March 6, 1951 P. W. STUTSMAN **2,544,513**

GAS DISCHARGE DEVICE

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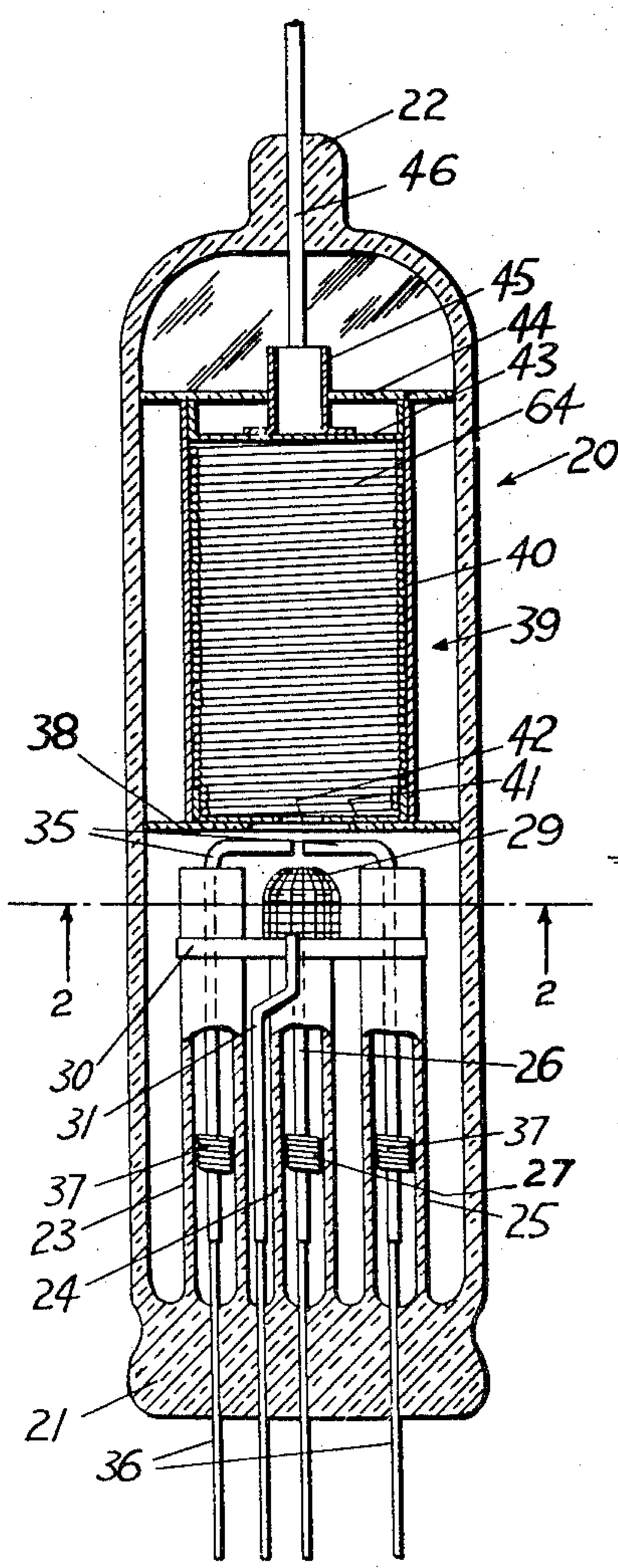

