Nov. 18, 1952 H. L. VON GUGELBERG 2,618,767

MULTICATHODE GASEOUS DISCHARGE DEVICE

Filed Dec. 15, 1949

FIG. 1

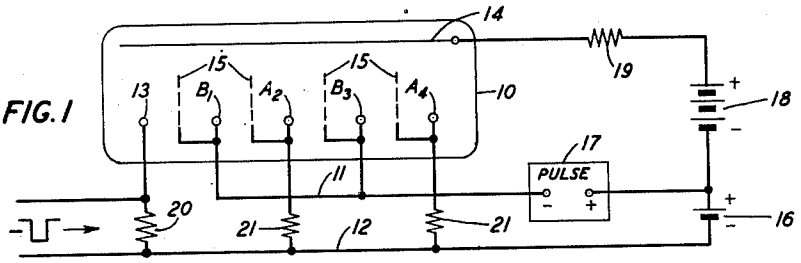


FIG. 2

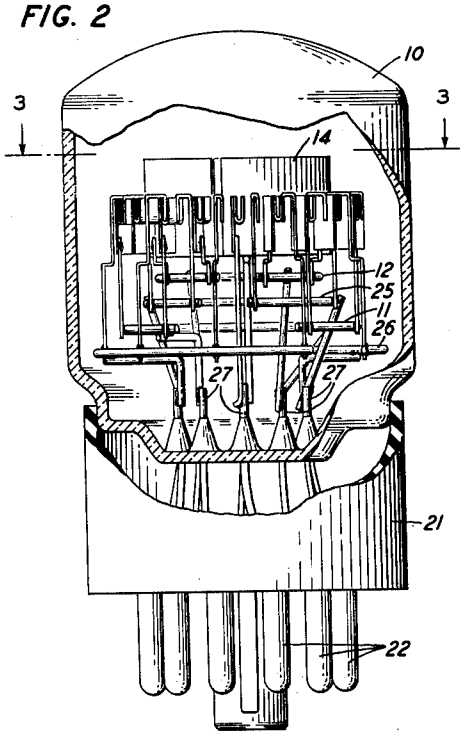


FIG. 3

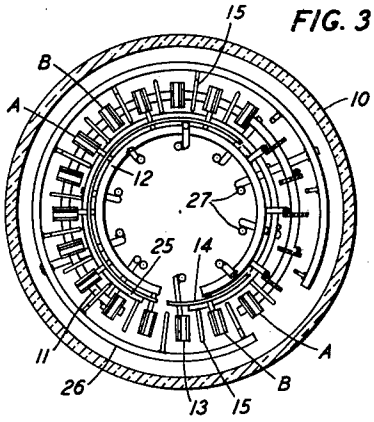


FIG. 4

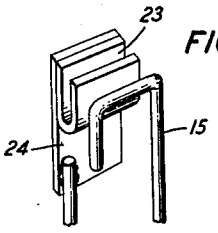
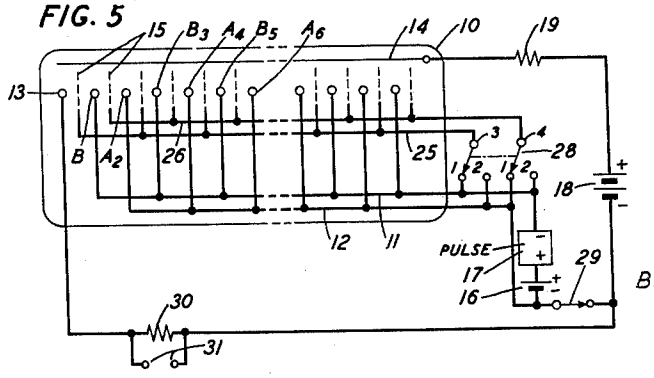


FIG. 5



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MULTICATHODE GASEOUS DISCHARGE DEVICE

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8 Claims. (Cl. 315—169)

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This invention relates to electric discharge devices and more particularly to multicathode glow discharge devices of the general type disclosed in the applications Serial No. 101,322, filed June 25, 1949, of M. A. Townsend, now Patent No. 2,575,370, granted November 20, 1951 and Serial No. 117,316, filed September 23, 1949, of H. L. von Gugelberg.

