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H. KLEMPERER  
ELECTRON DISCHARGE DEVICE

2,067,966

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*Fig. 1*

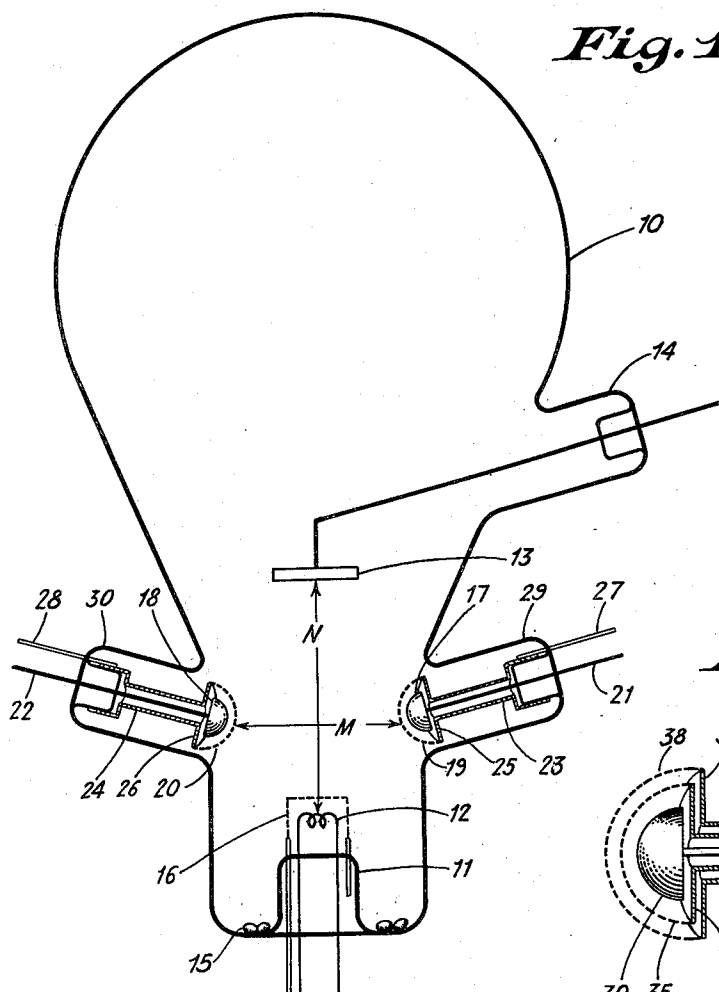


*Fig. 2*

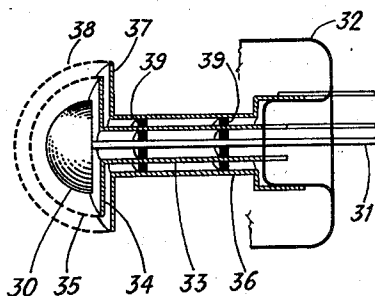
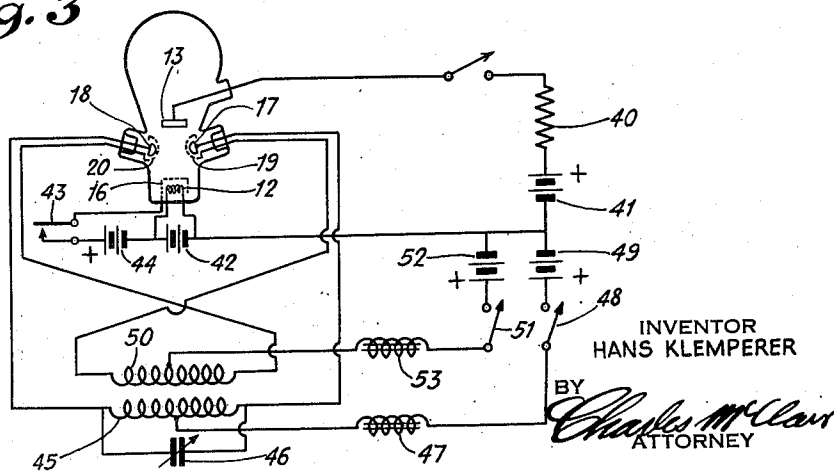


*Fig. 3*



## UNITED STATES PATENT OFFICE

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## ELECTRON DISCHARGE DEVICE

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4 Claims. (Cl. 250—27.5)

My invention relates to electron discharge devices of the gaseous type, more particularly to such devices using an arc as a source of electrons.

