

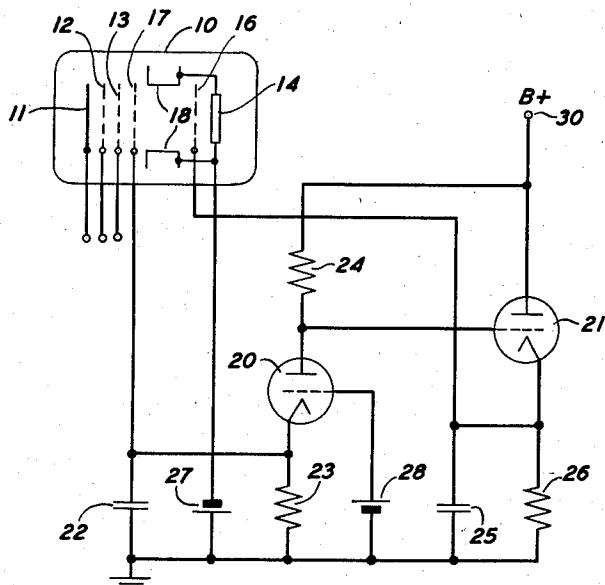
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VIRTUAL CATHODE STABILIZATION MEANS

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## VIRTUAL CATHODE STABILIZATION MEANS

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This invention relates to electrical circuits for electron discharge devices and, more particularly, to such circuits for stabilizing virtual cathodes in such devices.

When electron discharge devices are utilized in amplifier circuits, it is desirable that the cathode characteristics be constant during the life of the device. However, these devices are subject to certain defects which affect their operation and the attainment of the desired high figure of merit. The electron current through the device may not remain constant, for constant voltages on other electrodes, during the life of the device due to deterioration of the cathode. This may be caused, for example, by the loss of electron emissive material from the surface of the thermionic cathode. Another defect that arises during the life of the tube due to deterioration of the cathode is an increase of resistance associated with the emissive coating and particularly with the interface between the emissive coating and the base metal.

The devices may also have their characteristics altered during operation due to thermal effects. When such devices are employed as amplifiers, the circuit operation is very sensitive to movements and distortion of the thermionic cathode as well as the other electrodes. Thus, the cathode-control grid spacing may be critical, yet be subject to variation due to movement of the cathode or the grid as a result of heating of the cathode; such movements cannot easily be compensated for by the initial relative location of the electrodes.

Accordingly, it is an object of this invention to provide an improved electron discharge device substantially free from the above defects.

Another object of this invention is to provide an electron discharge device insensitive to changing characteristics and not requiring accurate positioning of a control grid adjacent the thermionic cathode.

A further object of this invention is to substantially eliminate the effects of aging deterioration of the thermionic cathode on the characteristics of an electron discharge device.

A further object of this invention is to provide an electron discharge device which is insensitive to movements of the electrodes and distortion of the thermionic cathode.

A still further object of this invention is to provide an electron discharge device wherein the critical electrodes are all operated at relatively low temperatures, which electrodes can thereby be very precisely located.

Briefly, in accordance with aspects of this invention, a high figure of merit electron discharge device employs a first and a second grid positioned between the thermionic cathode and the control grid of the device, the first and second grids serving to regulate a virtual cathode located between the second grid and control grid. A negative direct current feedback path is established between the second grid and the first grid to control the quantity of electrons in the electron stream in inverse relationship to the quantity of electrons collected by the second grid. The effect of this control is a constant

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virtual cathode under variable conditions of tube age and spacing of electrodes. The utilization of a virtual cathode as the source of electrons rather than a thermionic cathode permits the operation of the principal control grid at a relatively low temperature. A focusing electrode may be placed between the first and second grids and grounded to the cathode to aid the maintenance of a constant virtual cathode.

It is a feature of this invention that an electron discharge device have a first grid and a second grid between the thermionic cathode and the control grid of the device and that there be a negative direct current feedback path from the second grid to the first grid.

It is another feature of this invention to utilize a feedback circuit from the second grid of the electron tube to the first grid comprising an anode follower and a cathode follower connected in driving and driven relationship, respectively.

It is a further feature of this invention that a first and a second grid be inserted between the cathode and control grid of an electron tube and each of these grids have applied thereto suitable fixed potentials, the second grid being positive with respect to the cathode.

A complete understanding of this invention and of these and various other features thereof may be gained from consideration of the following detailed description and the accompanying drawing which is a schematic representation of an electron discharge device illustrative of one specific embodiment of this invention.

Turning now to the drawing, there is depicted an electrical circuit in accordance with one specific embodiment of this invention which may be utilized in a high figure of merit amplifier circuit and which includes an electron discharge device 10 having an anode 11, a screen grid 12, a control grid 13, and a thermionic cathode 14. A first grid 16 and a second grid 17 are interposed between the thermionic cathode 14 and the control grid 13. Located between the first grid 16 and the second grid 17 is a focusing electrode 18 which is advantageously connected to thermionic cathode 14.

