Sept. 13, 1938. W. L. MEIER 2,130,191

ELECTRON DISCHARGE DEVICE AND CIRCUIT

Filed Jan. 25, 1938

Fig. 1

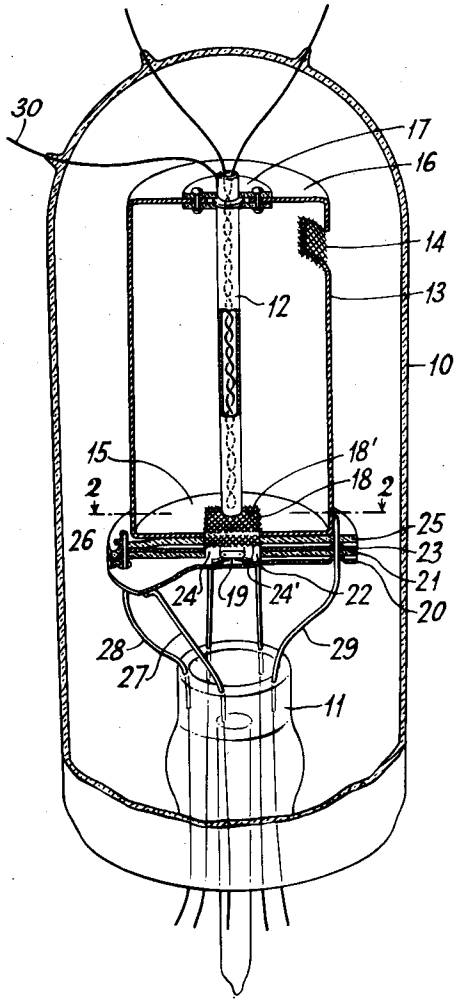


Fig. 2

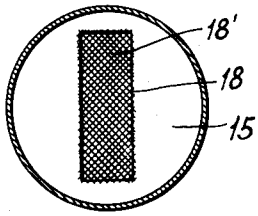
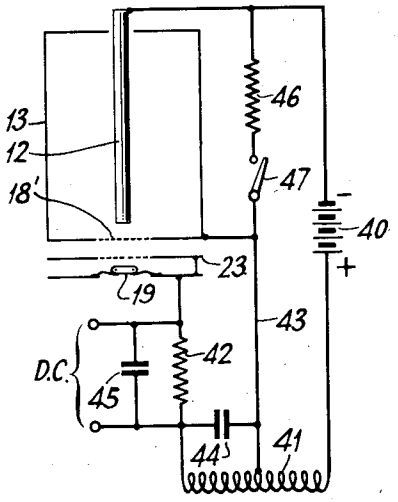


Fig. 3



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ELECTRON DISCHARGE DEVICE AND CIRCUIT

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Application January 25, 1938, Serial No. 186,789

5 Claims. (Cl. 171—97)

My invention relates to devices for amplifying direct currents and using electron discharge tubes having a gaseous atmosphere and capable of being continuously controlled.

The present application is a continuation in part of my copending application, Serial No. 133,300, filed March 27, 1937 and assigned to the same assignee as the present invention.

In the conventional grid controlled vacuum tubes provided with a thermionic cathode, control grid and anode, the space charge which builds up around the cathode makes necessary the use of comparatively high voltages, such as 100 volts or more, for obtaining current sufficiently large for practical purposes. It is also necessary to use comparatively large grid voltage swings to produce usable variations in the output of the tube. Thus, in the conventional high vacuum tubes comparatively large transconductances are not easily obtainable nor can large anode currents be obtained with small anode voltages. It has been recognized that by introducing a gas in a tube and ionizing the gas the space charge around the cathode could be neutralized and thus large anode currents obtained with the usual anode voltages. However, in the conventional grid controlled tube containing gas, ionization of the gas causes the control grid to lose its control of the electron stream so that while initiation of ionization can be controlled the current cannot be controlled by the control electrode after ionization takes place. Furthermore, in these types of tubes comparatively high voltages, much above ionization voltages, are applied between the anode and cathode to cause a gas discharge between the anode and the cathode. Thus while comparatively high currents can be obtained the loss of grid control and the necessity for high anode-cathode voltages limits the application of this type of tube and prevents its use in conventional radio circuits.

It is the principal object of my invention to provide a device particularly suitable as a direct current amplifier and utilizing an improved electron discharge device of the continuously controlled gas type depending upon gas ionization for operation and described and claimed in my copending application identified above.