FIG. 1

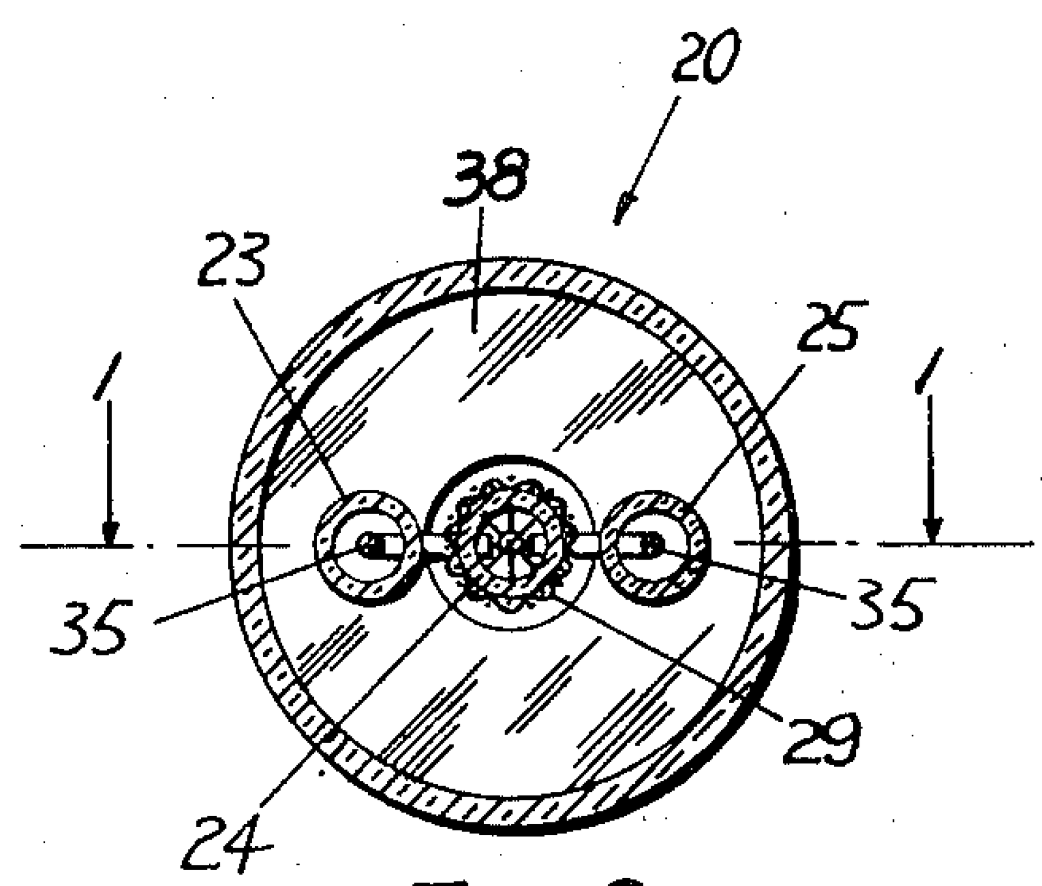

FIG. 2

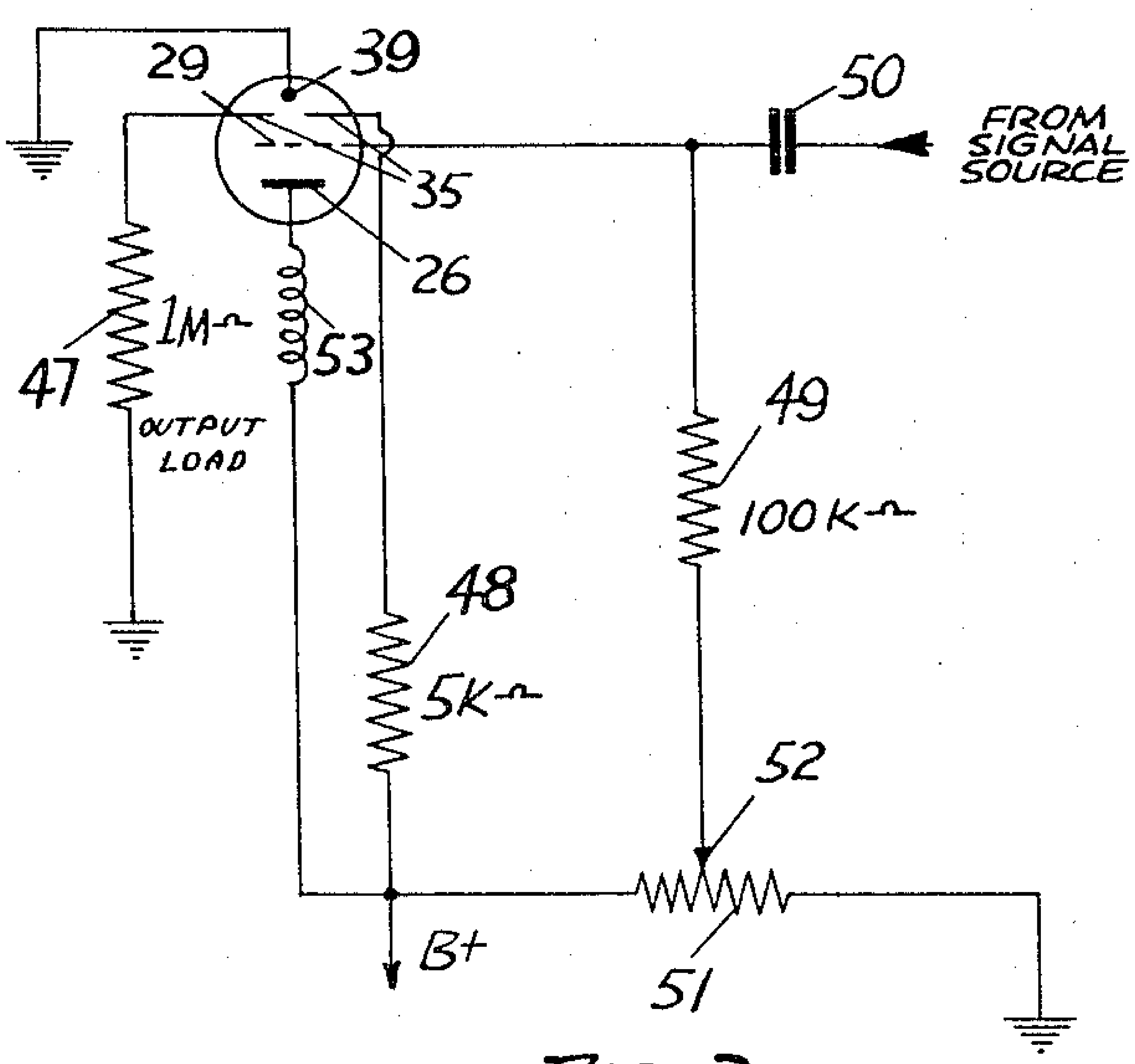

FIG. 3

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GAS DISCHARGE DEVICE

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11 Claims. (Cl. 313—188)

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This application relates to electron discharge devices and more particularly to the structure and utilization circuits of gas-filled, grid-control tubes having cold, main cathodes.

Heretofore in order to obtain gaseous discharge devices having a relatively high grid sensitivity, it has been necessary to thermionically heat the cathode or a portion thereof in order to provide a source of free electrons on which the grid may act. Applicant has produced an improved device wherein free electrons are provided by a glow discharge between a pair of auxiliary electrodes spaced between the cathode and grid of the device. Applicant has discovered that this glow discharge may be reliably operated with currents of less than one milliampere while still providing a sufficient supply of electrons to initiate discharge of the device upon the application of a proper signal to the grid.

Applicant has further provided for initiating the glow discharge with a minimum applied potential by positioning the electrodes at minimum breakdown distances apart for the gaseous medium used. Since these electrodes are simple in shape, being merely bent rods, they may be accurately positioned and spaced. Applicant provides electron emissive material on one or both of said electrodes to aid in reducing the starting potential, the emitting life of said material being relatively long due to the low current of the glow discharge.

By proper spacing of the electrodes and proper choice of a gaseous medium, tubes of this type may be operated over a wide range of voltages, for example, from less than 100 volts to greater than 1,000 volts.

Applicant further provides a cold, main cathode which is hollow, thereby conserving material sputtered from the cathode surface during the main discharge. This main discharge may be varied by the use of different load impedances and different applied voltages from a glow discharge having a current of the order of 100 milliamperes or less up to high peak currents of an arc discharge which may be on the order of 100 amperes.

Also, applicant provides for a gaseous filling in the tube comprising mainly neon containing a small percentage of argon and xenon, whereby the more desirable characteristics of a gaseous medium comprising almost entirely xenon are obtained. Since neon is relatively inexpensive compared with xenon, applicant's filling creates a commercially feasible device.

