Nov. 17, 1936. G. H. ROCKWOOD, JR 2,061,254

ELECTRIC DISCHARGE DEVICE

Filed Oct. 3, 1934 2 Sheets-Sheet 1

FIG. 1

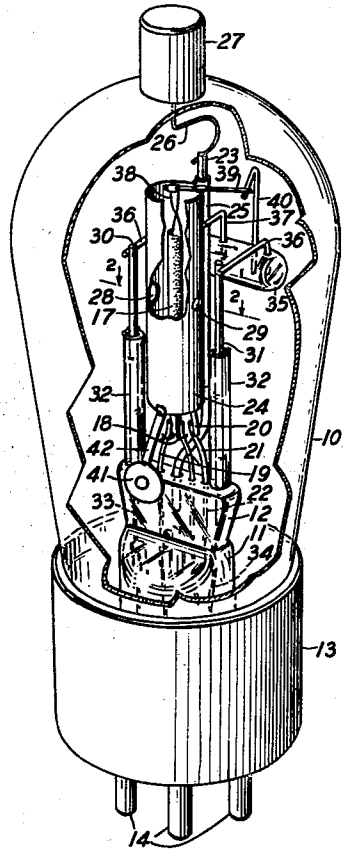

FIG. 3

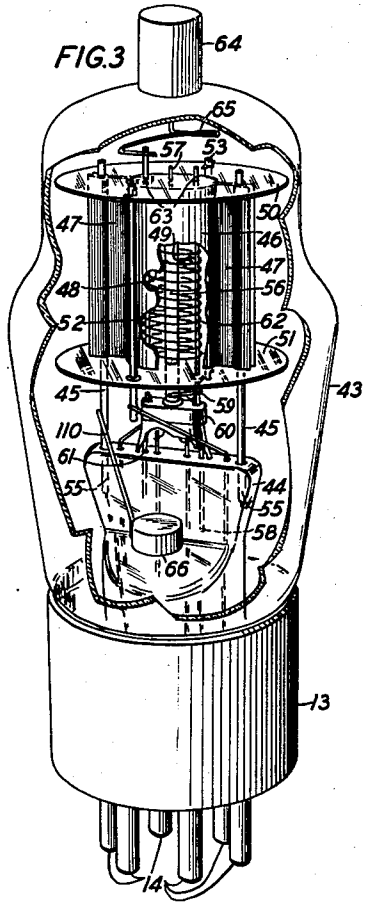

FIG. 2

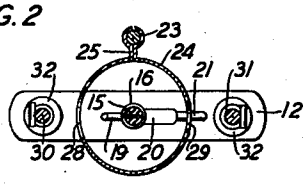

FIG. 4

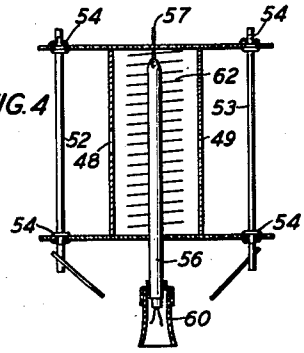

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FIG. 5

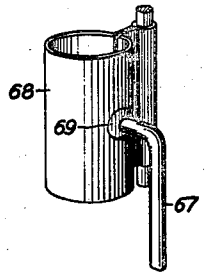


FIG. 6

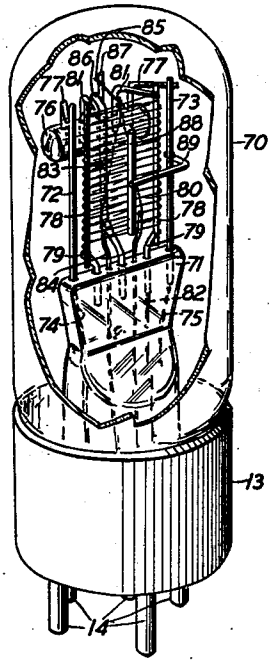


FIG. 7

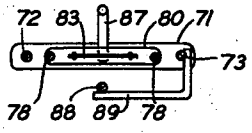


FIG. 8

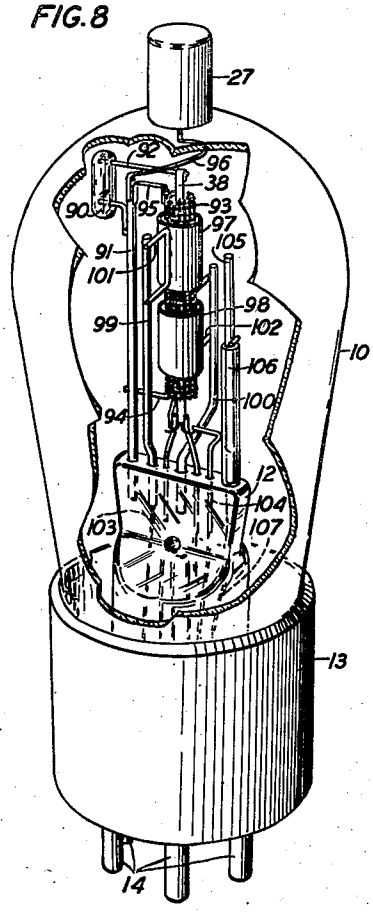
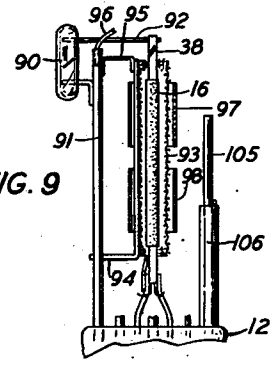


FIG. 9



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UNITED STATES PATENT OFFICE

2,061,254

ELECTRIC DISCHARGE DEVICE

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Application October 3, 1934, Serial No. 746,630

12 Claims. (Cl. 250—27.5)

This invention relates to electric discharge devices and more particularly to such devices of the trigger type wherein the initiation of a discharge between a cathode and an anode is controllable by the potential upon a third electrode.

One object of this invention is to control effectively the initiation of separate discharges between a single cathode and a plurality of anodes in electric discharge devices.

Electric discharge devices constructed in accordance with this invention comprise, in general, a cathode, a plurality of anodes, which may be metallic rods, and a control electrode disposed between the cathode and the anodes and having openings through which the several cathode-anode discharges may pass. The several electrodes are so constructed and arranged relative to each other that the breakdown characteristics of the various anodes are different. The control electrode may be used as a trigger, as known in the art, to control the initiation of a discharge between the cathode and one of the anodes. This discharge in turn is a prerequisite to and controls the initiation of a discharge between the cathode and another of the anodes.

In one embodiment of this invention, the control electrode is a cylindrical shell having a plurality of apertures disposed one in juxtaposition to each of the anodes. In order to provide the different breakdown characteristics desired for the several anodes, the apertures are made of different areas. The different breakdown characteristics may be obtained also by spacing the anodes unequal distances from the control electrode in which case the apertures may be of equal or unequal areas.

In another embodiment of this invention, the control electrode may be a helical grid carried by one or more supports. One of the anodes is positioned in alignment with one of the supports and the cathode so that the one support screens the anode from the cathode. Another anode is positioned remote from the supports so that an unimpeded discharge path is provided thereto from the cathode. To effect a further difference in the anode impedances and the breakdown characteristics, the anodes may be spaced unequal distances from the control electrode.