The tube described in my copending application above identified has an envelope containing the electrodes immersed in a gas at a low pressure. The space between the cathode and the anode is ionized to neutralize the space charge and thus make available a large number of electrons. Only a very small voltage of the order of 6 volts, for example, which is considerably below ionizing voltage may be applied between the anode and cathode to obtain a comparatively large anode current. The flow of electrons from the cathode to the anode can then be continuously controlled by an electrode to which may be applied comparatively small voltage swings inasmuch as there is no gas discharge between the main cathode and the anode. To produce the ionization of the gas between the cathode and anode an auxiliary cathode may be employed. A discharge is established between this auxiliary cathode and anode electrode, the electrode being so positioned that the space between the main cathode and the anode is in the path of the auxiliary discharge initiated between the auxiliary cathode and its cooperating electrode.

In the tube described in the above identified copending application there is mounted within an envelope containing gas at low pressure, a straight indirectly heated cathode surrounded by a cylindrical anode closed at both ends. An aperture, preferably covered by a mesh material, is provided at one end of the anode. Registering with this aperture are a control grid and an auxiliary cathode for supplying the electrons within the anode to ionize the gas between the main cathode and the anode. The auxiliary cathode, grid and the aperture covered by mesh material are all spaced less than the mean free path of electrons in the gas so that no ionization takes place between these electrodes. This arrangement permits continuous grid control of the ionization within the main anode. A voltage less than that required to produce ionization is applied between the main cathode and the main anode. A voltage sufficiently high to cause the electrons to have a great enough velocity in entering the space between the main cathode and the main anode is applied between the auxiliary cathode and the main anode, the control voltage being applied through an input circuit to the control grid.

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 drawing in which Figure 1 is a vertical section in perspective of an electron discharge device of the type described above, Figure 2 is a section along 2—2 of Figure 1 showing details of construction, and Figure 3 is a diagrammatic showing of a direct current amplifier

arrangement made according to my invention and using a tube of the kind shown in Figure 1.

The tube shown in Figure 1 includes an envelope 10 containing a gas at low pressure for example between 150–600 microns' pressure. Helium at pressures between 250 and 300 microns is very satisfactory. A stem 11 supports the electrode mount assembly within the envelope. The electrode mount assembly comprises an indirectly heated cathode 12 enclosed within a cylindrical anode 13 provided with a screen covered aperture 14 and closed ends 15 and 16. Aperture 14 is to provide a gas communication between the interior of the anode and the inside of the envelope. The cathode 12 is insulatingly supported from the upper closed end 16 of the anode by means of the insulating bushing 17. The lower end 15 is provided with an aperture 18 covered with foraminous or mesh material 18', the shape of this aperture being best shown in Figure 2. The cathode 12 and anode 13 are the main discharge electrodes between which the output current passes.

In order to neutralize the space charge around the cathode 12 during operation of the tube I provide an auxiliary electrode system comprising an indirectly heated cathode and grid in registry with the aperture 18 to project electrons from the auxiliary cathode into the space surrounding the cathode 12.

This electrode system comprises an indirectly heated auxiliary cathode 19 supported and electrically connected to the metal disc 20. Insulatingly separated from the disc 20 by means of an insulating disc member 21 having an aperture 22, in which the cathode 19 is positioned, is a grid comprising a metallic disc member 23 having an aperture 24 covered with a mesh material 24', this aperture being in registry with the aperture 18 in the lower end of the anode. This grid is insulatingly separated from the anode by means of the insulating disc 25 having an aperture 26 in registry with the aperture 18. This whole mount assembly is supported from the stem 11 by means of the supports and leads 27, 28 and 29 connected respectively to the cathode disc, grid disc and anode. The main cathode 12 is provided with a lead 30.

In operation a low voltage less than that required for maintaining ionization is applied between the main cathode 12 and anode 13 so that a gas discharge cannot take place between these electrodes. Voltages are applied between the auxiliary cathode 19 and the anode 13, which are high enough to cause electrons from the cathode to be projected through the aligned apertures into the space around the cathode 12 with sufficient velocity to ionize the gas and thus neutralize the space charge. The grid 23 may have applied to it a control voltage which will control the flow of electrons from the auxiliary cathode 19 into the space surrounding the main cathode 12 to thereby control the ionization and hence the current from cathode 12 to anode 13.

According to my invention I provide a D. C. amplifier comprising a self-excited oscillating circuit which can be used to provide a high voltage D. C. output source from a low voltage D. C. source. In Figure 3 the cathode 12 is connected through the low voltage D. C. source or battery 40 to one side of the inductance 41, the other side of which is connected through an output resistor 42 to the auxiliary cathode 19. The voltage obtained from battery 40 is less than that required to maintain ionization between cathode 12 and anode 13. An intermediate point of the inductance 41 is connected by means of conductor 43 to the anode 13. The grid 23 may be connected to the cathode. A condenser 44 connected across a part of the inductance 41 furnishes with the inductance 41 an oscillating circuit. The output resistor 42 is shunted by a filter condenser 45. In order to start oscillations a resistance 46 and switch 47 is provided.