Devices of the type disclosed in the applications above identified comprise, in general and in one form, a plurality of glow cathodes mounted in a row and connected electrically in two groups, the cathodes of the two groups being in alternate relation, and an anode opposite the cathodes. The latter are of asymmetrical construction or relation relative to the anode, for example have two portions of different efficiencies as glow discharge elements, whereby when a discharge obtains between any cathode and the anode, the discharge concentrates near one end portion of the cathode, that is at the portion of greater efficiency, thereby providing a region of high ionization density. Further, the cathodes are arranged with the portion of higher efficiency of each in juxtaposition to the less efficient portion of the next succeeding cathode in the row. There is thus provided a preference mechanism such that when signal pulses are applied between the two groups of cathodes, the discharge is stepped from cathode to cathode in a prescribed direction along the row of cathodes. The asymmetrical construction or relation of the cathodes provides a marked difference in the voltage requisite to effect stepping of the discharge from any cathode to the next succeeding or next preceding cathode, this difference being designated the counting margin.

Cathodes of the type included in such devices are subject to contamination which reduces the efficiency thereof as glow discharge elements. In multicathode devices of the general type above described, such contamination, it has been found, reduces the counting margin, alters the operating characteristics of the several cathodes, and may substantially shorten the operating life of the devices.

One general object of this invention is to improve the construction and operating performance of multicathode glow discharge devices. More specifically, objects of this invention are to simplify the construction of multicathode discharge devices of the general type hereinabove described, to increase the operating life thereof, to maintain the counting margins, and to realize uniformity of operating characteristics for the several cathodes over long operating periods.

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In one specific and illustrative embodiment of this invention, an electric discharge device comprises a plurality of glow cathodes mounted in a row and an anode opposite the cathodes, the cathodes being connected together electrically in two groups with the cathodes of the two groups in alternate relation.

In accordance with one feature of this invention, a plurality of auxiliary or grid electrodes is provided, each grid electrode being positioned between two respective adjacent cathodes and connected or arranged to be connected to one of the cathodes of the respective pair.

In the operation of the device, signal pulses are impressed between the two groups of cathodes, whereby the discharge is stepped from cathode to cathode along the row. Each grid electrode functions to draw positive ions from the vicinity of the cathode at which the discharge obtains toward the next succeeding cathode in the row, whereby transfer of the discharge to the latter cathode is facilitated. The grid associated with the cathode from which the discharge is stepped, being at the same potential as this cathode, partially prevents the passage of positive ions from the discharge toward the next preceding cathode. Thus, the grids provide a preference mechanism whereby the discharge will be shifted only in the desired direction along the row of cathodes.

The cathodes may be of symmetrical and simple construction. Further the grid electrodes are inactive elements. Thus, the problem of contamination of the cathode surfaces is minimized whereby long operating life, uniform cathode characteristics and maintenance of counting margin are realized.

The invention and the above-noted and other features thereof will be understood more clearly and fully from the following detailed description with reference to the accompanying drawing in which:

Fig. 1 is a schematic illustrating the principal elements and the association thereof in a glow discharge device constructed in accordance with this invention and illustrating also one way in which the device may be operated;

Fig. 2 is an elevational view of a multicathode gaseous discharge device illustrative of one embodiment of this invention, a portion of the enclosing vessel being broken away to show the internal structure more clearly;

Fig. 3 is a plan view of the electrode assembly

taken along plane 3—3 of Fig. 2, certain of the cathodes being broken away to show details of construction;

Fig. 4 is a detail perspective view of one of the cathodes and an adjacent auxiliary or grid electrode; and

Fig. 5 is a schematic showing another way in which the device illustrated in Fig. 2 may be utilized.

