thereby. The conductors 14 and 16 are bent over and secured to opposite sides of the tab 25.

The cathode 21 has a substantially M-shaped cut-out portion 26 at the base of one side, preferably the integral side, the other side having an end seam closed as by welding or brazing or being left open as shown in Fig. 1. An extended projection or leg 27 integral with the cathode 21 and defining a starter cathode element depends into the cut-out portion 26, the end of the leg 27 being flat. A substantially S-shaped or angular cross-sectioned starter anode 30 also projects into the cut-out portion 26, the starter anode 30 having a curved tab 31 extending through the spacer 8 and secured thereby. Lead-in conductor 13 is bent over and attached to the tab 31. The end 32 of the starter anode is flat and directly adjacent the flat end of the depending leg 27.

As best seen in Figs. 2 and 3 the starter anode 30 is supported by the curved tab 31 exterior to the flat cylindrical cathode 21. However, the innermost portion of the S extends within the cathode adjacent the main anode 24 and the upper end 32 is substantially perpendicular to the plane of the cathode surface.

A spot of radium bromide 36, such as one microgram, is placed on the inner wall of the envelope 5. There may also be advantageously formed on the interior of the glass wall a coating of electrode metal deposited there during the aging process, as disclosed in the application of M. A. Townsend, Serial No. 104,264, filed July 12, 1949, to attain maximum stability in operation, the metal performing a gettering action and imprisoning contaminants in the envelope that might otherwise evolve during the operation of the device and have deleterious effects thereon. A getter 34 is secured across a U-shaped lead 33 which is attached to conductor 17. The vessel is filled with a gas, such as argon, though other gases may be employed as is known by those skilled in the art.

One advantage of devices constructed in accordance with this invention is in the simplicity of construction and efficiency of attaining the accurate spacings required with nevertheless a very rigid and stable structure. In assembling the device, the cathode 21, anode 24, and curved starter anode 30 are each mounted on the spacer block by the curved tabs 22, 23, 25 and 31 extending through and tightly fitting into the appropriate apertures in the spacer block. The extensions of the curved tabs below the block are then flattened, as easily seen in Fig. 2, to securely lock the electrodes in position. The spacing between the upper end 32 of the starter anode 30 and the edge of the depending leg 27 is then easily measured by an optical comparator, which magnifies the distance and compares it to calibrated distances, a feeling gauge, or other measuring device. Corrections can easily be made by a tool applying pressure to the upper end 32 of the starter anode 30. Because of the curved shape of the starter anode, these corrections do not effect movement of the end 32 out of the plane of the cathode adjacent the depending leg 27. The end 32 is only moved to or from the extension 27 in that plane, the slack being taken up or supplied by the upper curved portion of the starter anode 27 adjacent the main anode, as the spacing between the main anode and the starter anode is not critical. Various tools which alter the bend of this upper curved portion while shifting the position of upper end 32 in the same plane can be employed.

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It is apparent that in accordance with the features of this invention the measurements and corrections of this critical spacing can be easily made and observed by the person assembling the device. Thus, it is a feature of this invention that the assembler can directly visually observe the starter gap while he is measuring it and correcting the spacing, thereby having a better control over the accuracy of the final spacing. The invention enables production of devices meeting a tolerance requirement that the spacing of the elements defining the starter gap be kept within variances of $\pm .002$ inch.

After this exact assembling, the tabs of the electrodes are secured, as by welding, to their respective lead-in conductors. The base is then sealed to the enclosing vessel, evacuated, and aged as disclosed in the above-mentioned Townsend application. As the electrodes are firmly locked in position by the spacer block 8, there is no tendency for the position of the electrodes above the spacer block to be altered by bimetallic action of the electrode tabs and lead-in conductors due to differences in thermal expansions of the two materials employed. Thus, any bending because of the high temperatures employed during the welding, exhausting, or aging processes takes place entirely beneath the spacer block and has no effect on the spacings above the block.

The upper end 32 of the starter anode is substantially perpendicular to the plane of the cathode so that a relatively large starter anode area is adjacent the edge of the depending leg of the cathode. This not only facilitates the accurate spacing, as discussed above, but also aids in obtaining the desired low breakdown voltage. Further, by the particular shape of the starter anode 30, the starter anode can be securely and accurately supported together with the other electrodes from the same platform while still attaining the advantageous angle of the starter adjacent the cathode and still allowing the main anode an unobstructed view of the complete starter gap.

