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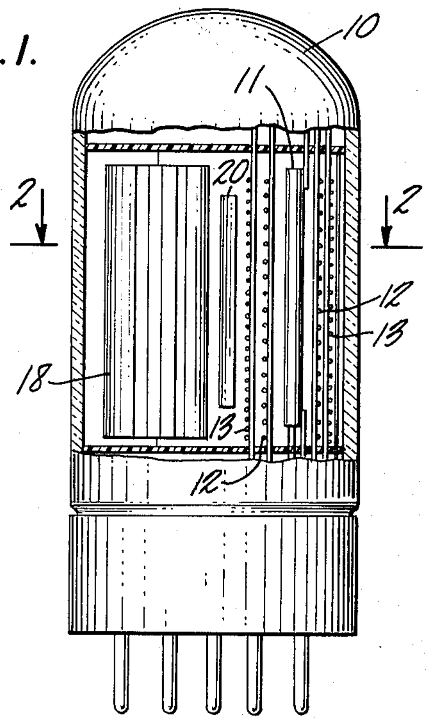
VACUUM TUBE HAVING THYRATRON CHARACTERISTICS

Filed July 13, 1959

FIG. 1.



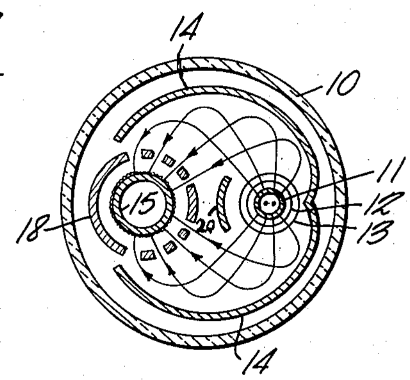


FIG. 2.

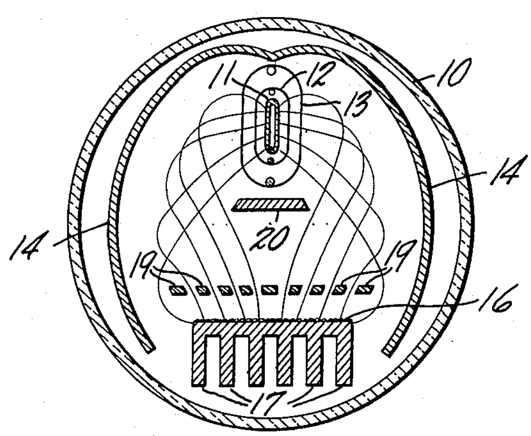


FIG. 3.

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VACUUM TUBE HAVING THYRATRON CHARACTERISTICS

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8 Claims. (Cl. 313—71)

This invention relates to a vacuum tube which has all the characteristics of a gas-filled thyratron discharge device. It has patricular reference to a vacuum discharge device having one cold cathode and one hot cathode with means for initiating a discharge between the cold cathode and an adjacent anode which, when started, continues to conduct regardless of the condition of the initiating control unit.

Thyratrons having either hot or cold cathodes with firing grids and various types of gas fillings have been well known for some time and have been very useful in the electronic industry. An important characteristic of the thyratron is its ability to support conduction between its anode and cathode after having been fired by the control electrode. After conduction has been started the thyratron can be changed to a non-conducting condition only by reducing the anode voltage to zero. When the conduction between anode and cathode is stopped the anode voltage can not again be applied until after a certain time interval known as the deionization time. Some selected gases at certain pressures have a very short deionization time but this feature of the thyratron tubes is a distinct disadvantage when working with high frequencies.

The present invention comprises a vacuum tube without any appreciable gas within its envelope and for this reason the gas deionization time is zero. After conduction has been cut off between the anode and its adjacent cold cathode the voltage may be applied immediately without starting anode-cathode conduction. This feature and other advantages to be described later make the discharge device a useful electronic component with a combination of features exhibited by no other electronic tube.

One of the objects of this invention is to provide an improved electron discharge device which avoids one or more of the disadvantages and limitations of prior art arrangements.

Another object of the invention is to provide a vacuum discharge device having most of the characteristics of a thyraton gaseous discharge device.

Another object of the invention is to provide a cold cathode discharge device which has low internal resistance and high efficiency.

Another object of the invention is to provide a discharge device having most of the characteristics of a gaseous thyratron without the disadvantages encountered because of gas clean up, gas impurities, change in pressure due to temperature effects, and many other disadvantages generally associated with gas-filled tubes.