Referring now to the drawing, Fig. 1 illustrates the principal components and the cooperative relation thereof in a device constructed in accordance with this invention. For purposes of simplicity of illustration, the device has been shown as a two-stage one involving four cooperating cathodes although as will appear presently a much greater number of stages may be utilized. The device comprises an enclosing vessel 10 having therein an ionizable atmosphere such as a rare gas or mixture of rare gases. Mounted in a row within the vessel are two groups of glow cathodes B_1 and B_3 and A_2 and A_4, the cathodes of each group being connected together electrically by a tie wire 11 or 12 as illustrated. Mounted adjacent one end of the row of cathodes A and B is an auxiliary or reset glow cathode 13, the function of which will be described hereinafter. Opposite all the cathodes is an anode 14. A plurality of auxiliary or grid electrodes 15 is provided in association with the cathodes, each of the auxiliary or grid electrodes being between a respective pair of the cathodes and connected to a corresponding cathode of the respective pair as shown in the figure. The connection between corresponding cathodes and auxiliary or grid electrodes, it will be understood, may be established either interiorly or exteriorly of the enclosing vessel 10.

The A cathodes are biased negatively with respect to the B cathodes by a suitable source 16 and the anode is biased positive relative to all the cathodes by a source 18 in series with the anode resistor 19. Negative pulses from a source 17 are applied between the two groups of cathodes. Associated with the auxiliary or reset cathode 13 by way of a resistor 20 is a source, not shown, for applying a sharp negative pulse to this cathode.

In the operation of the device, upon the application of a negative pulse to the auxiliary cathode 13, a discharge is initiated between this cathode and the anode 14. If then a negative pulse is applied to the B cathodes by the source 17 the cathode B_1 and grid electrode coupled thereto are driven negative relative to the cathode 13. Because of the negative potential of the grid associated with the cathode B_1, positive ions from the discharge between the cathode 13 and the anode 14 are attracted to the vicinity of the cathode B_1 whereby the discharge is transferred from between the cathode 13 and anode 14 to between the cathode B_1 and anode 14. When the applied negative pulse from the source 17 ceases, the cathode A_2 is more negative relative to the anode 14 than is the cathode B_1. Consequently the discharge transfers from the cathode B_1 to the cathode A_2. A succeeding negative pulse from the source 17 applied to the B cathodes steps the discharge from cathode A_2 to cathode B_3 and on cessation of this pulse the discharge shifts to cathode A_4.

It will be appreciated, thus, that in response to the application of pulses from the source 17 the discharge is stepped along the row of cathodes, advancing two cathodes for each pulse. When a pulse is applied to the B cathodes the grid connected to the B cathode nearest the A cathode at which the discharge obtains, attracts positive ions from the discharge thereby to facilitate breakdown of the anode-cathode gap at the B cathode following the A cathode at which the discharge obtains. However, the grid associated with the A cathode at which the discharge obtains, being at the same potential as this cathode, substantially inhibits the flow of positive ions from the discharge towards the next preceding B cathode. Thus, the grids provide a preference mechanism whereby the discharge may be transferred along the row of cathodes only in a prescribed direction.

Individual load circuits indicated generally by resistors 21 may be provided for each of the A cathodes. Thus a discharge may be transferred from the auxiliary cathode 13 to any one of the A cathodes to operate the load associated therewith by the application of a corresponding number of pulses from the source 17.

In one illustrative construction of the glow discharge device illustrated in Fig. 2, the enclosing vessel 10 is affixed to a suitable base 21 having terminal prongs 22 thereon. The several cathodes and auxiliary or grid electrodes are mounted in a circular row as illustrated in Fig. 3 coaxial with the anode 14 which may be, for example, a cylinder of sheet refractory material such as molybdenum. Each of the A and B cathodes, as shown clearly in Fig. 4, comprises a channel-shaped section or portion 23 of refractory metal, such as molybdenum or tantalum, extending radially with respect to the anode, and a supporting stem 24, for example, of nickel. The auxiliary or grid electrodes 15, as seen most clearly in Fig. 4, may be inverted L-shaped wires, for example of nickel, the plane of each electrode being radial with respect to the anode. As illustrated in Fig. 3, each grid electrode may be positioned mid-way between two adjacent cathodes. The auxiliary cathode 13 also may be channel-shaped and extends radially with respect to the anode 14. The supporting stems 24 for the A cathodes are joined to a metallic ring 11 which is connected to a respective one of the terminals 22 by leading-in conductors 27. Similarly, the stems of the B cathodes are affixed to a metallic ring 12 connected to one of the terminals 22. The several grid or auxiliary electrodes 15 are connected in two groups to metallic rings 25 and 26, alternate grid electrodes being connected to the same ring. The rings 25 and 26 also are coupled to corresponding terminals 22.

