June 7, 1938. C. DEPEW 2,119,855

ELECTRIC DISCHARGE DEVICE

Filed April 8, 1932 2 Sheets-Sheet 1

FIG. 1

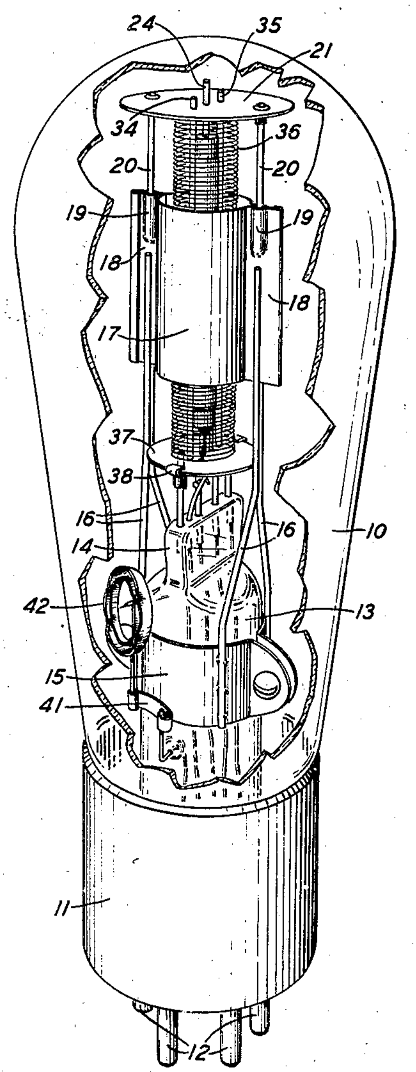


FIG. 3

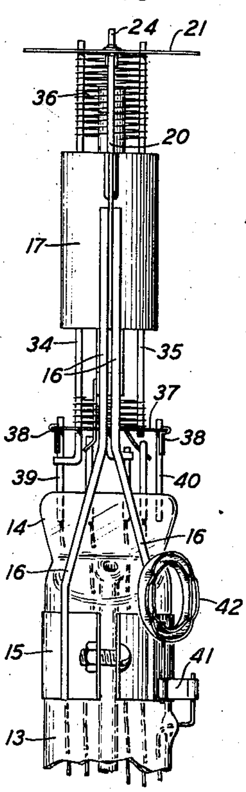
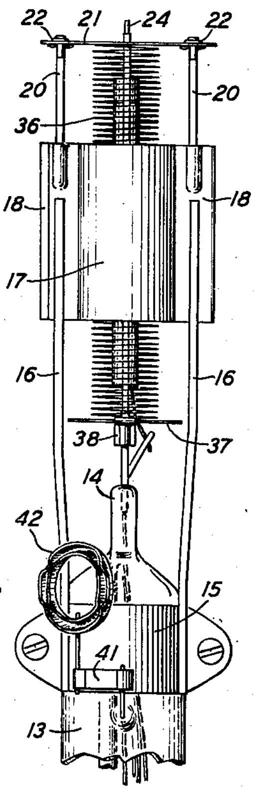


FIG. 2



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Filed April 8, 1932 2 Sheets-Sheet 2