The new vacuum tube includes a diode comprising a cold cathode with a magnesium oxide coating and an adjacent anode with apertures for the application of electrons from an outside source. In the same envelope a hot cathode is mounted surrounded by a control grid and a screen grid. In order to direct electrons from the hot cathode to the cold cathode an electrostatic shield is used. This shield generally surrounds the hot cathode elements and is maintained at a zero or a negative potential with respect to the hot cathode.

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For a better understanding of the present invention, together with other and further objects thereof, reference is made to the following description taken in connection with the accompanying drawing.

Fig. 1 is a side view of the vacuum discharge device with some parts in section.

Fig. 2 is a cross sectional view of the tube shown in Fig. 1 and is taken along line 2—2 of that figure.

Fig. 3 is a cross sectional view similar to Fig. 2 but showing an alternate arrangement of components.

Referring now to the drawing, the discharge device includes an envelope **10** which encloses a hot cathode **11** surrounded by a control grid **12** and a screen grid **13**. The hot cathode may be fabricated in the usual manner and includes a heater and a hollow metallic support for emitter material. The control grid **12** is preferably made of a wire mesh or the usual parallel wire construction and is connected to an external source of potential which may be varied between a negative cut-off potential of about 10 volts to zero potential when the diode elements are to be made conductive. The screen grid has the same general structure as the control grid and is maintained at a positive potential with respect to the cathode **11** of about 150 to 250 volts. The screen grid is designed to give the electron beams a medium velocity for traveling toward the cold cathode.

Surrounding most of the hot cathode structure is an electrostatic shield **14** which is maintained at zero potential with respect to the hot cathode. This shield serves to deflect and redirect the electron beams as they are emitted from the hot cathode.

The diode portion of the vacuum tube includes a hollow cylindrical cold cathode **15** as shown in Fig. 2. The same cathode is shown in Fig. 3 as a plane metal surface **16** having cooling fins **17** on one side. The cold cathode surface is coated with a porous coating of magnesium oxide and may be maintained at a potential of 200 volts positive with respect to the hot cathode **11**. Surrounding the cathode, as shown in Fig. 2, is a cylindrical anode **18** having a plurality of apertures for the passage of electron streams from the hot cathode. As shown in Fig. 3 the anode **19** comprises a plurality of vertical rods connected together at their ends but spaced apart from each other for the passage of electrons. In order to shield the cold cathode coating, a mask **20** is placed adjacent to one portion of the screen grid. This mask protects the magnesium oxide from molecular impurities given off by the hot cathode. It is normally connected to the hot cathode.

When the tube is operated, the following voltages are applied to the electrodes:

Hot cathode **11**	0 volts—ground.
Control grid **12**	−10 volts.
Screen grid **13**	200 volts.
Electrostatic shield **14**	0 volts—ground.
Cold cathode **15, 16**	200 volts.
Anode **18, 19**	400 to 600 volts.

With the above potentials, no conduction results because the negative potential of the control grid prevents any electrons from leaving the space adjoining the hot cathode. To produce conduction between the cold cathode and anode, the control grid is raised from −10 volts to about zero and a supply of electrons is projected through the two grids to the space within the shield **14**. The electrons have considerable speed because of the high voltage on the screen grid, and they are deflected by the electrostatic field between the shield and the other electrodes and are directed toward the cold cathode which is 200 volts more positive than the hot cathode.

When the streams of electrons strikes the cold cathode they cause secondary emission from the porous magnesium oxide coating. These secondary electrons are drawn toward the anode **18** of Fig. 2 or **19** of Fig. 3. The emission from the magnesium oxide coating is thereby started and such emission continues as long as the anode is maintained at a voltage of at least 180 volts above that of the cold cathode. The anode-cathode current is maintained between the cold cathode and anode as long as the potential difference between them is sufficient to cause electron emission regardless of the action of the hot cathode source **11, 12, 13.** It is even possible to turn off the heater current and disconnect all voltage sources to the cathode **11,** grids **12** and **13** and to the shield **14.**

When the potential difference between anode **18** or **19** and the respective cold cathode **15** or **16** is reduced to a low value or zero, the current between them immediately stops, irrespective of the voltages applied to the hot cathode and grids **12** and **13.** After the potential difference is restored conduction is again under control of the control grid **12** which controls the electron streams from the hot cathode. Thus the new tube, like a gas thyratron tube, is triggered by application of voltage to the control grid **12,** assuming the anode voltage is sufficiently above that of the cold cathode, and is quenched by reduction of anode potential, the control grid losing control once conduction is started and anode voltage is maintained. Unlike a gas thyratron, no delay in quenching is introduced by deionization time.