To shock the system into operation switch 47 is momentarily closed causing a flow of current through the right hand portion of inductance 41, which in turn induces a voltage across the left hand portion of inductance 41 and condenser 44. The resistance 46 may have any suitable value for limiting the current to a desired amount. This voltage which is stepped up by proper ratio of turns of the two portions of inductances 41 acting as an auto transformer is applied between the cathode 19 and the anode 13 and causes electrons to discharge into the space surrounding the cathode 12 causing ionization which neutralizes the space charge thereby permitting a large flow of current between the cathode 12 and anode 13. This current flowing through the right hand portion of the inductance 41 again feeds back energy to the left hand portion producing a regenerative action so that the system is maintained in oscillation. Due to the rectifying action between the cathode 19 and anode 18, rectified voltages appear across the output resistance 42, the condenser 45 acting as a filter so that substantially uniform D. C. voltage appears across this output circuit comprising resistor 42 and condenser 45. By proper circuit constants a step-up voltage can be provided across the D. C. output terminals.

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.

What I claim as new is:—

1. An electron discharge device having an envelope containing a gas, a thermionic cathode within said envelope for emitting electrons, an anode for receiving electrons from said cathode and means for ionizing the space between the thermionic cathode and the anode and including an auxiliary cathode for providing an electron discharge in the space between the thermionic cathode and anode, an inductance, and a source of voltage less than that required for producing ionization between said thermionic cathode and anode and connected between the thermionic cathode and one side of said inductance, and a load connected between the other side of said inductance and the auxiliary cathode, and a connection between the anode and an intermediate point on said inductance.

2. An electron discharge device having an envelope containing a gas, a thermionic cathode within said envelope and an anode spaced from said cathode, and an auxiliary cathode for providing an electron discharge between the thermionic cathode and anode to ionize the space between the thermionic cathode and anode, an inductance and a source of voltage less than that required to produce ionization between the ther-

mionic cathode and anode connected between the thermionic cathode and anode, a second inductance and a resistor connected between the anode and the auxiliary cathode, said inductances being so positioned that current flowing in the inductance connected between the anode and the thermionic cathode will induce a voltage in the inductance connected between the anode and the auxiliary cathode.

3. An electron discharge device having an envelope containing a gas, a thermionic cathode within said envelope for emitting electrons, a hollow anode surrounding said thermionic cathode for enclosing the space between said thermionic cathode and the anode, and means for ionizing the space between the thermionic cathode and anode and including an auxiliary cathode, an inductance, a source of voltage connected between one end of said inductance and said thermionic cathode, said source of voltage being less than that required to produce ionization between the thermionic cathode and anode, a resistor connected between the auxiliary cathode and the other end of said inductance, and a connection between the anode and an intermediate point on said inductance, and a condenser connected between the intermediate point on said inductance and the end of said inductance connected to said resistor.

4. An electron discharge device having an envelope containing a gas, a thermionic cathode within said envelope for emitting electrons, a hollow anode surrounding said thermionic cathode for enclosing the space between said thermionic cathode and the anode, and means for ionizing the space between the thermionic cathode and anode and including an auxiliary cathode and an inductance, a source of voltage connected between one end of said inductance and said thermionic cathode, said source of voltage being less than that required to produce ionization between the thermionic cathode and anode, a resistor connected between the auxiliary cathode and the other end of said inductance, and a connection between the anode and an intermediate point on said inductance, and a condenser connected between the intermediate point on said inductance and the end of said inductance connected to said resistor, and a resistor and a switch connected between the anode and the thermionic cathode.

5. An electron discharge device comprising an envelope containing a gas, a thermionic cathode within said envelope, a hollow anode surrounding said thermionic cathode to enclose the space between said thermionic cathode and said anode and having an aperture provided in said hollow anode, an auxiliary cathode positioned in registry with said aperture for supplying an electron discharge between the thermionic cathode and anode to ionize the gas between said thermionic cathode and anode, an inductance, a source of voltage vonnected between one end of said inductance and said thermionic cathode and said source of voltage being less than that required to produce ionization between the thermionic cathode and anode, a resistor connected between the other end of said inductance and said auxiliary cathode, and a condenser connected across said resistor, a connection between an intermediate point on said inductance and said anode, and a condenser connected between said intermediate point and between the resistor and the end of said inductance, and a switch and a resistor connected between the anode and the thermionic cathode.

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