

June 13, 1933.

D. S. BOND
ELECTRIC DISCHARGE DEVICE

1,913,427

Filed Sept. 17, 1930

3 Sheets-Sheet 1

FIG. 1

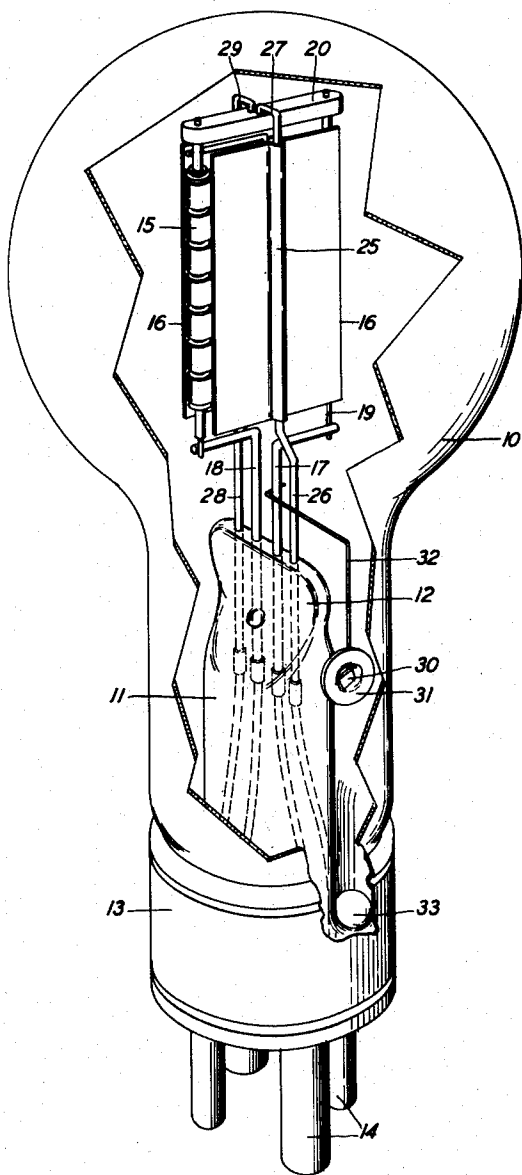


FIG. 3

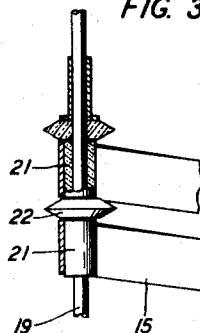
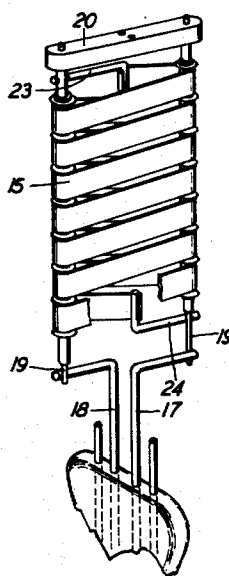


FIG. 2



INVENTOR
D. S. BOND
BY
Walter C. Kiesel
ATTORNEY

June 13, 1933.

