Feb. 13, 1940. W. L. MEIER 2,190,079

GAS DISCHARGE TUBE

Filed Oct. 29, 1937 2 Sheets-Sheet 1

Fig. 1

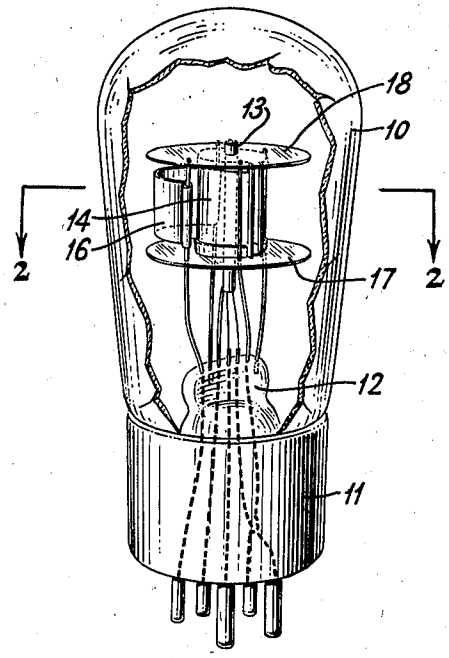


Fig. 2

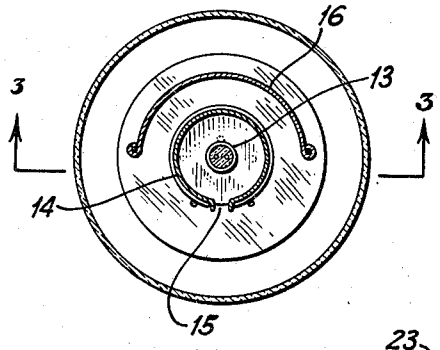


Fig. 3

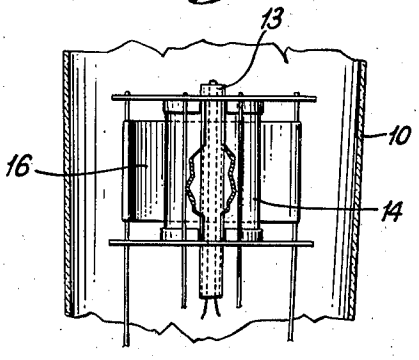
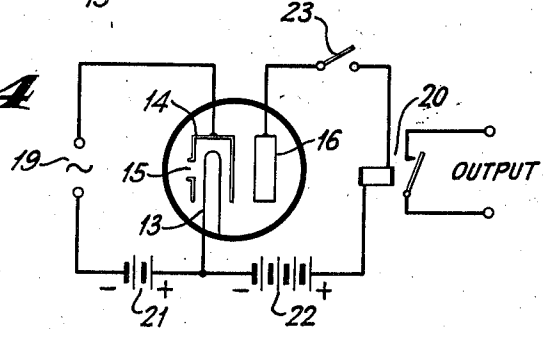