In one form of conventional electron discharge device in which an arc is established in a gaseous atmosphere to provide a source of electrons, the discharge takes place between a pair of electrodes separate and distinct from the output anode, and a control grid is interposed between the anode and the arc discharge to control the electron flow to the output anode. The conventional tubes of this type have so far been unsatisfactory in oscillating circuits particularly in radio frequency circuits because of the large and variable lag of the controlled electron current behind the controlling voltage. Because of this lag the use of this type of tube has not been feasible for the generation of high frequency oscillations, and has not been practical for amplification of audio frequencies because of the difficulty of obtaining constant amplification characteristics between zero current and the arc-over point, particularly with low frequency alternating voltages applied to the control grid. Furthermore, because of the heavy grid current drawn by these tubes the power dissipated in the grid circuit has been very high, making these tubes inefficient.

It is the principal object of my invention to provide an improved type of gas discharge tube using an arc to provide a source of electrons.

It is a further object of my invention to provide such a tube which is satisfactory at radio frequencies, is efficient in operation, and has a large power output.

The preferred embodiment of my invention comprises an envelope containing a pair of electrodes and an ionizable medium at a pressure such that a self-sustaining discharge may be maintained in a path between the electrodes and a pair of output anode members positioned on opposite sides of the discharge path, each of the anodes being completely shielded from the discharge by a shield and a control grid spaced from the anode a distance less than the mean free path of a positive ion in the ionizable medium under operating conditions of the electron discharge device. By properly spacing the anodes with respect to the arc discharge path I am able to obtain at radio frequencies accurate control similar to that of a high vacuum tube having a thermionic cathode as a source of electrons. The tube is particularly suitable for the generation of high frequency oscillations and has a large power output.

The novel features which I believe to be char-

acteristic 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 drawing in which Figure 1 is a vertical section of an electron discharge device shown diagrammatically and embodying one form of my invention; Figure 2 is a section of a modification of the oscillation anode used in the electron discharge device shown in Figure 1; and Figure 3 is a diagrammatic representation of an electron discharge device made in accordance with my invention incorporated in an oscillating circuit.

In Figure 1 the electron discharge device has an evacuated envelope 10 provided at one end with a press 11. The self-sustaining discharge is maintained between a thermionic cathode 12 in the press and a main anode 13 supported in an arm 14 at one side of the envelope. The gaseous atmosphere for supporting the self-sustaining discharge between these two electrodes when proper operating voltages are applied, may be any inert gas such as argon and the like, although I prefer a mercury vapor atmosphere supplied by a few drops of mercury 15 in the bottom of the tube. The vapor within the tube is ionized and the discharge between the cathode 12 and anode 13 initiated by an auxiliary control electrode 16. When once established the arc will maintain itself as long as the operating voltage is maintained.

In accordance with my invention I mount on opposite sides of the discharge path between the electrodes 12 and 13 a pair of oscillation anodes 17 and 18 with control grids 19 and 20 interposed between the anodes and the discharge path. The control grids preferably cover the anodes and may for example be hemispherical as shown in the drawing. The spacing between the anodes 17 and 18 and their control grids 19 and 20 is less than the mean free path of a positive ion in the ionizable medium under operating conditions of the tube to prevent any chances of sufficient ionization to support a self-sustaining discharge in this space. The oscillation anodes and the control grids may be supported in any convenient manner, preferably by mounting the anodes on support leads 21 and 22 and the grids on tubular grid leads 23 and 24 surrounding and shielding the anode leads and having on their inner ends disc members 25 and 26 to which the grids are secured and connected at their other ends to grid leading-in wires 27 and 28. The anode leads and grid conductors may be carried

by stems in the outer ends of arms 29 and 30 on the envelope. In operation the arc discharge between the cathode 12 and main anode 13 is a source of electrons which are drawn from the arc stream thru the control grids to the oscillator anodes.

While the spacing between the oscillator or output anodes 17 and 18 and the arc discharge path is not critical, I have found for best results that the distance between these anodes and the arc discharge path should be less than one-half but greater than one-quarter of the distance between the cathode 12 and anode 13. If the distance between the cathode 12 and anode 13 is represented by N and the distance between the oppositely disposed oscillator anodes is represented by M, then M should be less than the distance N but greater than one-half the distance N. If the anodes are spaced too close to the arc discharge, loss of control will result and instead of obtaining a pure electron flow an arc discharge will take place between cathode 12 and the oscillator anodes, thus interfering with the proper operation of the tube at radio frequencies. If the anodes are placed too far away from the arc discharge path, the electrons available will be insufficient for proper functioning of the tube and if an attempt is made to increase the number of electrons to the oscillator anodes by raising the voltage on the anodes an arc discharge to these anodes may take place.