D. S. BOND

1,913,427

ELECTRIC DISCHARGE DEVICE

Filed Sept. 17, 1930

3 Sheets-Sheet 2

FIG. 4

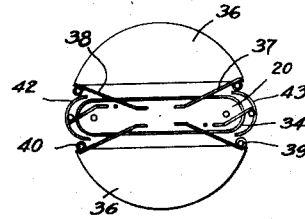
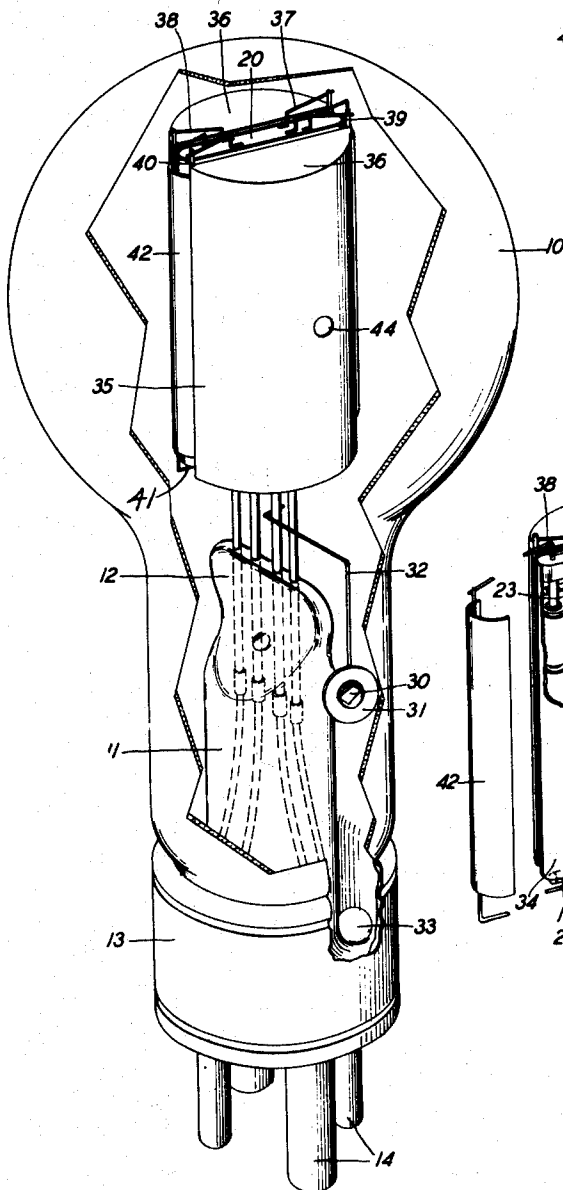
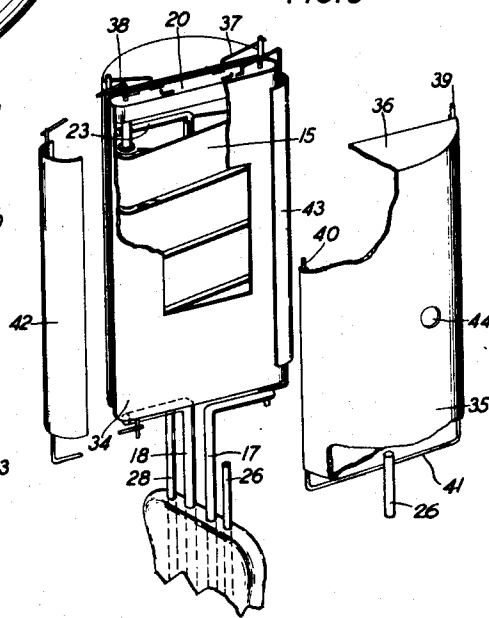


FIG. 5A.

FIG. 5



INVENTOR
D. S. BOND
BY
Walter C. Kiesel
ATTORNEY

June 13, 1933.

D. S. BOND

1,913,427

ELECTRIC DISCHARGE DEVICE

Filed Sept. 17, 1930

3 Sheets-Sheet 3

FIG. 6.