Fig. 4



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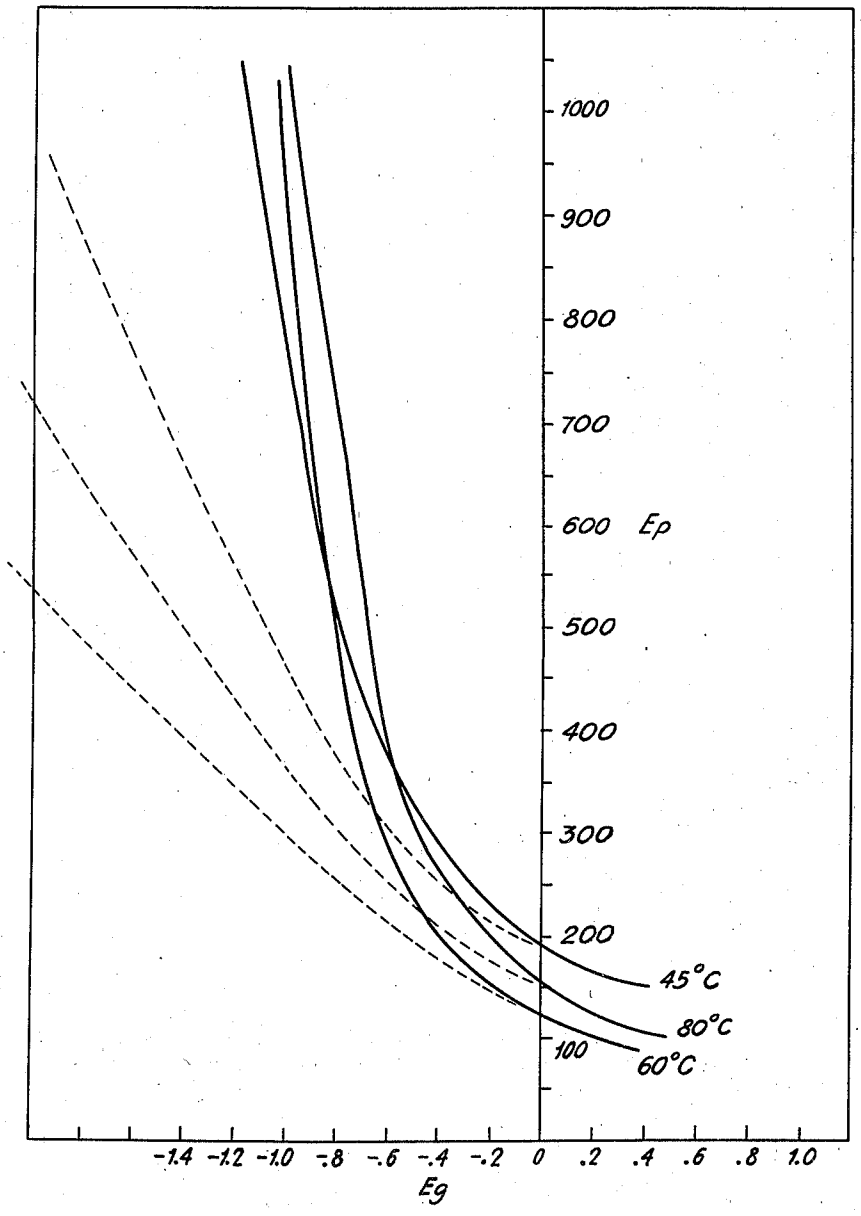
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Fig. 5



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UNITED STATES PATENT OFFICE

2,190,079

GAS DISCHARGE TUBE

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Application October 29, 1937, Serial No. 171,637

7 Claims. (Cl. 250—27.5)

My invention relates to electron discharge devices, more particularly to grid controlled gas discharge tubes.

In one form of gas discharge tube employing a vapor atmosphere, particularly mercury vapor, the tube is provided with a thermionic cathode and anode and a control electrode positioned between the two, the gas discharge being controlled by the voltage applied to the control electrode. In this type of tube the control electrode or grid controls the starting of the discharge but normally has no effect upon stopping the discharge. The anode voltage is usually removed to stop the discharge and return control to the grid. With this conventional arrangement the voltage applied to the grid is usually just sufficiently negative to prevent the tube from breaking down to permit a gas discharge until such time as desired by the application of a positive voltage to the grid to overcome its bias. This negative voltage must be increased as the condensed mercury temperature and vapor pressure increases to prevent an undesired discharge. This change in the grid breakdown voltage with change of temperature and gas pressure is particularly undesirable since the constants of the circuit elements are usually fixed and a change in the grid starting voltage interferes with the proper operation of the tube and circuit with which it is employed. It has been customary in order to prevent this erratic operation with changing temperature and pressure to provide some means for controlling the temperature of the tube so that its characteristics would remain constant. These arrangements usually result in additional apparatus which is not always simple, increasing the cost and complicating the apparatus in which the tube is used.

It is, therefore, a principal object of my invention to provide a grid controlled gas discharge tube having improved characteristics, more particularly a gas discharge tube having a grid voltage breakdown characteristic which is substantially independent of varying condensed mercury temperature and vapor pressure.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims, but the invention itself will best be understood by reference to the following description taken in connection with the accompanying drawings in which Figure 1 is a perspective with part of the envelope broken away of an electron discharge device made according to my invention, Figure 2 is a section taken along the line 2—2 of Figure 1, and Figure 3 is a longitudinal section taken along the line 3—3 of Figure 2, Figure 4 is a circuit diagram including an electron discharge device made according to my invention, and Figure 5 is a graph showing the characteristics of a conventional grid controlled gas discharge tube and a gas discharge tube made according to my invention.