FIG. 4

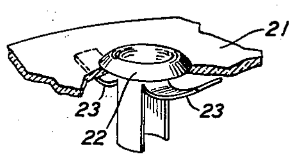


FIG. 5

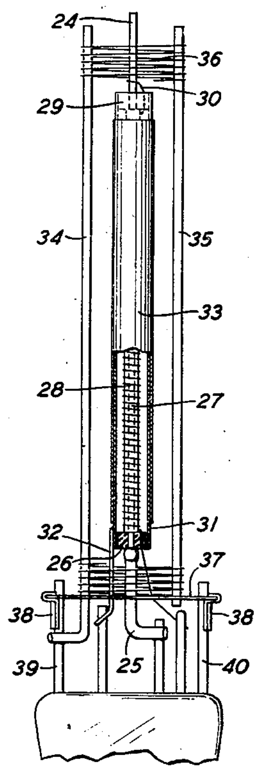


FIG. 7

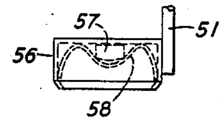


FIG. 6

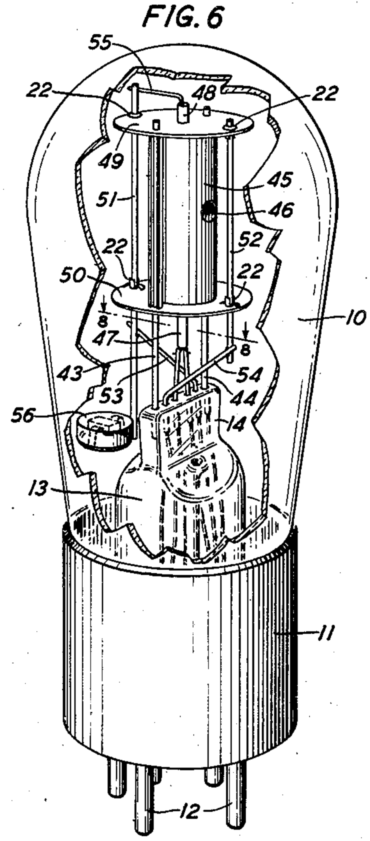
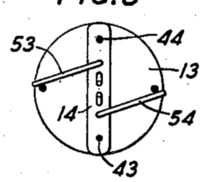


FIG. 8



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UNITED STATES PATENT OFFICE

2,119,855

ELECTRIC DISCHARGE DEVICE

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8 Claims. (Cl. 250—27.5)

This invention relates to electric discharge devices and more particularly to such devices in which the discharge is aided by a gaseous atmosphere.

In three-electrode discharge devices in which an ionizing gas is employed and the grid only controls the discharge under certain conditions of impressed voltage and gas pressure, it is expedient to determine the operating characteristics of the grid and moreover maintain a uniform linear operating characteristic which will not be affected by factors tending to vary the characteristic of the grid nor affect the discharge to such an extent as to alter the range over which the grid maintains control of the discharge.

In devices in which the grid functions as a trigger electrode, the operating characteristic of the grid is controlled by the degree of electrostatic shielding which the grid presents to the passage of electrons between the cathode and the anode. Usually the grid surrounds the cathode and offers a substantial electrostatic shield between the cathode and anode. However, the fact that the open ends of the grid offer ionization paths between the cathode and anode causes the characteristic of the grid to extend over a wide range of the grid-voltage, plate-voltage curve. Consequently, the control range of the grid is prolonged and may vary over wide limits before breakdown.

An object of the invention is to improve the operating characteristics of a three-electrode discharge device in which gas is present as an ionizing medium.

In accordance with one embodiment of this invention, the electrodes of the discharge device are supported coaxially from a single stem in the vessel and consist of a cylindrical cathode surface heated to emission temperature by a separate heating element, a cylindrical grid surrounding and electrostatically shielding the complete length of the cathode, and an anode outside of the cathode and grid. An insulating member or barrier supported from the anode engages the supports of the grid and cathode and serves as a shield for one end of the grid. A similar insulator supported independently of the anode and extending from the stem of the vessel closes the opposite end of the grid and serves as a spacer for the cathode and grid coaxially extending therethrough. The device is filled with argon to a suitable pressure so that the device operates as a trigger valve or relay.

It is evident that the insulating barriers at the ends of the grid and the electrostatic effect of the grid which surrounds the cathode and extends substantially to the surface of the insulating barriers completely shield the cathode. This shielding together with the length of the grid causes the control characteristics of the grid to simulate a substantially straight line throughout the operating range of the device. Therefore, the control before breakdown may be regulated within close limits of grid potential.

A feature of the invention relates to the overall length of the cathode and grid with respect to the area of the anode. The elongated cathode structure extends substantially the full length of the space between the press and the top of the vessel and is surrounded by a cylindrical grid of similar length, while the anode surrounds the cathode and grid only along the intermediate portions thereof. This arrangement insures a maximum concentration of current density in the space discharge between the cathode and anode.

The various features of the invention will be more clearly understood from the following detailed description in connection with the accompanying drawings, in which:

Fig. 1 is a perspective view of one embodiment of the discharge device made in accordance with this invention with a portion of the enclosing vessel broken away to show the internal electrode assembly;

Fig. 2 illustrates a front elevation of the electrode assembly as shown in Fig. 1 with the enclosing vessel removed;

Fig. 3 is a side view in elevation of the electrode assembly shown in Fig. 2;

Fig. 4 illustrates in perspective an enlarged segment of the insulating disc disclosed in the assembly of Fig. 1 to show the connection of the supporting eyelet with the disc.

Fig. 5 is an enlarged view partly in section of the cathode and grid assembly illustrating the detailed structure of the cathode;

Fig. 6 shows another embodiment of the invention in perspective in which the grid is substantially a solid wall member and the anode is offset with respect to the axis of the cathode and grid;

Fig. 7 is an enlarged detailed view of the getter receptacle and the means for supporting the getter pellet; and

Fig. 8 is a cross-sectional view of the stem shown in Fig. 6 along the line **8—8** of Fig. 6.