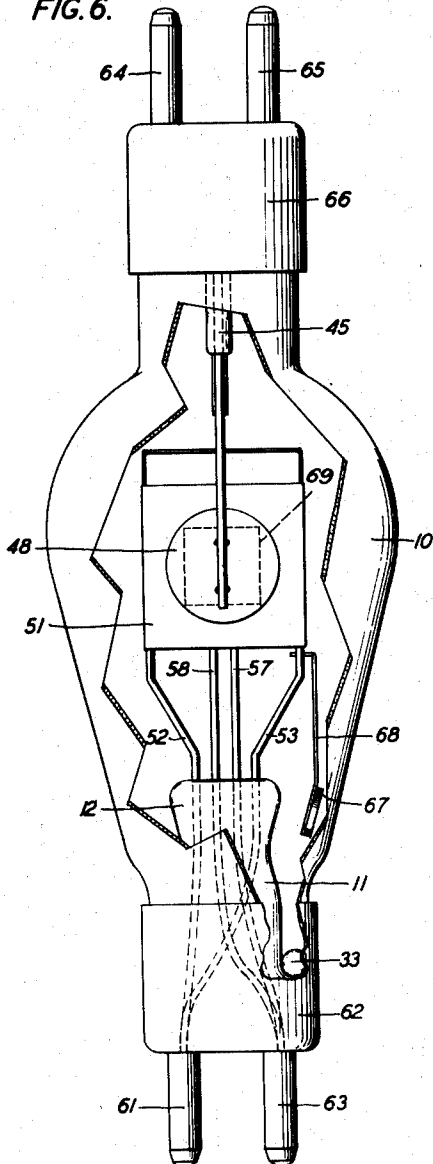


FIG. 7

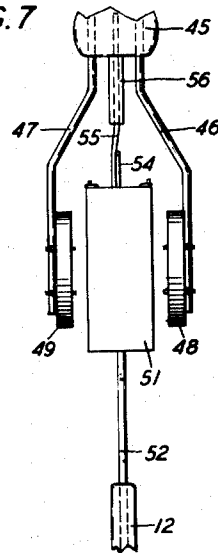
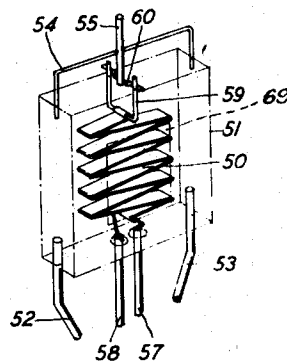


FIG. 8



INVENTOR
D. S. BOND
BY
Walter C. Kiesel
ATTORNEY

UNITED STATES PATENT OFFICE

DONALD S. BOND, OF BROOKLYN, NEW YORK, ASSIGNOR TO BELL TELEPHONE LABORATORIES, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK

ELECTRIC DISCHARGE DEVICE

Application filed September 17, 1930. Serial No. 482,425.

This invention relates to electric discharge devices and more particularly such devices for rectifying alternating current.

An object of the invention is to obtain a large current output from a full wave rectifying device.

Another object of the invention is to eliminate arcing between the anodes of the discharge device.

10 The broad aspect of the invention consists in supporting two parallel spaced anodes in a vessel containing a vapor producing substance and positioning the electron emitting element or cathode between the anode so that
15 the cathode completely shields each anode during each half cycle of operation and prevents inter-action or arcing between them. In one embodiment of the invention the full wave rectifying device comprises an enclosing
20 vessel supporting two spaced upright rods connected at one end by an insulating plate, the rods supporting a ribbon cathode or filament wound in the form of a helix on the rods with adjacent turns of the ribbon insulated by spacers and an anode in the form
25 of a rectangular metallic plate which is positioned on each side of the ribbon filament structure. The enclosing vessel is filled with a gas or a vapor producing substance, such
30 as mercury, to a suitable pressure, to form the conducting medium between the electrodes.

In full wave gas or vapor rectifiers considerable difficulty has been experienced in
35 preventing positive ions from the arc stream of the conducting half of the wave from being accelerated to the other anode, which during part of the cycle is negative with respect to the anode in operation. In accordance
40 with this invention the construction of the electron emitting electrode or cathode forms an electrostatic shield between the two anodes. This is accomplished by the form of the helical cathode wound on the support
45 in parallel planes with the sections on one side blocking the spaces between the edges of the adjacent sections on the other side. The electron emitting cathode, therefore, serves two functions, one being its usual
50 function of supplying electrons in the stream

to each anode and the other being the shielding effect, either physical or electrical or both, so that there is no direct path from one anode to the other through the cathode winding, and while the electrons are easily
55 deflected through the narrow spaces between the turns of the cathode, the mercury ions, because of their greater mass and lower mobility, cannot flow from one anode to the other.