In addition, applicant provides a circuit par-

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ticularly adapted to use this discharge device, whereby the main voltage is used to provide a keep-alive voltage for the auxiliary glow discharge electrodes and bias for the control grid, thereby eliminating the necessity of auxiliary heater and biasing power supplies.

The particular manner whereby the foregoing advantages may be obtained will now be described in detail, reference being had to the accompanying drawings wherein:

Fig. 1 represents one embodiment of my invention showing a longitudinal cross-sectional view thereof taken along line 1—1 of Fig. 2;

Fig. 2 illustrates a transverse cross-sectional view of the device of Fig. 1 taken along 2—2 of Fig. 1;

Fig. 3 illustrates a circuit utilizing the discharge device shown in Figs. 1 and 2.

Referring now to Fig. 1, there is shown a glass envelope 20 consisting of a tube, one end of which is pressed together as at 21 and through which extend a plurality of lead-in wires. The other end of the glass tube 20 is curved together and contains at its center a mass of glass 22 which is used to seal the envelope after filling of the envelope with the correct gaseous medium. Extending upward from the glass press 21 inside envelope 20 are three glass tubes 23, 24 and 25 whose axes are all parallel and lying in the same plane and spaced an equal distance apart. The center glass tube 24 extends slightly less than half the length of envelope 20. Inside the glass tube 24, which is hollow, is an anode rod 26 which extends from the open end of the glass rod 24 toward the glass press 21 through a spacer 27 consisting of a wire spirally wrapped around anode rod 26. Anode rod 26 is then joined, for example, by welding to a lead-in wire 28 which extends through the glass press 21.

The end of the tube 24, which is open, is covered by a cup-shaped grid 29 of wire mesh which may be made of 60 x 60 strands per inch screening using .005 inch nickel wire. The diameter of the cup-shaped grid 29 is slightly larger than the diameter of the glass tube 24 and extends for somewhat more than one diameter of the glass tube over the end of said rod. The bottom of said cup-shaped grid 29 is in close proximity but not touching the end of the tube 24 and the anode element 26. Cup-shaped grid 29 is supported by being attached as by welding to a strap 30 at the lip of said cup-shaped grid. The strap 30 extends around the tubes 23 and 25, thereby rigidly supporting the grid 29. The tubes 23 and 25 are somewhat longer than the tube 24 and extend further into the envelope 20 past the end of tube 24 covered by grid 29. A lead-in wire 31 is attached to the strap 30 as by welding and extends along the side of envelope 20 through the glass press 21.

Extending the length of rods 23 and 25, which are hollow, are a pair of support rods 35 which are butt welded to a pair of the lead-in members 36 extending through the glass press 21. The rods 35 contain spacers 37 thereon similar to the spacer 27 on anode rod 26. The ends of rods 35 extending out of the glass sleeves 23 and 25 are bent together until they nearly touch, thus forming a gap which is directly above anode 26 and grid 29.

Above the gap between electrodes 35 is a mica support member 38 having a hole therein somewhat greater in diameter than and concentric with grid 29. Above mica member 38 is a cathode 39 comprising a metallic cylinder 40 which may be, for example, of nickel whose diameter is somewhat smaller than the diameter of envelope 20 and whose length is somewhat greater than its diameter. The lower end of the cylinder 40 rests on the mica member 58 and has attached thereto an end plate 41 which may be of nickel and which has a hole 42 therein, concentric with grid 29, and whose diameter is somewhat less than the inside diameter of the glass rod 24. The upper end of the cylinder 40 is sealed by a second end plate 43, and rests against a mica member 44 similar to member 38. A member 45 is attached to the center of end plate 43 and extends through the hole in mica member 44. Attached to the member 45 is a lead-in member 46 which extends through the glass 22 in the upper end of envelope 20. Inside the cylinder 57 is wound a wire 47 which contains electron emissive material, said wire completely covering the inside of cylinder 40.