Referring to the drawings, Fig. 1 illustrates one application of the features of this invention in a discharge device comprising three electrodes enclosed in a glass vessel **10**, which is highly evacuated and filled with argon at a pressure of approximately two-tenths of a millimeter of mercury. The vessel is attached to a base 11 supporting pins or terminal prongs 12 which are connected to the electrodes within the device. The glass vessel 10 is provided with an inwardly projecting stem 13 terminating in a flat press 14 in which are sealed the leading-in wires for the electrodes. Surrounding the stem 13 is a metallic collar 15 formed of two semi-cylindrical sections clamped together around the stem. Extending from the collar 15 are rigid rods 16 arranged in pairs on opposite sides of the press 14. Each pair of rods is bent inwardly above the collar 15 and extends parallelly beyond the bent portion to engage the outer surfaces of a cylindrical metallic anode 17. This anode is formed of two semi-cylindrical sections having outwardly extended flanges 18 which are engaged by the upright rods 16 to support the anode from the collar 15. One end of the flanges 18 of the anode is formed into sockets 19 in which upright rods 20 are rigidly fastened by pressing in the sides of the sockets 19 or welding the rods 20 in the sockets. The rods 20 support a circular disc or barrier 21 of insulating material, such as mica.

The connection between the insulating material 21 and the rods 20 may be clearly understood from Fig. 4 which shows a portion of the disc provided with a tubular eyelet 22 which pierces the disc 21 and the tubular portion of the eyelet being slotted to provide four segments, two of the opposed segments being turned outwardly as shown at 23 and engaging the under surface of the disc 21 to rigidly attach the eyelet to the disc. The remaining segments of the eyelet embrace the rods 20 and are welded thereto to rigidly fasten the disc to the upright rods. The mica disc 21 is made of large area to extend over the cylindrical boundary of the electrode assembly and being close to the wall of the vessel counteracts the electrostatic grid effect of the glass wall. The disc 21 also serves as a centering means for the cathode structure shown more clearly in Fig. 5 which consists of a central upright rod 24 extending through a central aperture of disc 21 and welded to a bent extension 25 which is attached to one of the leading-in wires in the press 14. The weld between the upright rod 24 and the extension 25 forms a stop for a perforated insulating disc 26 which in turn forms a seat for a tubular insulator 27 which surrounds the rod 24. A heater wire 28, preferably of tungsten, helically surrounds the insulator 27 and is threaded through an insulator 29, seated on the tubular insulator and attached to the rod 24 as shown at 30. The opposite end of the heater wire extends through the insulator 26 and is connected to a leading-in wire in the press 14. The insulator 29 positioned on the end of the tubular insulator 27 together with the insulator 26 form spacing means for a cylindrical metallic cathode surface 31, to prevent contact with the heater element 28. The cathode surface 31 is attached to a support wire 32 which is welded to one of the leading-in wires in the press 14 and the cathode surface is coated with thermionically active material 33, such as barium and strontium oxides. The large cathode surface insures a copious supply of electrons which are emitted from the thermionically active material 33 and this supply of electrons is attracted to the anode 17 which is considerably shorter than the cathode surface to insure a concentrated current density in the space between the cathode and anode.

Since the electrodes function in an atmosphere of gas, which may be argon or other inert gas or vapor, such as mercury, at a relatively low pressure, for instance two-tenths of a millimeter of mercury, it is essential in order to control the discharge between the cathode and anode to insert a grid therebetween. Due to the configuration of the cathode and anode, the grid is in the form of a cylindrical helix. The grid consists of a cylindrical wire helix 36 having its laterals welded to supporting upright parallel rods 34 and 35. The upright rods 34 and 35 extend through apertures in the disc 21 and at the opposite end extend through a smaller diameter disc 37 which is situated within the boundary of the anode supports 16. This disc also serves as a shield between the cathode and the press 14. The disc 37 is provided with apertures near the periphery thereof in order to fit over support wires 39 and 40 extending from the press 14 and the disc is supported from these wires by clips 38 which are provided with a bent portion to clamp the periphery of the disc 37 and a downwardly extended fluted portion which makes contact with the upright wires 39 and 40 in the press 14 and is welded thereto. The disc 37 also maintains coaxial relationship between the cathode structure and the grid since the support rods of these electrodes extend through the disc and accurately center the cathode structure within the grid structure. An extension on the upright rod 34 is welded to the wire 39 which serves as a leading-in wire for the grid 36.