Referring to Figures 1 and 2, an electron discharge device made according to my invention is provided with the usual envelope 10 having a base 11 and press 12 from which the electrode mount assembly is supported. The mount assembly may comprise an indirectly heated cathode 13 surrounded by a solid metal control electrode 14 of cylindrical shape coaxial with the cathode and provided with a longitudinally extending aperture 15 parallel to the cathode. Mounted on the outside of the control electrode 14 and on the opposite side from said longitudinal slot is a semi-cylindrical anode 16, which is out of a direct line with the aperture 15, the electrode 14 serving also as an electrostatic shield and segregating the cathode from the anode and preventing the field from the anode extending to the cathode. The electrodes are supported between a pair of insulating spacers 17 and 18, preferably of mica, which with the control electrode 14 completely surround the cathode 13, except for the longitudinal opening 15.

A circuit employing a tube made according to my invention is shown in Figure 4. The input voltage is applied by a source 19 between the control electrode 14 and cathode 13, the voltage supply source 21 being that required for negatively biasing the electrode 14 to prevent discharge until voltage from source 19 is applied. The anode 16 is connected through an output 20 to one side of the voltage supply source 22. A switch 23 may be used to remove the anode voltage and stop the discharge after it has once been started. With a tube made according to my invention temperature and pressure changes have substantially no effect on the biasing voltage required to prevent breakdown with the anode voltage selected. This biasing voltage is substantially the same under different temperature and pressure conditions so that the circuit constants for a given anode voltage need not be changed and the circuit will operate satisfactorily under substantially all conditions of temperature and pressure within the tube.

While I do not wish to be limited to any particular theory, I believe that the successful op-

eration of a tube made according to my invention can be explained as follows:

In the conventional grid controlled gas discharge tube, as the temperature and vapor pressure increase, ionization takes place more readily so that the number of electrons necessary to cause sufficient ionization for a gaseous discharge is decreased. Thus with a given negative bias sufficient electrons may be present in the grid-anode space at the higher temperatures and pressures to cause breakdown where this number would be insufficient at the lower temperatures and pressures. It is, therefore, necessary to reduce the number of electrons in this space to prevent a discharge at these higher vapor temperatures and pressures. To obtain this condition it is necessary to increase the negative bias on the grid to prevent breakdown. In a tube made according to my invention the tube is self-regulating so that the available electrons for starting the discharge are automatically decreased in the proper extent to prevent the discharge as the temperature and pressure of the vapor increase.

In operation of a tube made according to my invention, the control electrode 14 has applied to it a negative voltage so that the electrons emitted by the cathode assume a distribution such that the electron density is greatest near the cathode and less at a greater distance from the cathode except at the opening 15. This results in the formation of a cloud of electrons on the outside of and adjacent the opening 15 in the control electrode 14. Since the cathode is shielded from the anode field, only the electrons in this cloud are affected by the field from the anode and are attracted to the anode. With proper voltages applied to the grid and anode, a sufficient number of electrons will be attracted from the cloud to provide the ionization necessary of the mercury vapor within the tube to cause breakdown of the tube. With a tube made according to my invention the grid breakdown voltage for any selected anode voltage is substantially independent of the mercury vapor temperature and pressure. It is believed that as the temperature of the mercury vapor and its pressure increase the cloud of electrons is in effect compressed toward the cathode through the opening in the control electrode 14 so that the available electrons for providing the starting cathode-anode current is decreased. However, at higher vapor temperatures and pressures ionization takes place more readily so that fewer electrons will produce the ionization necessary to cause breakdown. Thus, these two effects balance each other, and by properly designing the elements of the tube it is possible to provide a tube such that the electrons available in the electron cloud are just sufficient at various mercury vapor temperatures and pressures to cause breakdown of the tube at substantially the same grid voltage for a selected anode voltage. In this way the grid breakdown voltage is made independent of the mercury vapor temperature and pressure. In the conventional type of tube, where the anode is not completely shielded from the cathode, as the mercury vapor pressure is increased it is necessary to increase the negative bias on the grid to prevent breakdown, as described above.

A comparison of the grid voltage breakdown characteristic of a conventional grid controlled gas discharge tube and a tube made according to my invention is shown in Figure 5. The dotted lines represent the characteristics of the conventional tube and the solid lines a tube made according to my invention. It will be noted that with the conventional tube that with different tempertures of the condensed mercury vapor that the differences in the grid breakdown voltage vary considerably and increase with an increase in anode voltage, at 500 volts the difference between 45 and 60° C. being substantially .8 of a volt, this difference increasing at higher anode voltages. In a tube made according to my invention the difference between the starting voltages at 45 and 60° C. is substantially zero. The curves for 45, 60 and 80° C. in a tube made according to my invention substantially overlie each other. The difference in starting voltages is less than minus .2 volt over a wide range of voltages. It will thus be apparent in a tube made according to my invention, that the grid breakdown voltage is substantially independent of changes in condensed mercury temperatures and corresponding pressure.