Under operating conditions, a fixed potential is applied to first grid 16, a higher positive potential is applied to second grid 17 and a negative potential is applied to control grid 13. Due to these relationships, a virtual cathode forms between second grid 17 and control grid 13. This virtual cathode is under the control of grids 16 and 17 and focusing electrode 18. In accordance with this invention the amount of electrons collected by grid 17 regulates the potential applied to first grid 16 in an inverse relationship by means of the feedback amplifiers 20 and 21 and thereby maintains the apparent electron emission of the virtual cathode constant despite variations in the actual thermionic cathode 14.

Amplifier 20 is employed as an anode follower having its input from the second grid 17 applied across cathode load resistor 23. A suitable anode load 24 is connected to the anode of amplifier 20 as well as to the control grid of cathode follower amplifier 21. The output from cathode follower amplifier 21 is derived across a cathode load. Capacitors 22 and 25 are used to insure stability of the feedback system by effectively grounding the first and second grids with regard to alternating current signals. A suitable bias source 27 is connected to thermionic cathode 14. A source 28 of positive potential is connected to the control grid of amplifier 20 to maintain it in a conducting condition. A suitable source of positive potential is connected to terminal 30, thereby applying positive potential to the anodes of amplifiers 20 and 21 as well as to the control grid of amplifier 21.

Assume for the purposes of explanation of the opera-

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tion of this specific embodiment of the invention that electrodes 11, 12 and 13 are employed in an amplifier circuit in a conventional manner. A fixed potential is applied to the first grid 16 from the source of potential connected across a voltage divider comprising cathode follower amplifier 21 and cathode resistance 26. A more positive potential is applied to grid 17 than to grid 16 by way of the voltage divider including resistors 23 and 24 and amplifier tube 20. As electrons are emitted from thermionic cathode 14, they are accelerated by the positive potential on the first grid 16, pass between focusing electrodes 18, and then pass through the positive second grid 17, respectively. Since the control grid 13 is maintained at a negative potential, the electrons are now both swept toward control grid 13 by the positive second grid 17 and repelled by control grid 13 and thus form a virtual cathode between the second grid 17 and control grid 13.

If the number of electrons reaching second grid 17 is increased, which would result in an increase in the apparent electron emission of the virtual cathode, the current flow from grid 17 through resistor 23 decreases the cathode bias as this current is in opposition to the current through biasing resistor 23. As a result of the decreased bias on the cathode, increased anode current through resistor 24 increases the voltage drop across resistor 24 causing a more negative potential to be applied to the grid of amplifier 21. A resulting decrease in current through amplifier 21 causes a decrease in the potential at the point between resistor 26 and the cathode of amplifier 21, thereby decreasing the potential applied to first grid 16. This decrease in potential on first grid 16 causes a decrease in the quantity of the electrons flowing toward the virtual cathode and thereby results in a diminution of the amount of electrons in the virtual cathode, thereby serving to maintain constant the apparent electron emission of the virtual cathode.

Conversely, a decrease in the amount of electrons reaching second grid 17 results in an increase in the voltage of first grid 16 and thus causes an increase in the number of electrons supplied to the virtual cathode.

It is therefore apparent that, under operating conditions, a constant virtual cathode exists between second grid 17 and control grid 13, which virtual cathode is substantially independent of the location of the control grid relative to the thermionic cathode, and this virtual cathode will be substantially independent of the deterioration of the thermionic cathode due to aging. Further, the existence of the virtual cathode will be substantially independent of movements and distortion of the thermionic cathode. Due to the isolation between the thermionic cathode and the principal elements of the tetrode, namely, the control grid, the screen grid and the anode, these electrodes are all operated at relatively low temperatures and therefore can be very precisely located.

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It is to be understood that the above-described arrangements are illustrative of the application of the principles of the invention. Numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. In an electrical circuit, an electron discharge device having an anode, cathode, and a control grid, a first and a second grid in that order between said cathode and said control grid, means for applying potentials to said first and second grids to maintain a virtual cathode between said second grid and said control grid, and means for maintaining substantially constant the electron current from said cathode to said virtual cathode, said last mentioned means including an anode follower amplifier and a cathode follower amplifier connected respectively in driving and driven relationship for providing negative feedback effective at direct current from said second grid to said first grid.

2. In an electrical circuit, the combination in accordance with claim 1 wherein said anode follower amplifier and said cathode follower amplifier are connected to said second grid and said first grid respectively as a direct current feedback circuit.

3. In an electrical circuit, an electron discharge device having an anode, a cathode, and a control grid; a first and a second grid in that order positioned between said cathode and said control grid; first circuit means connected to said second grid for applying potentials thereto to maintain a virtual cathode between said control grid and said second grid and for detecting the electron current at said second grid; and second circuit means connected to said first grid and said first circuit means for applying a potential to said first grid in response to the detection of the electron current at said second grid whereby the electron current to said virtual cathode is maintained substantially constant, said first and said second circuit means describing a direct-current path between said first and said second grids.

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