A feature of the invention relates to substantially surrounding the cathode with a heat reflecting shield to confine the heat generated in the cathode and thereby maintain
60 the cathode at a uniform operating temperature. In one embodiment of the invention the heat shield comprises a hollow bright metallic member substantially enclosing the cathode and provided with openings through
65 which the electrons can pass to the anodes.

Another feature of the invention relates to providing anode surfaces of large area to dissipate the heat generated in the device during operation. In accordance with one
70 embodiment of this invention the anode is in the form of a semi-cylindrical structure closed on the ends to prevent buckling of the anode and provided with a small aperture so that the operator can observe the character
75 of the discharge between the electrodes of the device.

These and other features of the invention will be clearly understood from the following detailed description taken in connection
85 with the accompanying drawings.

Fig. 1 illustrates in perspective an electric discharge device made in accordance with this invention with a portion of the enclosing vessel broken away to show the details of the electrode assembly;
90

Fig. 2 is a perspective view showing in detail the cathode and supporting structure of the device shown in Fig. 1;

Fig. 3 is an enlarged detailed view of a portion of the cathode supporting structure
95 partly in cross-section, shown in Fig. 2;

Fig. 4 illustrates in perspective another form of the invention with a portion of the enclosing vessel broken away to show the internal electrode structure;
100

Fig. 5 is a partly exploded view shown in perspective of the electrode assembly shown in Fig. 4 with portions of the elements broken away to clearly illustrate the invention;

Fig. 5—A is a plan view of the top of the electrode assembly shown in Fig. 1 to illustrate the connection of the various electrode supports to the insulator.

Fig. 6 illustrates another form of the invention with the electrodes supported at opposite ends of the vessel, the vessel being broken away to show the structure and the relationship of the electrode;

Fig. 7 is a partial side view of the electrode assembly shown in Fig. 6 showing the spaced parallel anodes supported from one stem and the cathode assembly supported between the anodes; and

Fig. 8 illustrates in perspective the detailed structure of the cathode and supporting assembly employed in the device shown in Fig. 6.

Referring to Figs. 1, 2 and 3 the electric discharge device made in accordance with this invention comprises an enclosing vessel 10 having a reentrant stem portion 11 terminating in a press 12 which supports the electrodes. The vessel 10 is provided with a base 13 having terminals 14 to which the leading-in wires of the electrodes are connected and which form external connections for the electrodes. An incandescent ribbon cathode or filament 15 and a plate anode 16 arranged in parallel relation on each side of the filament 15 form the electrodes of a full wave rectifier having a high current output.

The cathode supporting structure comprises two leading-in wires 17 and 18 sealed through the press 12 and bent at right angles within the enclosing vessel. An upright supporting rod 19 is attached in any suitable manner, to each angular termination of the leading-in wires and the rods 19 are connected at their free ends by an insulating plate 20, of porcelain or lavite. The cathode 15 consists of a long length of nickel ribbon coated with alkaline earth oxides, such as barium and strontium oxides and is wound helically around the supporting rods 19, held in spaced relation by the insulating plate 20 and the leading-in wires 17 and 18. Since the upright rods 19 serve as the conductors for the ends of the ribbon cathode 15, they are provided with insulating sleeves 21 arranged in superposed relation along the greater length of each supporting rod. In order to maintain the section of the cathode out of electrical contact with each other an annular spacer 22 of insulating material is interposed between two adjacent insulating sleeves. The ribbon cathode 15 is wound helically around the insulated section of the supporting rods 19 and the ends connected to

wires 23 and 24 which are welded respectively to each upright supporting rod 19.