While I have indicated the preferred embodiments of my invention of which I am now aware and have also indicated only one specific application for which my invention may be employed, it will be apparent that my invention is by no means limited to the exact forms illustrated or the use indicated, but that many variations may be made in the particular structure used and the purpose for which it is employed without departing from the scope of my invention as set forth in the appended claims.

What I claim as new is:

1. An electron discharge device having an envelope containing a vapor atmosphere, a thermionic cathode within said envelope for emitting electrons, discharge control means surrounding and enclosing said cathode but electrically insulated therefrom and provided with a single opening through which said electrons may pass, and an anode outside of said control means and outside of a direct line with said opening but symmetrically positioned with respect to the control means and said cathode whereby the control means shields said cathode from the anode so that the field from the anode does not extend to said cathode.

2. An electron discharge device having an envelope containing a vapor atmosphere, a straight thermionic cathode within said envelope for emitting electrons, a solid discharge control electrode surrounding and enclosing the cathode but electrically insulated therefrom and having a single longitudinal opening parallel to the cathode, an anode outside of said control electrode and symmetrically positioned with respect to the solid control electrode and the cathode and so disposed with respect to the opening in said control electrode that said control electrode shields said cathode from said anode whereby the field from the anode does not extend to the cathode.

3. An electron discharge device having an envelope containing a mercury vapor atmosphere, a straight thermionic cathode within said envelope for emitting electrons, a solid cylindrical discharge control electrode having closed ends surrounding said cathode and electrically insulated from said cathode and provided with a single longitudinal slot parallel to said cathode and an anode outside of said control electrode and on the opposite side of said control electrode from said slot and symmetrically positioned with respect to the solid cylindrical control electrode and said cathode.

4. An electron discharge device having an envelope containing a mercury vapor atmosphere, a

thermionic cathode within said envelope for emitting electrons, a solid discharge control electrode electrically insulated from but surrounding and enclosing and coaxial with said cathode and provided with a single opening through which electrons can pass to form a cloud of electrons outside of said control electrode adjacent said opening and an anode outside of said control electrode and positioned symmetrically with respect to the solid control electrode and the cathode and so disposed that the field from said anode extends to said cloud of electrons but not to said cathode.

5. An electron discharge device having an envelope containing a vapor atmosphere, a single thermionic cathode within said envelope, a cylindrical discharge control electrode electrically insulated from and surrounding and coaxial with said cathode and provided with a longitudinal opening, insulating members closing the ends of said control electrode whereby the cathode is completely enclosed except through said opening, an anode outside of said control electrode and positioned on the other side of said control electrode from said opening and symmetrically with respect to the control electrode and the cathode.

6. An electron discharge device having an envelope containing a vapor atmosphere, a straight thermionic cathode within said envelope, and a discharge control electrode surrounding but electrically insulated from said cathode and provided with a longitudinal opening parallel to the cathode, said control electrode having its ends closed by insulating members whereby the cathode is completely enclosed except through said opening, said control electrode confining the electrons from said cathode within the space between the cathode and the control electrode except for the opening adjacent which and outside of which control electrode a cloud of electrons forms, and an anode positioned symmetrically with respect to the control electrode and the cathode and outside said control electrode and out of a direct line between the cathode and said opening whereby the field from said anode does not extend to said cathode but does reach the cloud of electrons adjacent the opening in said control electrode.

7. An electron discharge device having an envelope containing a vapor atmosphere, a single electron emitting cathode within said envelope, a solid metallic cylindrical electrode surrounding and enclosing said cathode but electrically insulated from said cathode and having a single longitudinal opening in the side wall thereof for controlling initiation of the discharge through said device and an anode outside of said control electrode, said metallic control electrode segregating said cathode from said anode to provide a discharge barrier between the cathode and anode except through the opening in said control electrode, said anode being positioned symmetrically with respect to the cathode and cylindrical electrode surrounding the cathode and disposed so that the field from said anode cannot extend through said opening to said cathode.

WILBER L. MEIER.