The invention and the features thereof will be understood more clearly and fully from the following detailed description with reference to the accompanying drawings in which:

Fig. 1 is a perspective view of an electric discharge device illustrative of one embodiment of this invention, portions of the enclosing vessel and of the control electrode being broken away to show the structure of the cathode and control electrode more clearly;

Fig. 2 is a cross-sectional view along the line 2—2 of the electrodes in the device illustrated in Fig. 1, showing the configuration and relative disposition of the electrodes;

Fig. 3 is a perspective view of another embodiment of this invention wherein the electrodes are fabricated in a unitary assembly, portions of the control electrode being broken away to show the inner electrodes more clearly;

Fig. 4 is an elevational view in cross-section of the electrode assembly in the device shown in Fig. 3;

Fig. 5 is a fragmentary view of a modification of the embodiments of this invention illustrated in Figs. 1 and 3;

Fig. 6 is a perspective view of an electric discharge device illustrative of another embodiment of this invention wherein the control electrode is in the form of a helical grid;

Fig. 7 is a lateral cross-sectional view showing the configuration and relative disposition of the electrodes in the device illustrated in Fig. 6;

Fig. 8 is a perspective view of an electric discharge device suitable for full wave rectification, illustrative of still another embodiment of this invention; and

Fig. 9 is an elevational view partly in cross-section of the electrodes in the device illustrated in Fig. 8.

Referring now to the drawings, the electric discharge device shown in Fig. 1 comprises an enclosing vessel 10 having an ionizable atmosphere, for example argon at a pressure of the order of 0.25 mm. of mercury, therein, and having a stem 11 terminating in a press 12 from which the electrodes are mounted. The vessel 10 is suitably secured, as by cementing, to an insulating base 13 which carries a plurality of terminal prongs 14 through which the electrodes of the device may be associated with an external circuit. Supported from the press 12 is a heater type equipotential cathode including an insulating rod 15 having a heater filament threaded therethrough, and a metallic sleeve 16 secured about the insulating rod 15 and coated with a thermionic material 17, such as barium and strontium oxides. The ends 18 of the heater filament are individually secured to short wires or stubs 19 embedded in the press 12 and electrically associated with two of the terminal prongs 14. The metallic sleeve 16 is provided with an integral extension 20 secured to a wire 21 embedded in the press 12

and electrically connected to another of the terminal prongs 14 by a conductor 22.

A control electrode is supported from the press 12 by a rigid wire or rod 23 and comprises a cylindrical portion 24 encompassing the cathode and coaxial therewith, and a flange 25 secured to the wire or rod 23. Electrical connection to the control electrode is established by a bent wire 26 secured at one end to the wire or rod 23 and at the other end to a terminal cap 27 affixed to the enclosing vessel 10. The control electrode is provided with two apertures 28 and 29, which may be diametrically opposite, allowing egress of electrons from the cathode.

Disposed one in juxtaposition to each of the apertures 28 and 29 are two anodes which may be linear rods 30 and 31 respectively embedded at one end in the press 12. The anodes 30 and 31 may be encompassed throughout a material portion thereof between the press 12 and the apertures 28 and 29 by insulating sleeves 32, such as glass tubes, for preventing a discharge thereto through the lower end of the control electrode, and are individually associated with two of the terminal prongs 14 by conductors 33 and 34 respectively.

The several electrodes may be maintained in proper space relation by an insulating bead 35 carried by short rigid wires 36 embedded in the insulating bead and affixed to the anodes 30 and 31. The control electrode is coupled to the bead 35 by a rigid bent wire 37 embedded in the bead and secured to the flange 25, and the cathode is coupled to the bead by a strip 38 integral with the metallic sleeve 16 and secured to a flexible wire 39 carried by a rigid wire 40 embedded in the bead.

A getter material, such as magnesium, is carried by a disc 41 supported from the control electrode by a strip 42, and may be vaporized during the outgassing treatment of the device to fix undesirable gases within the enclosing vessel 10.

As is known in the art, the control electrode 24, 25 may be utilized as a trigger to control the initiation of a discharge between the cathode and the anodes. However, it is desirable in some instances that the discharges between the cathode and the several anodes should not be initiated simultaneously. In accordance with this invention, the electrodes are so constructed and arranged that a discharge between the cathode and one of the anodes is a prerequisite to the initiation of a discharge between the cathode and the other anode, whereby the electric discharge device may be utilized as a means for interlocking two separate circuits. More specifically, the electrodes are so constructed and arranged that the breakdown characteristics of the two anodes are different and sufficient positive ions will not be present between the cathode and one anode to maintain a discharge, until a discharge is established between the cathode and the other anode.