A pair of anodes 16 is supported on opposite sides of the cathode structure and consists of rectangular metallic plates having a central longitudinal ridge 25 which strengthens the anode plate against buckling from heat during operation and provides a groove for welding the anode to the supporting wire 26 which is a continuation of the leading-in wire for the anode, the upper end of the supporting wire 26 being anchored in the insulating plate 20 as shown at 27. A similar wire 28 is attached to the opposite anode and anchored at the upper end in the plate 20 as shown at 29. After the electrode assembly is sealed into the vessel 10 the electrodes and the glass vessel are out-gassed and a high vacuum obtained within the vessel. In order to fix residual gases within the vessel a vaporizable substance, such as magnesium, is vaporized, to absorb the gases and form a film on a portion of the enclosing vessel 10. The magnesium is shown as a small piece of ribbon 30 contained in a dished disc 31 supported by a wire 32 connected to the leading-in wire 17 of the cathode. An easily ionizable gas or a vapor producing substance may be injected into the device to serve as the conducting medium. Preferably, a body of mercury 33 is sealed in the enclosing vessel 10 to form the conducting medium.

In full wave rectifying devices capable of attaining a high current output there is considerable arcing between the two anodes due to one anode being negative with respect to the other anode during each half cycle of operation. In accordance with this invention the arcing between the anodes is prevented by the particular configuration of the cathode which forms an electrostatic shield between the two anodes and prevents positive ions from the arc stream of the conducting half of the rectifier from being accelerated to the other anode which is negative. It will be seen that the configuration of the ribbon cathode is in the form of a helical grid extending between the two faces of the anodes so that the sections on one side block or cover the spaces between adjacent sections on the other side of the cathode. This arrangement forms a physical shield between the two anodes so that there is no direct path from one anode to the other through the wound cathode. The large emitting surface of the cathode also forms an electrostatic shield due to the large mass of electrons being emitted from the cathode, the mass of electrons being so great that the mercury ions because of their greater mass and lower mobility do not pass from one anode to the other. The anodes are made relatively large in order to dissipate the heat generated during operation and at the same time these anodes serve as heat shields for the ribbon cathode to con-

fine the heat generated by the cathode within the space containing the cathode so that the heat is reflected back to the cathode to maintain it at a uniform temperature.

5 Figs. 4 and 5 illustrate another embodiment of the invention and operates on the same principle as described in connection with Fig. 1. In this modification the cathode structure is substantially the same as heretofore described except that the cathode ribbon is made wider to provide the proper area to obtain the desired current voltage characteristics for the cathode. The cathode and supporting structure is surrounded by a heat reflecting shield 34, of bright metallic material. The shield 34 conforms to the contour of the cathode structure and is held in position by embracing the insulating plate 20. The shield 34 is provided with rectangular openings on opposite surfaces to permit the flow of electrons from the cathode 15.

In high voltage discharge devices in which a great amount of heat is dissipated it is preferable to form the anodes of semi-cylinders to provide a larger surface area for heat dissipation. In this invention each anode is formed into a semi-cylindrical structure 35 having a closure portion 36 at each end of the semi-cylinder to form a box-like structure which sufficiently increases the surface area of the anode to dissipate the required heat generated during operation. The closure ends also serve to rigidly maintain the shape of the anode and thereby prevent buckling of the anode surface. Each anode is supported at one end by two supporting wires 37 and 38 which are connected to the parallel supporting wires 39 and 40 respectively of the anode and anchored in the insulating plate 20 supported at the end of the cathode assembly. A tie member 41 is joined to the opposite ends of the supporting wires 39 and 40 and connected to the leading-in wire 26.

45 Since the cathode assembly does not effectively shield the edges of the anodes in this modification it is desirable to prevent arcing between the edges of the anodes by curved metallic shields 42 and 43 interposed between the adjacent edges of the anode surfaces on the longitudinal boundaries of the cathode structure. These end shields are supported by wires at one end from the insulating plate 20 and connected at their other ends of the leading-in wires 17 and 18. Since the cathode structure is substantially enclosed by the heat reflecting shield and the configuration of the anodes and end shields prevent any visual observation of the character of the discharge taking place between the cathode and the anodes, it is desirable to form an aperture 44 in the center of the curved surface of each anode, to permit the operator to observe the discharge taking place within the electrode structure.