In gaseous discharge devices employing a grid, the grid control ratio, that is, the ratio of anode voltage to negative grid voltage that will just allow current to flow between the cathode and anode, is determined on the one hand by the effectiveness of the grid as an electrostatic shield to control emission from the cathode to the anode and on the other hand by the amplification factor, which in gaseous devices, is controlled by the largest opening in the grid, in contradistinction to the average effective opening in the grid in pure electron devices. Therefore, in order for the grid to effectively form an electrostatic shield around the cathode, it must extend beyond the whole length of the cathode in order to counteract end effects between the cathode and anode. If this fact were neglected, the open ends of the grid may inadvertently determine the amplification factor of the device as representing the largest effective opening of the grid. By making the grid long, it shields the whole cathode and controls emission from the cathode to the anode. By the same reasoning, it is apparent that shielding the ends of the grid by the insulating discs or barriers 21 and 37, it is possible to completely and electrostatically shield the cathode so that the discharge can only pass between the cathode and anode through the lateral openings in the grid helix. Another advantage of the end shields of mica is the elimination of the unknown variable grid effect of the glass wall of the vessel which may be introduced due to the electrostatic field of the glass reaching the cathode and tending to vary the grid control ratio. Finally the end shields tend to straighten out the control characteristic of the grid so that the grid control ratio is a constant throughout the operating range of the device. These advantages insure consistent and accurate grid control of the discharge between the cathode and anode whereby current flows to the anode instantaneously when the grid reaches the critical operating condition and further control of the current is transferred to the anode. The discharge may be disrupted by removing the potential applied to the anode or by lowering the potential below a value necessary to sustain ionization. The voltage source for the anode 17 is supplied through one of the prongs 12 on the base which is connected to a leading-in wire extending through the side of the stem 13. This wire is connected to a strap 41 having its center portion welded to the collar 15 whereby a suitable potential may be applied to the anode 17. The other end of the strap 41 supports a rigid wire connected to a metallic grooved ring 42 having pinched portions which hold strips of easily vaporizable material, such as magnesium. This material is vaporized in the final step of the exhausting process to absorb and fix residual gases within the vessel.

Another embodiment of the invention is shown in Fig. 6 which illustrates a gaseous discharge device in which grid control may be attained as in the device described in Fig. 1; since in this figure the grid which is in the form of a metallic cylinder with a single opening for the passage of the discharge between the cathode and anode and in which the ends of the grid are closed, to completely control the emission from the cathode. In this device the enclosing vessel 10 is attached to a base 11 supporting contact prongs 12, the same as in the device of Fig. 1 and the vessel is provided with an inwardly projecting stem 13 having a press 14 in which the leading-in wires for the electrodes are sealed. A pair of straight, vertical rods 43 and 44 extend from the press 14 and support a cylindrical metallic grid 45 in the form of two semi-cylindrical sections fastened together and embracing the greater portion of the rods 43 and 44. The grid is provided with a single opening 46 which determines the amplification factor of the device. The grid 45 surrounds an indirectly heated cathode which is positioned coaxially with respect to the grid 45 and is in the form of the conventional heater type cathode consisting of a quartz insulator 47 enclosing a hairpin heater element having the ends connected to two spaced wires in the press 14. A metallic cathode surface 48 is wrapped around the quartz insulator 47 and is coated with thermionically active materials over an area within the boundary of the grid 45.

The ends of the grid 45 are closed by mica discs 49 and 50, respectively. These discs serve to center the cathode structure in the axis of the grid 45, to completely shield the cathode so that emission from the cathode takes place only through the opening 46 in the grid, and to eliminate the variable grid effect of the electrostatic field of the glass vessel 10. The discs 49 and 50 are rigidly fastened to upright wires 51 and 52 which are arranged longitudinally on opposite sides of the grid 45 in positions 90° from the rods 43 and 44, respectively. The attaching means between the rods and the discs is the slotted tubular eyelet 22, described in connection with Fig. 4, and these eyelets are attached to the discs and rods in the same manner as described heretofore. The rods 51 and 52 are rigidly attached to outwardly bent wires 53 and 55 projecting from the press 14. The cathode 48 is connected to the upright rod 51 by a cross-wire 55 so that a suitable connection may be made to the cathode through one of the prongs 12, bent wire 53, upright rod 51 and cross-wire 55. In the same manner the bent wire 54 offers a means of supplying a suitable potential to the upright rod 52 which, in the device shown in Fig. 6 serves as an anode and is placed directly opposite the opening 46 in the cylindrical grid 45.