To these ends, in accordance with this invention, the apertures 28 and 29 are made of unequal areas and the anodes 30 and 31 are spaced unequal distances from the control electrode, the anode in juxtaposition to the larger aperture being positioned nearer the control electrode than the other anode. For example, as shown in Figs. 1 and 2, the aperture 28 is of greater area than the aperture 29 and the anode 30 is positioned nearer the control electrode than is the anode 31. The control electrode, then, serves as a trigger controlling the initiation of the discharge to the anode 31 and this discharge produces sufficient positive ions in the field between the cathode and the anode 30 to allow and maintain a discharge to the anode 30.

Although in the embodiment of the invention illustrated in Figs. 1 and 2, the apertures 28 and 29 are shown of different sizes and the anodes are unequally spaced from the control electrode, it will be understood that the desired different breakdown characteristics for the anodes may be obtained if the apertures are made of the same size and the anodes are spaced proper unequal distances from the control electrode. Conversely, the anodes may be spaced equal distances from the control electrode and the desired different breakdown characteristics obtained by making the discharge apertures in the control electrode of proper unequal areas.

Furthermore, it will be understood that more than two anodes may be embodied in the device, the control electrode being provided with an aperture for each anode.

In another embodiment of this invention shown in Figs. 3 and 4, an electric discharge device comprises an enclosing vessel 43 having a filling of an ionizable medium, for example argon at a pressure of the order of 0.25 mm. of mercury, and provided with a stem terminating in a press 44. Extending from the press is a pair of parallel uprights or supports 45 which mount a unitary assembly including a control electrode having a cylindrical portion 46 and diametrically opposite flanges 47 to which the uprights or supports 45 are secured. The cylindrical portion 46 of the control electrode is provided with discharge apertures 48 and 49 which may be diametrically disposed and of unequal areas. Insulating members 50 and 51, which may be mica discs, extend across the ends of the control electrode and are seated upon the flanges 47. The insulating members or discs 50 and 51 are held against the flanges 47 by parallel metallic members or rods 52 and 53 which extend through the discs and carry eyelets 54 for securing the discs thereto. The rods 52 and 53 are disposed in juxtaposition to the apertures 48 and 49, respectively, and serve as anodes of the device, the rods being electrically associated with two of the terminal prongs 14 by conductors 55 extending from the press 44 and connected to the rods and terminal prongs. The anodes may be equally or unequally spaced from the control electrode, as described with reference to the embodiment of the invention illustrated in Figs. 1 and 2, so that they have different breakdown characteristics.

An equipotential cathode, which may be of the same general construction as that in the tube shown in Fig. 1, is coaxially disposed within the cylindrical portion 46 of the control electrode and comprises a metallic sleeve 56 fitted in a central aperture in the insulating disc 51 and having secured thereto a short wire 57 extending through a central aperture in the disc 50. A wire 58 embedded in the press 44 and connected to one of the terminal prongs 14 serves as a leading-in conductor for the cathode and is connected to the sleeve 56 by a tie wire or stub 59. A flattened bell shaped metallic shield 60 encompasses the leading-in conductors for the heater filament of the cathode and is supported from the press 44 by the wire 58 and another wire or support member 61.

Disposed between the cathode and the control electrode and coaxial therewith is a helical wire grid 62 which is carried by a pair of uprights 63

extending between the insulating discs 50 and 51 and fitted in apertures therein, one of the uprights 63 being connected to a terminal cap 64 on the enclosing vessel by a flexible wire 65.

The grid 62 may have a relatively high negative potential applied thereto when it is desired to render the device inoperative and serves to decrease the deionization period.

A metallic cup 66 is supported from one of the uprights or supports 45 by a metallic member 110 and carries a quantity of a getter material, such as magnesium, for fixing undesired gases within the enclosing vessel.