Referring now to Fig. 3, there is shown a circuit utilizing the species of Figs. 1 and 2. The cathode 39 is connected to ground. One of the electrode wires 35 is connected to ground through a resistance 47, for example, of one megohm. The other electrode wire 35 is connected to a voltage source B+ through a resistance 48, for example, of five kilohms. The grid 29 is connected to a source of positive potential through a resistor 49. The positive potential to which grid 29 is connected through resistor 49 is the variable tap 52 of a potentiometer 51, one end of which is grounded and the other end of which is connected to the aforementioned voltage source. Signals are fed to grid 29 from a signal source through a D. C. blocking condenser 50. The anode 26 is connected to B+ through a load 53, shown here by way of example as a relay coil.

Due to the proximity of the ends of the wires 35 to each other, a voltage applied therebetween causes an electron current to flow from ground through resistor 57 across the gap between electrodes 35, in the form of a glow discharge, and through the resistance 58 to B+ thus providing a keep-alive current. One or both of these electrode tips may be made, for example, of tungsten which is a durable and reliable electron emitter, or they may be coated with any desired electron emissive material.

In operation the variable tap 52 of potentiometer 51 is adjusted so that the device will not fire in the absence of an input signal to the grid 29. This adjustment will vary for different designs of this tube dependent on electrode spac-

ing, gas filling and pressure and the plate voltage applied. When a positive pulse is applied through condenser 50 from the signal source to grid 29, electrons are attracted from the glow discharge between electrodes 35 through grid 29 and are accelerated towards anode 26. When they attain sufficient velocity to ionize the gas between anode 26 and grid 29, the space therebetween breaks down, thus creating a sufficient electrostatic field between grid 29 and cathode 39 to cause positive ions in a gaseous medium to strike cathode 39 with sufficient velocity to cause substantial emission therefrom, thereby creating a discharge between cathode 39 and anode 26. The discharge is then used to operate any desired load, such as the relay 53.

The glow discharge between electrodes 35 is maintained at a low value principally due to the limiting action of resistors 47 and 48. For example, if the B+ voltage were 150 volts, the glow discharge current for the particular design in gaseous filling used herein would be on the order of 100 microamperes and the potential at the glow discharge electrodes would be in the neighborhood of 100 volts relative to ground. Thus it may be seen that by adjusting the tap 52 of potentiometer 51, a bias voltage of substantially less than 100 volts may be applied to grid 29, thereby maintaining grid 29 at a potential more negative than the potential of the glow discharge, with the result that electrons from the glow discharge will not pass through grid 29 to the anode 26. By the use of this circuit, an extra voltage source to act as a bias for the grid as well as the use of an extra voltage source for heating either the cathode 39 or producing the glow discharge between electrodes 35 has been eliminated thereby creating a relatively inexpensive and simplified circuit wherein this particular gas tube may be used.

Since a solid, main cathode is used rather than a mercury cathode, inert gases may be used for filling the device. One desirable mixture comprises a pressure of about twenty centimeters of neon, one millimeter of argon and one millimeter of xenon. With this mixture, very low breakdown voltages may be obtained, with the result that a relatively low voltage is required to initiate the glow discharge. Since the gas pressure used may be relatively high, deterioration of the main cathode by sputtering is minimized. This mixture and pressure has a relatively small breakdown distance which may be utilized by the electrodes used herein since they may be accurately spaced and positioned.

This completes the description of the specific embodiment of the invention illustrated herein. However, many modifications thereof will be apparent to persons skilled in the art without departing from the spirit and scope of this invention. For example, more grids may be used if desired, and different cathode and auxiliary discharge electrode shapes may be used. Therefore, applicant does not wish to be limited to the specific details of the embodiment of the invention illustrated herein except as defined in the appended claims.

What is claimed is:

1. An electron discharge device comprising an envelope containing a gaseous medium, a cathode, an anode, a grid shielding said anode from said cathode, and means for maintaining a discharge in the space between said anode and said cathode independent of electron flow from said cathode to said anode comprising a pair of addi-

tional electrodes between which said discharge occurs.