The upright rod 51 extends below the plane of the press 14 and carries an inverted metallic cup 56, shown more clearly in Fig. 7. This cup carries a pellet 57, of a thermit reaction mixture, such as magnesium and aluminum. The pellet is held within the cup 56 by a resilient metallic strip or clip 58 which positions the pellet in the flat portion of the cup and engages the inwardly turned edge of the cup 56. The thermit reaction mixture is vaporized during the final evacuation period of the vessel, to absorb residual gases in order that the inert gaseous filling, such as argon, in the vessel will remain pure. The purpose of using a thermit reaction mixture as a getter material in the device as shown in Fig. 6 is to simplify the evacuation process since the electrodes can be outgassed and the reaction mixture vaporized in a single operation by surrounding the vessel with a high frequency coil and heating the electrodes by induction to free them of gas. The vaporizing temperature of the reaction mixture is so high during the initial heating of the electrodes that it does not vaporize. However, after a minute or two of heating the electrodes, all the gas is removed therefrom and at the end of this interval the temperature is sufficient to vaporize the getter or reaction mixture to absorb the residual gases. This procedure simplifies to a great extent the manufacturing process of the device and materially reduces the cost of manufacture.

What is claimed is:

1. An electric discharge device comprising an enclosing vessel, a cathode extending along the axis of said vessel, a grid having a plurality of turns surrounding said cathode throughout its length, an anode outside said grid, said cathode, grid and anode being immersed in an atmosphere of an inert gas at low pressure, and insulating shields in contact with the opposite end turns of said grid, one of said shields being substantially parallel to and close to an end wall of said vessel and the area of said shield being so proportioned as to counteract the electrostatic grid effect of said vessel wall on said cathode.

2. An electric discharge device comprising an enclosing vessel having a stem and an inert gaseous filling at low pressure, an elongated cylindrical cathode surface supported above said stem, means for heating said cathode to emission temperature, a cylindrical wire grid surrounding said cathode throughout its length, insulating discs extending in planes coincident with the ends of said grid and centering said cathode coaxially within said grid, and a cylindrical anode surrounding said grid and cathode, said anode being proportioned and located intermediate the ends of said cathode and grid whereby maximum current density concentration of the discharge is accomplished.

3. An electric discharge device comprising an enclosing vessel having a stem, an inert gas in said vessel, a plate electrode supported from said stem, an insulating member carried by said plate electrode at one end thereof, a cathode within said plate electrode and centrally supported by said insulating member, a second insulating member supported from said stem independent of said plate electrode, and a helical grid interposed between said cathode and plate electrode, said grid having its end turns in contact with said insulating members.

4. An electric discharge device comprising a vessel having a stem, an inert gas in said ves-

sel, an elongated cylindrical cathode, a central support therefor, a cylindrical anode surrounding said cathode, an insulating member supported from said anode engaging said cathode support, an individually supported insulating member extending from said stem and engaging said cathode support, and a helical electrode shielding said cathode throughout its length, the ends of said electrode engaging said insulating members.

5. An electric discharge device comprising an enclosing vessel having a stem, an inert gas in said vessel, a collar surrounding said stem, upright supports extending from said collar, a flanged anode attached to said supports, wires extending from said anode, an insulating disc attached to said wires and extending across one end of said anode, a second disc supported from said stem, the periphery of said disc being within the boundary of said upright supports, a cylindrical cathode and a coaxial grid within said anode, said grid extending wholly within the limits of said insulating discs, and supports for said cathode and grid projecting through said discs.

6. An electric discharge device comprising an enclosing vessel having a stem, an inert gas in said vessel, a collar surrounding said stem, upright supports extending from said collar, a flanged anode attached to said supports, wires extending from said anode, an insulating disc attached to said wires and extending across one end of said anode, a second insulating disc between said anode and stem, upright wires extending from said stem and piercing said second insulating disc, a cylindrical cathode supported between said discs along the axis of said anode, a grid surrounding said cathode within said anode and extending wholly within the limits of said insulating discs, and metallic clips attached to said upright wires, said clips having bent portions clamping the peripheral edge of said second disc.

7. An electric discharge device comprising an enclosing vessel having an ionizable medium therein, a cathode, a cylindrical control electrode encompassing said cathode, insulating discs electrostatically sealing the ends of said control electrode, and an anode encompassing a restricted portion only of said control electrode.

8. An electric discharge device comprising an enclosing vessel having a filling of gas at a low pressure, a cathode, an enclosure for said cathode comprising a helical grid encompassing said cathode and insulating discs in immediate proximity to and extending across the ends of said grid, and a cylindrical anode of materially less length than said grid encompassing an intermediate portion of said grid.

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