Fig. 5 shows a convenient arrangement for closely positioning an anode with respect to the control electrode. The anode is a metallic rod 67, which may extend from a press, and the free end thereof is bent toward the control electrode 68. Preferably the bent portion of the anode is disposed coaxially with the discharge aperture 69 in the control electrode.

The invention may be embodied also in electric discharge devices of the trigger type in which the control electrode is a helical wire or mesh grid. A device illustrative of such embodiment is shown in Figs. 6 and 7 and comprises an enclosing vessel 70 having a stem terminating in a press 71. Extending from the press 71 are parallel metallic members or rods 72 and 73 which are individually connected to two of the terminal prongs 14 by conductors 74 and 75, respectively. The members or rods 72 and 73 are spaced at the upper end by an insulating bead 76 supported from the members or rods by rigid wires or stub 77.

A pair of parallel uprights or rods 78, disposed coplanar with the members or rods 72 and 73, are supported from the press 71 by short wires or stubs 79 embedded in the press, and carry a flattened helical wire control electrode or grid 80. The uprights or rods 78 have secured to their upper end rigid wire stubs 81 extending from the bead 76 and thereby are maintained in proper space relation. One of the rods is electrically associated with one of the terminal prongs 14 by a conductor 82 sealed in the stem.

Disposed within, and in the medial plane of, the control electrode or grid 80 is an inverted V-shaped filamentary cathode 83, the ends of which are affixed to leading-in conductors 84 embedded in and extending from the press 71. The apex of the cathode 83 is engaged by a resilient hook member 85 which is supported by a wire stub 86 embedded in the bead 76 and having secured thereto a brace or support 87 extending from the press 71.

The metallic member or rod 72 serves as an anode which is partially screened from the cathode 83 by the upright or rod 78 thereadjacent. The metallic member 73 supports another rod-like anode 88, which is carried by a rigid metallic member 89 affixed to the metallic member 73, and which is disposed parallel to the metallic member or rod 72 and to the plane of the grid laterals. Preferably the anode 88 is spaced from the control electrode or grid 80 a distance greater than the spacing between the anode 72 and the control electrode or grid.

Because of the difference in spacing between the control electrode or grid and the two anodes and inasmuch as the anode 72 is partially screened from the cathode, the breakdown characteristics of the anodes will be different. The grid 80 may be utilized as a trigger to control the initiation of a discharge between the cathode 83 and the anode 88, this discharge being a prerequisite to the initiation of a discharge between the cathode 83 and the anode 72.

Figs. 8 and 9 illustrate an embodiment of this invention in an electric discharge device suitable for full wave rectification. This device comprises a cathode similar in construction to the cathode described with reference to the embodiment of the invention illustrated in Figs. 1 and 2, which is supported from an insulating bead 90, carried by an upright or rod 91 embedded in the stem, by a short metallic member or wire 92 embedded in the bead 91 and affixed to the integral extension 38 of the metallic sleeve 16. The cathode is encircled by a cylindrical mesh control electrode or grid 93 which is supported from the upright or rod 91 at opposite ends by a rigid metallic member 94 and a flexible metallic strip 95. Leading-in connection to the control electrode or grid is established through a flexible conductor 96 secured at one end to the upright or rod 91 and at the other end to a terminal cap 27 secured to the enclosing vessel 10.

The control electrode or grid 93 is encircled by two coaxial cylindrical anodes 97 and 98 which are individually supported from metallic uprights or rods 99 and 100, respectively, extending from the press 12, by U-shaped brackets 101 and 102, respectively. The uprights or rods 99 and 100 are electrically connected to two of the terminal prongs 14 by conductors 103 and 104, respectively, and serve as leading-in conductors for the anodes 97 and 98.

A rod-like anode 105, a portion of which is encased in an insulating sleeve 106, such as a glass tube, extends from the stem 12, parallel to the cathode, and is electrically connected to another of the terminal prongs 14 by a conductor 107.