In a specific and illustrative device, the channels in the several cathodes may be 0.020 inch wide by $\frac{3}{32}$ inch deep and $\frac{3}{32}$ inch long, the grid electrodes may be formed of 0.015 inch diameter nickel wire, the cathode to anode spacing may be 0.040 inch and the cathode to grid spacing may be $\frac{1}{32}$ inch. For a gas filling in the vessel 10 of neon at a pressure of 35 to 40 millimeters of mercury, the breakdown voltage is substantially 180 volts and the sustaining voltage at a current of 5 milliamperes is about 110 volts. The B cathodes may be biased, as by the source 16 in Fig. 1, approximately 20 volts positive with respect to the A cathodes. Stepping of the discharge may be effected by negative pulses of approximately 60 volts peak value. Stepping frequencies up to about 1,500 cycles per second may be employed.

The device shown in Figs. 2 and 3 is particularly suitable for use as a pulse counter and may be operated for this purpose as in the manner

described in the application of M. A. Townsend identified hereinabove. It will be understood, of course, that although in the specific construction illustrated the cathodes and auxiliary electrodes are connected in groups within the vessel, individual leading-in connections for the electrodes may be provided whereby, for example, individual load circuits may be associated with the A cathodes and selective switching effected as discussed hereinabove with reference to Fig. 1.

The cathodes and auxiliary or grid electrodes may be associated electrically also in such manner that stepping of the discharge in either direction along the row of cathodes may be obtained. One arrangement suitable for this purpose is illustrated in Fig. 5. As shown in this figure, the A and B cathodes are connected in two groups by the conductors 11 and 12 each of which is connected to a respective pair of terminals 1 and 2 of the two-pole switch 28. The grid or auxiliary electrodes 15 also are coupled in two groups by the conductors 25 and 26 each of which is connected to the respective terminal 3 or 4 of the switch 28. A second switch 29, the function of which will appear presently, is provided between the A and B cathodes and the negative terminal of the source 18. The auxiliary cathode 13 is connected to this terminal through a series resistor 30 opposite ends of which lead to the output or indicator terminals 31.

The mechanism and principles of stepping the discharge from cathode to cathode are similar to those discussed in connection with Fig. 1. However, the direction of stepping will be determined by the relative polarities of the two groups of auxiliary or grid electrodes. This will be understood from detailed consideration of an example. Assume that the discharge obtains at the cathode A_4, that the switch 28 is in the position shown and that a pulse is applied by the source 17. Such pulse drives all of the B cathodes and all the grid or auxiliary electrodes 15 connected by the conductor 25 to the left-hand terminal 1, in Fig. 5, more negative. It will be noted that, upon application of the pulse, the grid electrode adjacent and to the left of the cathode A_4 is at the same potential as this cathode and thus inhibits flow of positive ions from the discharge toward the cathode B_3. However, the grid electrode adjacent and to the right of the cathode A_4 is driven negative relative to this cathode and, thus, attracts positive ions from the discharge toward the cathode B_5. Hence, upon application of the pulse, the discharge is stepped or shifted from the cathode A_4 to the next succeeding cathode B_5 and upon cessation of the pulse to the cathode A_6.

Assume now that the switch 28 is operated to close the circuits over terminals 2, that the discharge obtains at the cathode A_4 and a pulse is applied by the source 17. As in the case discussed above, the pulse drives all of the B cathodes negative. However, the pulse now is applied to those grid electrodes connected by the conductor 26 to the right-hand terminal 2 of the switch 28. Thus, upon application of the pulse, the grid electrode adjacent and to the right of the cathode A_4 is at the same potential as this cathode whereas the grid electrode adjacent and to the left of this cathode is negative with respect thereto. Thus, in response to the pulse, the discharge shifts from the cathode A_4 to the cathode B_3 and, upon cessation of the pulse, to the cathode A_2.