In Figs. 6, 7 and 8 another modification of the invention is shown embodying the same principles as heretofore described. In this device the enclosing vessel 10 is provided with an inwardly projecting stem 11 at one end and another stem 45 at the opposite end. A pair of leading-in wires 46 and 47 extend into the vessel 10 and support thick disc anodes or electrodes 48 and 49, preferably formed of graphite. The electron emitting electrode or cathode of this device consists of a metallic ribbon coated as heretofore described and having a configuration as shown in Fig. 8 of zig-zag form or accordion-pleated form supported with the edges of the cathode facing the anodes 48 and 49. The cathode 50 is surrounded by a metallic box-like structure 51 having heat reflecting properties and provided with a rectangular opening 69 on each side adjacent the edges of the cathode 50. The heat reflecting shield 51 is supported from the stem 11 by leading-in wires 52 and 53 and at the opposite end is connected by a bridging member 54 welded to a centering wire 55 projecting into a glass tube 56 joined to the glass stem 45 on the end of the enclosing vessel 10.

The box-like reflecting shield 51 not only confines the heat generated by the filament to the area containing the filament but also serves as one of the conductors for the cathode 50. As shown in Fig. 8 one end of the cathode 50 is connected to a wire joined to the leading-in conductors 57 and 58 which extend through apertures in the box-like shield 51. The other end of the cathode 50 is connected to a yoke member 59 which is suspended from the top of the box-shaped shield 51 and connected by a wire 60 which is welded to the centering wire 55 at the top of the box-like structure. The leading-in wires 52 and 53 are connected to terminals 61 on the base 62 and the leading-in wires 57 and 58 are connected to the terminal 63 in order to supply heating current to the cathode through the shield enclosure and the leading-in wires 57 and 58.

While in the previous devices heretofore described the shielding of the anodes against arcing is accomplished by the physical configuration of the cathode in combination with the electrostatic effect of the mass of electrons emitted by the cathode, the full wave rectifier shown in Fig. 6 prevents arcing between the two anodes 48 and 49 solely by the electrostatic effect of the mass of electrons contained between the adjacent surfaces of the zig-zag ribbon cathode 50. This mass of electrons serves as a wall or barrier through which the slower mercury ions cannot penetrate, so that the cathode electrostatically shields each anode from the other during each half cycle of operation of the mercury full wave rectifier. The leading-in wires 46 and 47 of the graphite anodes are connected ex-

ternally to the terminals 64 and 65 on the base 66 cemented to the enclosing vessel 10. The support for the magnesium consists of a grooved ring 67 containing a section of magnesium ribbon and supported from the leading-in wire 53 by a connection 68. The enclosing vessel is filled with a quantity of mercury 33 to serve as the conducting medium between the electrodes.

In embodying the broader features of the invention in a number of devices which will enable the required operation of full wave rectifiers in a highly efficient manner, to produce large current outputs, various other features have been employed, which, while they are not essential to the broad features, are of importance in contributing to the efficiency of the rectifier device.

Furthermore, it is to be understood that the invention is not limited to the specific combination herein described and such variations which do not depart from the spirit and scope of the invention are intended to be covered in the appended claims.

What is claimed is:

1. An electric discharge device comprising an enclosing vessel, a pair of anode surfaces supported therein and having their major portions facing each other, and a ribbon cathode wound in the form of a flattened helix lying substantially parallel to and supported between said anode surfaces, said cathode preventing direct electrical action between said anodes.
2. An electric discharge device comprising an enclosing vessel, a pair of anodes supported therein, an electron emitting electrode interposed between said anodes, a heat shield surrounding said cathode, and separate end shields disposed at the side of said cathode to prevent interaction between the edges of said anodes.
3. An electric discharge device comprising an enclosing vessel, an electron emitting electrode supported therein, and an anode supported on each side of said electrode, each anode being formed of a hollow semi-cylindrical metallic enclosure having a semi-circular metallic portion on each end thereof.
4. A vapor discharge device comprising an enclosing vessel having a stem and containing a vapor producing substance, a plurality of supports extending from said stem, an insulating plate attached to said supports, a ribbon cathode wound helically on said supports in parallel planes with the sections in one plane blocking the spaces between adjacent sections in the other plane, and a plurality of anodes oppositely positioned with respect to each other.
5. A vapor discharge device comprising an enclosing vessel having a stem and containing a vapor producing substance, a plurality of supports extending from said stem, an