In one specific illustrative embodiment constructed in accordance with this invention, the electrodes 21, 24 and 30 are each formed from .010 inch sheet molybdenum, although other refractory metals such as tantalum or columbium may be used, and are prepared and cleansed by an acid etching process followed by a heat treatment in wet hydrogen at 1200° C. for fifteen minutes, though they may be cleansed by other processes known to those skilled in the art. No electron emitting coating need be applied to the inner surface of the cathode 21 as molybdenum is sufficiently active itself to supply the electron emission required for the device. However, if desired, a coating of electron emissive material, such as barium and strontium oxides, could be applied to the inner surface of the cathode. The exterior surface of the cathode is calorized to prevent spread of the glow to this surface, as with a coating of aluminum powder or other material known in the art.

In this illustrative embodiment, the cathode 21 is .518 inch along its major internal axis and .125 inch across its minor. It is also .812 inch from its top surface of the spacer 8 to the upper end. The anode is three-eighths of an inch wide and spaced $.057 \pm .010$ inch from the main sides of the cathode. The top end 32 of the starter anode 30 is $.008 \pm .002$ inch from the end of the depending leg 27. The leg is .030 inch wide and the starter anode .094 inch wide. The leg de-

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pend .050 inch into the cut-out portion 26. The distance between the starter anode and main anode where the starter anode curves closest to the main anode is $.021 \pm .006$ inch.

The spacer block 8 is of F-66 steatite and the lead-in conductors of .020 inch nickel wire. The device is filled with argon at a pressure of 23 millimeters of mercury.

Such devices, which are merely illustrative of this invention, were found to have operating characteristics of an operating current of from 5 to 40 milliamperes, a sustaining voltage of 99-102 volts at 5 milliamperes and 99-103 volts at 40 milliamperes, a starter breakdown voltage over a range centered at 140 volts, and a transfer current of approximately 50 microamperes.

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.

What is claimed is:

1. A glow discharge device comprising a main anode, a flat cylindrical cathode surrounding said anode and having a cut-out portion at one side thereof, and an auxiliary anode extending through said cut-out portion towards said main anode and turning back towards said cut-out portion, said auxiliary anode having one end adjacent the edge of said cathode in the cut-out portion.

2. A glow discharge device comprising a substantially flat anode, a hollow cathode surrounding said anode and having a cut-out portion at one side, said cut-out portion being substantially M shaped, and an auxiliary anode extending through said cut-out portion into the space between said flat anode and cathode and turning back towards said cut-out portion, said auxiliary anode having one end adjacent the central portion of said M.

3. A glow discharge device comprising a hollow flat cylindrical cathode, a flat anode at the median plane of said cathode, said cathode having a cut-out portion, an integral leg depending from said cathode into said portion, said leg having a flat end, and an auxiliary anode having its one end positioned external to said cathode, said auxiliary anode extending through said cut-out portion into the space between said flat anode and cathode and turning back towards said cut-out portion, said auxiliary anode having its other end flat, and said other end being adjacent the flat end of said leg and substantially perpendicular thereto.

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4. A glow discharge device comprising a hollow flat cylindrical cathode, a flat anode at the median thereof, said cathode having a cut-out portion, an integral leg depending from said cathode into said portion, a spacer block supporting said cathode and anode, and a substantially S-shaped auxiliary anode supported by said block external to said cathode, said auxiliary anode having the upper portion of said S extending through said cut-out portion towards said flat anode and turning back into said cut-out portion, the upper end of said S being adjacent said leg.

5. A glow discharge device comprising a flat anode, a cathode adjacent said anode having a flat surface and having a cut-out portion in said surface, an integral leg depending from said cathode into said portion, and an auxiliary anode having its one end positioned to the side of said cathode remote from said flat anode and extending through said cut-out portion into the space between said flat anode and said cathode, the upper end of said auxiliary anode turning back towards said cut-out portion and being adjacent and substantially perpendicular to the end of said leg.

6. A glow discharge device comprising a main anode, a cathode adjacent said anode having a flat surface and having a substantially M-shaped cut-out portion in said surface, and a substantially S-shaped auxiliary anode positioned to the side of said cathode remote from said main anode and having the upper portion of the S extending through said cut-out portion adjacent said main anode and turning back towards said cut-out portion, the upper end of said S being adjacent the central portion of said M.

7. A glow discharge device comprising a main anode, a cathode adjacent said anode, said cathode having a flat surface and an edge thereon, and a substantially S-shaped auxiliary anode positioned to the side of said cathode remote from said main anode and having the upper portion of said S extending adjacent said edge towards said main anode and turning back towards said cathode surface, the upper end of said S being closely adjacent said cathode edge.

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

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