It will be apparent, then, that groups of pulses may be added algebraically, the final position of the discharge being indicative of the difference in the number of pulses in the two groups. Whenever the discharge shifts to the cathode 13 a pulse is produced across the resistor 30 which may be utilized, for example, to operate an indicator connected to the terminals 31. Of course, individual load circuits may be coupled to the B cathodes as discussed in connection with Fig. 1.

The discharge may be reset, that is returned to the cathode 13, by opening the switch 29, whereby the A and B cathodes are disconnected from the source 18. Alternatively, the discharge may be reset by applying a large negative pulse to the cathode 13 as in the manner described in the discussion of Fig. 1.

Reference is made of the application, Serial No. 133,196, filed December 15, 1949 of W. A. Depp, wherein a related invention is disclosed and claimed.

Although specific embodiments of the invention have been shown and described it will be understood that they are but illustrative and that various modifications may be made therein without departing from the scope and spirit of the invention. For example, it will be understood that auxiliary or grid electrodes may be provided in devices of the constructions disclosed in my application heretofore identified.

What is claimed is:

1. A gaseous discharge device comprising an array of two groups of cathodes, the cathodes of the two groups being mounted in alternate relation, an anode opposite said cathodes, a plurality of auxiliary electrodes each positioned between a corresponding pair of adjacent cathodes in said array, and means for electrically connecting each auxiliary electrode directly to one of the cathodes of the corresponding pair.

2. A gaseous discharge device comprising a plurality of glow cathodes mounted in a row, an anode opposite said cathodes, a plurality of inactive auxiliary electrodes each mounted between a corresponding pair of adjacent cathodes, means for establishing a discharge between said anode and one of said cathodes, and means for energizing said cathodes and auxiliary electrodes simultaneously to step the discharge along said row.

3. A gaseous discharge device comprising an array of two groups of cathodes, the cathodes of the two groups being in alternate relation, a plurality of grid electrodes each mounted between a corresponding pair of adjacent cathodes, an anode opposite said cathodes, means for establishing a discharge between said anode and one of said cathodes, and means for simultaneously pulsing said grid electrodes and one of said groups of cathodes negative relative to the other group of cathodes.

4. A gaseous discharge device comprising an array of two groups of glow cathodes, the cathodes of the two groups being in alternate relation, means electrically connecting the cathodes of each group together, an anode opposite said cathodes, a plurality of auxiliary electrodes, one for each pair of adjacent cathodes and disposed therebetween, means biasing one group of cathodes negative with respect to the other, means for establishing a discharge between said anode and one of said cathodes, and means for stepping said discharge from cathode to cathode comprising means for impressing negative pulses upon the other group of cathodes and certain of said auxiliary electrodes.

5. A gaseous discharge device comprising a row

of cathodes, a plurality of auxiliary electrodes, one for each pair of adjacent cathodes and mounted therebetween, an anode opposite said cathodes, means electrically connecting one group of alternate cathodes together, means electrically connecting the other cathodes together, and means for electrically connecting each of said auxiliary electrodes directly to the next succeeding cathode in said row.

6. A gaseous discharge device comprising a plurality of glow cathodes mounted in a row, each cathode having therein a channel portion, an anode adjacent said cathodes, and a plurality of auxiliary electrodes, one for each pair of adjacent cathodes, each of said auxiliary electrodes having an L-shaped wire portion positioned between the channel portions of the respective pair of cathodes.

7. A gaseous discharge device comprising a cylindrical anode, a plurality of channel-shaped glow cathodes mounted adjacent said anode, in a circular boundary coaxial therewith and each extending substantially radially with respect thereto, and a plurality of wire electrodes, one for each pair of adjacent cathodes and positioned therebetween.

8. A gaseous discharge device comprising a cylindrical anode, two groups of glow cathodes mounted in a circular row coaxial with said anode, each of said cathodes having a channel-shaped portion extending substantially radially outward from adjacent said anode, a pair of conductive members each electrically interconnecting the cathodes in a respective one of said groups, a plurality of grid electrodes, one for each pair of adjacent cathodes and positioned therebetween, a conductive member electrically interconnecting one group of alternate grid electrodes, and another conductive member electrically interconnecting the other grid electrodes.

HANS L. VON GUGELBERG.

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