insulating plate attached to said supports, a ribbon cathode wound helically on said supports in parallel planes with the sections in one plane blocking the spaces between adjacent sections in the other plane, a plurality of anodes mounted in spaced relation to said cathode, and supporting connections from said anodes to said insulating plate.

6. A vapor discharge device comprising an enclosing vessel having a stem and containing a vapor producing substance, a plurality of supports extending from said stem, an elongated insulating member attached to said supports, a ribbon cathode wound helically on said supports, means on said supports for insulating and spacing said cathode therefrom, a plurality of anodes mounted in spaced relation to said cathode, and a metallic sheath surrounding said cathode and having central cut-out portions.

7. A vapor discharge device comprising an enclosing vessel having a stem and containing a vapor producing substance, a plurality of supports extending from said stem, an insulating plate maintaining said supports in parallel relation, a wide ribbon cathode wound helically on said supports, the ends of said cathode being electrically connected to said supports respectively, a pair of anodes mounted in spaced parallel relation to said cathode, a metallic sheath surrounding said cathode and having openings to permit the flow of electrons from said cathode to said anodes, and means supporting said metallic sheath from said insulating plate.

8. A vapor discharge device comprising an enclosing vessel having a stem and containing a vapor producing substance, a plurality of supports extending from said stem, an insulating member attached to said supports, a ribbon cathode wound helically on said supports in parallel planes, an anode supported on each side of said cathode and having a large surface area for heat dissipation, and a metallic apertured sheath surrounding said cathode, said sheath being insulatingly supported out of contact with said cathode.

9. A vapor discharge device comprising an enclosing vessel having a stem and containing a vapor producing substance, a pair of upright supports extending from said stem, an insulating plate attached to said supports, a ribbon cathode entwined about said supports and having sections lying in two separate parallel planes, an anode mounted on each side of said cathode and supported from said stem, and a heat confining shield substantially surrounding said cathode having centrally positioned openings therein to permit passage of electrons from the cathode to the anodes.

10. A vapor discharge device comprising an enclosing vessel having a stem and containing a vapor producing substance, a plu-

ality of supports extending from said stem, a ribbon cathode entwined about said supports in parallel planes, and a semi-cylindrical anode supported on each side of said cathode and having an aperture in the curved surface thereof, said anode having end shields confining the conducting path to the inner surfaces of said anodes and preventing buckling of said anodes.

10 11. A vapor discharge device comprising an enclosing vessel having a stem and containing a vapor producing substance, a plurality of supports extending from said stem, a ribbon cathode wound helically on said supports in parallel planes, a semi-cylindrical anode supported on each side of said cathode, and curved longitudinal shield members supported between the edges of said anodes.

15 12. An electric discharge device comprising an enclosing vessel, a pair of anodes supported therein insulatingly from each other, and an electron emitting ribbon cathode supported between the anodes, the electron emitting surface of said cathode having an area substantially equal to the area of the adjacent surfaces of each of the anodes.

20 13. An electric discharge device comprising an enclosing vessel, a pair of anodes therein supported and insulated from each other, and a cathode supported between facing surfaces of said anodes, said cathode comprising closely spaced sections of flat material, the cathode occupying substantially all the space between said anodes.

25 In witness whereof, I hereunto subscribe my name this 12th day of September, 1930.

DONALD S. BOND.

40

45

50

55

60

65