It will be obvious from the above description that the electrons from the hot cathode serve only to start the emission from the cold cathode and serve no other useful purpose. It has been found by experiment that very high speed starting of the cold cathode emission can be accomplished by this means. If the electron bombardment of the magnesium oxide coating has sufficient energy, starting times of the order of one microsecond or less are possible.

In the foregoing example, a hollow heated cathode was described within control grid **12.** A filamentary cathode of tungsten can be used with the same results.

The tube shown in Fig. 3 is the same as Fig. 2 except that the cathode emitting surface **16** is plane and its support is provided with heat radiators **17.** The anode **19** is disposed in parallel relationship and contains holes or channels for the passage of electron streams from cathode **11.**

The characteristics of the diode **15, 18** of Fig. 2 and the diode **16, 19** of Fig. 3 have been disclosed in U.S. patent applications filed February 25, 1959, Serial No. 795,514 and April 24, 1959, Serial No. 808,618, both by Bernard G. Firth.

The foregoing disclosure and drawings are merely illustrative of the principles of this invention and are not to be interpreted in a limiting sense. The only limitations are to be determined from the scope of the appended claims.

I claim:

1. An electron discharge device comprising: a sealed envelope enclosing a cold cathode having a coating of porous magnesium oxide, an anode adjacent to the cold cathode and having holes for the passage of electrons, a source of electrons which includes a hot cathode, a control electrode, and a screen grid, and an electrostatic shield surrounding said electron source, said shield designed to change the directions of electrons emitted by the hot cathode source to direct them toward the cold cathode.

2. An electron discharge device comprising: a sealed envelope enclosing a thermionic cathode with a control electrode for controlling the flow of electrons therefrom, a cold cathode having a coating of magnesium oxide, an adjacent anode containing holes for the passage of electrons, and means for directing a primary stream of electrons from the thermionic cathode through the anode holes to the cold cathode.

3. An electron discharge device comprising: a sealed envelope enclosing a thermionic cathode with a control electrode for controlling the flow of electrons therefrom, a cold cathode having a coating of magnesium oxide, an adjacent anode containing holes for the passage of electrons, and a curved electrode with its concave surface facing both cathodes for constraining the electrons emitted by the thermionic cathode to follow a curved path toward the cold cathode.

4. An electron discharge device comprising: a sealed envelope enclosing a thermionic cathode with a control electrode for controlling the flow of electrons therefrom, a cold cathode having a coating of magnesium oxide, an adjacent anode containing holes for the passage of electrons, means for directing a primary stream of electrons from the thermionic cathode to the cold cathode, and a solid shield mounted between said thermionic cathode and said cold cathode and extending across any straight line between any point of the thermionic cathode and the cold cathode.

5. An electron discharge device comprising: a sealed envelope enclosing a thermionic cathode having an adjacent control electrode and a screen grid, a cold cathode spaced apart from the thermionic cathode and having a coating of porous magnesium oxide, an anode mounted in parallel relationship to said cold cathode and containing holes for the passage of electrons from the thermionic cathode, a curved electrode with its concave surface facing both cathodes for constraining the electrons emitted by the thermionic cathode to follow a curved path toward the cold cathode, and a solid shield mounted between the thermionic cathode and the cold cathode and extending across any straight line between any point of the thermionic cathode and the cold cathode.

6. An electron discharge device comprising: an evacuated envelope enclosing a cold cathode having a porous coating thereon of the type adapted to emit a stream of electrons once emission is initiated, which emission becomes self-sustaining provided there is present an electrode of sufficiently higher potential for collection of the emitted electrons, an apertured anode adjacent said cold cathode to serve as a collector electrode for electrons emitted by said coating, a source of thermally generated electrons, at least one grid for controlling electrons from said source and an electrostatic shield for directing electrons from said source through the apertures in said anode toward said cathode to initiate electron emission therefrom, whereby conduction between said cathode and anode may be triggered by control potentials applied to said grid and quenched by reduction of potential of said anode.

7. The electron discharge device according to claim 6 including a solid shield mounted between said source and said cathode and extending across any straight line between any point of the source and the cathode.

8. The device according to claim 6 wherein said source of thermally generated electrons is a heated cathode, said grid is a control grid encompassing said heated cathode and wherein an electron accelerating grid encompasses said control grid.

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