In one example of my invention making use of mercury vapor and with a voltage of between 20 and 25 volts applied between the cathode 12 and anode 13, I have found that with a mesh grid of 10 mil. wire spaced approximately 1 or 2 millimeters apart and with the distance between the anode and the mesh control grid of the order of 2 millimeters a bias voltage of plus 3 volts on the grid will give very good control with oscillator anode voltages between zero and the voltage applied between the main anode 13 and the cathode 12.

If it is found desirable to have the oscillator anodes closer to the discharge path or if the capacity between the control grid and the anode limits the upper frequency at which the tube will operate, a screen grid may be placed between the anode and the control grid. This arrangement will decrease the liability of an arc discharge between the oscillator anode and the arc discharge path and by reducing the control grid to oscillator anode capacity will increase the upper frequency at which the tube will operate.

In Figure 2 I have shown the oscillator anode provided with a screen grid. The anode 30 is supported by means of the support and lead conductor 31 mounted in an extension 32 of an envelope. Surrounding the support is the tubular shield and grid lead 33 supporting the disc member 34 and screen grid 35. Concentric with the tube 33 is the outer shield and grid lead 36 supporting the disc-like member 37 and the control grid 38. Insulating members 39 properly separate the shields 33 and 36 and conductor 31.

While I have shown the grid conductors or anode shields in Figures 1 and 2 as concentric metal tubes, the capacity introduced by these metal tubes can be reduced either by shortening of the extensions 29, 30 and 32 and thus shortening the supports and shields, or I may make these shields of insulating material.

While not limited thereto I prefer to use the electron discharge device embodied in my invention in the type of circuit shown in Figure 3.

Voltage is applied between the cathode 12 and the main anode 13 thru resistor 40 from the voltage supply source 41. The arc discharge between the cathode 12 which is energized from a source of voltage 42, and the main anode 13 is initiated when switch 43 is closed to connect the supply voltage source 44 to the auxiliary grid 16. After it is established, the arc is self-sustaining but can be interrupted by removing the anode voltage. The oscillator anodes 17 and 18 are connected to opposite sides of an oscillating circuit comprising an inductance 45 and variable condenser 46 by means of which the frequency of the oscillating circuit can be changed. Voltage is applied to the anodes 17 and 18 thru a choke 47 when switch 48 is closed to complete a circuit to the voltage supply source 49. The control grids 19 and 20 are connected to opposite ends of an inductance 50 coupled to the oscillating circuit to provide oscillations when switch 51 is closed to apply a voltage to the grids from the voltage supply source 52 thru choke 53. This circuit operates in the well-known push-pull fashion. The frequency range can be varied by changing the condenser setting.

While I have indicated the preferred embodiment 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.

#### I claim:

1. An electron discharge device having an envelope containing a pair of electrodes and an ionizable medium for supporting a self-sustaining discharge between said pair of electrodes, an anode within said envelope spaced to one side of the discharge path between said pair of electrodes at a distance greater than one fourth the distance between said pair of electrodes, a control electrode over said anode and shielding all parts of the anode from said discharge for controlling the electron current to said anode, the distance between said anode and said control electrode being less than the mean free path of positive ions in the ionizable medium during operation of the electron discharge device.

2. An electron discharge device having an envelope containing a pair of electrodes and an ionizable medium for supporting a self-sustaining discharge between said pair of electrodes, a pair of oppositely disposed anodes positioned on opposite sides of the path of said discharge between said pair of electrodes and spaced therefrom, and a control electrode over each of said anodes and shielding all parts of the anode from said discharge the distance between said anodes being less than the distance between said pair of electrodes but greater than one-half the distance between said pair of electrodes.

3. An electron discharge device having an envelope containing a pair of electrodes, and an ionizable medium for supporting a self-sustaining discharge between said pair of electrodes, an anode within said envelope spaced to one side of the discharge path between said pair of electrodes a distance less than half but more than a quarter of the distance between said pair of electrodes and having a support rod supported from the wall of said envelope, a shield surrounding said sup-

port rod and provided with a foraminous portion over the anode, the distance between said foraminous portion and said anode being less than the mean free path of positive ions in the ionizable medium during operation of said electron discharge device.

4. An electron discharge device having an envelope containing a pair of electrodes and an ionizable medium for supporting a self-sustaining discharge between said pair of electrodes, an anode within said envelope spaced to one side of

the discharge path between said pair of electrodes and having a support rod supported from the wall of said envelope, a shield surrounding said support rod and provided with a foraminous portion over the anode, a second shield between said support rod and said first shield and provided with a foraminous portion between the foraminous portion on said first shield and the surface of said anode.

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10