The grid 93 is utilized as a trigger to control the initiation of a discharge to the anode 105, and when such a discharge is established sufficient positive ions are present between the cathode and the anodes 97 and 98 to support a discharge therebetween.

Although several specific embodiments of the invention have been shown and described, it will be understood, of course, that modifications may be made therein without departing from the scope and spirit of this invention as defined in the appended claims.

What is claimed is:

1. An electric discharge device comprising an enclosing vessel having an ionizable atmosphere therein, a cathode, a plurality of electrically separate anodes, and a control electrode encompassing said cathode and having openings through which cathode-anode discharges may occur, said cathode, control electrode, and anodes being so constructed and arranged that the breakdown characteristics for said anodes are different.

2. An electric discharge device comprising an enclosing vessel having an ionizable atmosphere therein, a cathode, a plurality of anodes, and a control electrode encompassing said cathode, said control electrode having a plurality of apertures therein each in juxtaposition to a corresponding one of said anodes, said apertures being of different areas.

3. An electric discharge device comprising an enclosing vessel having an ionizable atmosphere therein, a cathode, a plurality of electrically separate anodes, and a control electrode between said cathode and anodes and having openings therein through which cathode-anode discharges

may occur, said anodes being unequally spaced from said control electrode.

4. An electric discharge device comprising an enclosing vessel having an ionizable atmosphere therein, a cathode, a cylindrical shell control electrode encompassing said cathode, said control electrode having a plurality of lateral openings of unequal areas, and a plurality of rod anodes disposed one in juxtaposition to each of said apertures.

5. An electric discharge device comprising an enclosing vessel having an ionizable atmosphere therein, a cathode, a cylindrical shell control electrode encompassing said cathode, said control electrode having lateral openings, and a plurality of rod anodes disposed one in juxtaposition to each of said openings, said anodes being unequally spaced from said control electrode.

6. An electric discharge device comprising an enclosing vessel having an ionizable atmosphere therein, a cathode, a helical control electrode encompassing said cathode, and a plurality of anodes outside of said control electrode and spaced unequal distances therefrom.

7. An electric discharge device comprising an enclosing vessel having an ionizable atmosphere therein, a cathode, a control electrode having a pair of discharge openings of unequal areas, and a pair of anodes disposed one in juxtaposition to each of said openings and spaced unequal distances from said control electrode, the anode in juxtaposition to the larger opening being disposed nearest said control electrode.

8. An electric discharge device comprising an enclosing vessel having an ionizable atmosphere therein, a cathode, a perforate control electrode, a plurality of anodes, and a screening member partially shielding only one of said anodes from said cathode.

9. An electric discharge device comprising an enclosing vessel having an ionizable atmosphere therein, a cathode, a support, a perforate control electrode carried by said support and encompassing said cathode, an anode outside of said control electrode and in alignment with said support and said cathode, and another anode outside of said control electrode and angularly displaced from said support.

10. An electric discharge device comprising an enclosing vessel having an ionizable atmosphere therein, a planar filamentary cathode, a metallic support coplanar with said cathode, a flattened helical control electrode encompassing said cathode and having one of its shorter sides secured to said support, a rod anode outside of said control electrode and coplanar with said support and cathode, and another rod anode disposed in juxtaposition to one of the longer sides of said control electrode.

11. An electric discharge device comprising an enclosing vessel having an ionizable atmosphere therein, a cathode, a perforate control electrode encompassing said cathode, a plurality of anodes encompassing said control electrode and equally spaced therefrom, and another anode outside of said first anodes, said first anodes being spaced to form an opening through which a discharge may occur to said second anode.

12. An electric discharge device comprising an enclosing vessel having an ionizable atmosphere therein, a cathode, a cylindrical mesh control electrode encompassing said cathode, a plurality of cylindrical coaxial anodes encompassing said control electrode and equally spaced therefrom, and a rod anode outside of said first anodes, said coaxial anodes being spaced longitudinally to form an opening through which a discharge may occur to said rod anode.

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