2. An electron discharge device comprising an envelope containing a gaseous medium, a cathode, an anode, a grid interposed between said anode and said cathode, and means for maintaining a glow discharge in the space between said anode and said cathode independent of electron flow from said cathode to said anode comprising a pair of electrodes, the spacing between said electrodes being substantially equal to the minimum breakdown distance.

3. An electron discharge device comprising an envelope containing a gaseous medium, a cathode, an anode, a grid shielding said anode from said cathode, and means for maintaining a glow discharge in the space between said anode and said cathode independent of electron flow from said cathode to said anode comprising a pair of electrodes, a portion of one of said electrodes comprising electron emissive material.

4. An electron discharge device comprising an envelop containing a gaseous medium, a cathode, an anode, a grid positioned between said anode and said cathode, and means for maintaining a glow discharge in the space between said anode and said cathode independent of electron flow from said cathode to said anode comprising a pair of electrodes between which said discharge occurs, the spacing between said electrodes being substantially equal to the minimum breakdown distance, a portion of one of said electrodes comprising electron emissive material.

5. An electron discharge device comprising an envelope containing a gaseous medium, a cathode, an anode surrounded by a sleeve of insulating material, a grid covering the end of said insulating sleeve and shielding said anode from said cathode, and electrode means for maintaining an electron discharge in the space between said anode and said cathode independent of electron flow from said cathode to said anode comprising a pair of electrodes, the spacing between said electrodes being substantially equal to the minimum breakdown distance.

6. An electron discharge device comprising an envelope containing a gaseous medium, a cathode, an anode surrounded by a sleeve of insulating material, a grid covering the end of said insulating sleeve and shielding said anode from said cathode, and electrode means for maintaining an electron discharge in the space between said anode and said cathode independent of electron flow from said cathode to said anode, comprising a pair of electrodes, the spacing between said electrodes being substantially equal to the minimum breakdown distance, a portion of one of said electrodes comprising electron emissive material.

7. An electron discharge device comprising an envelope containing a gaseous medium comprising neon containing a small percentage of argon and xenon, a cathode, an anode, and means for maintaining a glow discharge in the space between said anode and said cathode independent of electron flow from said cathode to said anode comprising a pair of electrodes, the spacing between said electrodes being substantially equal to the minimum breakdown distance, a portion of one of said electrodes comprising electron emissive material.

8. An electron discharge device comprising an envelope containing a gaseous medium, a cathode, an anode, a grid substantially shielding said anode from said cathode, and a plurality of additional electrodes in the space between said anode and said cathode, a load connected in circuit with said anode, said cathode and a voltage source, means for applying a voltage across said electrodes to maintain a discharge therebetween, and means for applying a biasing voltage to said grid.

9. An electron discharge device comprising an envelope containing a gaseous medium, a cathode, an anode, a grid substantially shielding said anode from said cathode, a source of electrons in the space between said first anode and said first cathode comprising a plurality of electrodes, a load connected in circuit with said anode, said cathode and a voltage source, means for applying a voltage across said electrodes through a current limiting impedance to maintain a discharge therebetween, and means for applying a biasing voltage to said grid comprising a circuit connecting said grid to a voltage divider network.

10. An electron discharge device comprising an envelope containing a gaseous medium, a cathode, an anode, a grid substantially shielding said anode from said cathode, and a plurality of electrodes in the space between said first anode and said first cathode, a load connected with said anode, said cathode and a voltage source, means for applying a voltage across said electrodes through a current limiting impedance to maintain a discharge between and terminating at said electrodes, and means for applying a biasing voltage to said grid comprising a circuit connecting said grid to a voltage divider network through a grid load impedance.

11. An electron discharge device comprising an envelope containing a gaseous medium, a cathode, an anode, a grid substantially shielding said anode from said cathode, and a source of electrons in the space between said first anode and said first cathode comprising a plurality of electrodes, a load connected with said anode, said cathode and a voltage source, means for applying a sufficient voltage across said electrodes through a current limiting impedance to maintain a glow discharge therebetween, and means for applying a biasing voltage to said grid comprising a circuit connecting said grid to a variable voltage divider network through a grid load impedance.

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