

Nov. 24, 1936.

G. JOBST

**2,061,733**

THERMIONIC DEVICE

Filed Aug. 29, 1933

*Fig. 1*

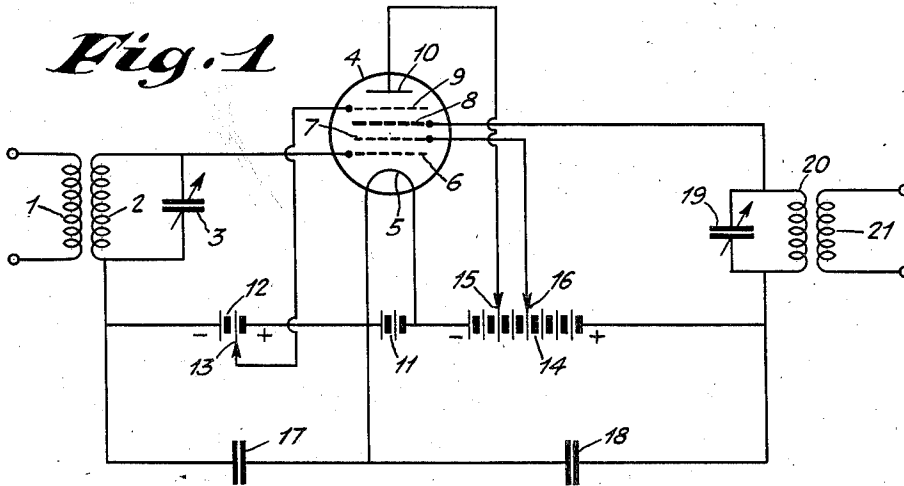


*Fig. 2*

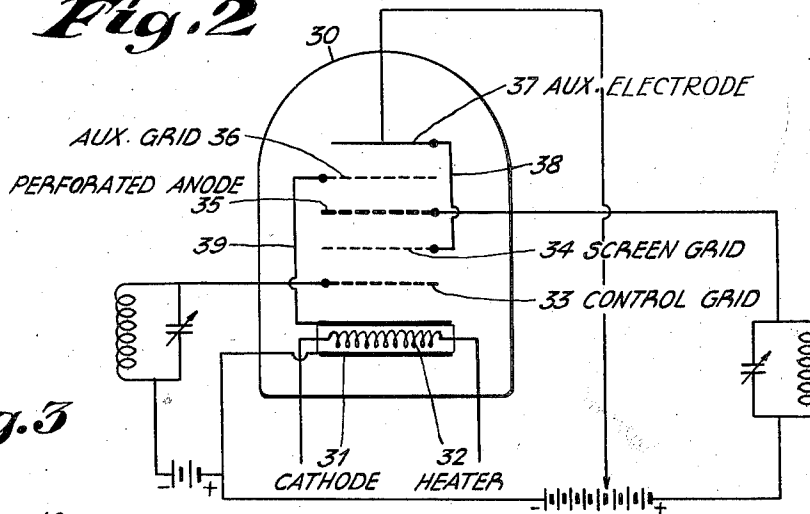
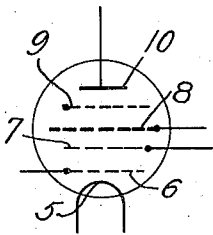


*Fig. 3*



INVENTOR  
GUNTHER JOBST  
BY *H. Groen*  
ATTORNEY

## UNITED STATES PATENT OFFICE

2,061,733

## THERMIONIC DEVICE

Günther Jobst, Berlin, Germany, assignor to  
Telefunken Gesellschaft für Drahtlose Tele-  
graphie m. b. H., Berlin, Germany, a corpora-  
tion of Germany

Application August 29, 1933, Serial No. 687,262  
In Germany August 31, 1932

9 Claims. (Cl. 250—27)

The present invention relates, in general, to a thermionic device and more particularly to a thermionic tube and to methods of operating the same.

The primary object of the present invention is to provide a thermionic tube of exceedingly high internal resistance. Other objects and features will be apparent as the specification is perused in connection with the accompanying drawing.

The internal resistance  $R_i$  of a tube is characterized by the differential quotient

$$\frac{dE_a}{dI_a}$$

wherein  $E_a$ =plate voltage and  $I_a$ =plate current and the potentials of the other electrodes are supposed to be kept constant. It is well known to those skilled in the art, that the internal resistance may be increased by providing a so-called screen grid between the control electrode and the plate or anode of the tube. A fine or close-meshed grid will give a higher internal resistance than an open or wide-meshed one. But it is impossible to proceed in this way to high internal resistances of any desired value, as in fact the plate current decreases the finer the meshes of the screen grid are chosen.

According to the present invention a higher internal resistance is obtained by providing a perforated plate or anode and one or more additional electrodes, which preferably are kept on constant potentials, beyond the plate. In this way the internal resistance  $R_i$  may reach values of more than 100,000  $\Omega$  or even may take negative values, so that the resistance of the plate circuit wholly or partially is neutralized.

For better understanding the principle of the present invention, the action of a tube may be considered, which comprises for instance a cathode, a control grid, a screen grid, a perforated plate or anode and one electrode beyond the anode. The last named auxiliary electrode is kept on a potential less positive than the plate potential; all the electrode potentials except the control or signal grid potential may be kept constant. As the anode is perforated, not all the electrons having passed the screen grid will strike the same; a part of the electrons passes the apertures of the anode and proceeds towards the auxiliary electrode. If the plate voltage is increased the electrons are more accelerated and therefore the number of electrons passing the anode and falling upon the auxiliary electrode behind the anode is increased. Referring to the plate current  $I_a$  it means, that the increase of  $I_a$  is not as great

as in absence of the auxiliary electrode or, in other words, the internal resistance  $R_i$  is higher than without the auxiliary electrode.

If the density of the electron stream to the auxiliary electrode becomes sufficient a negative space charge is built up between the anode and the auxiliary electrode. Some electrons, the velocity of which is too small, are repelled by the cloud of negative particles and return to the anode, the others break through the space charge and strike the auxiliary electrode. By raising the plate voltage the velocity of the electrons is increased so that a greater percentage breaks through the space charge. That means, as explained above, an increasing of the internal resistance  $R_i$ .

As the action of the space charge is very important for the resulting internal resistance, various means may be provided for supporting and controlling the space charge. It is proposed to insert one or more additional grid electrodes between the anode and the auxiliary electrode. Suppose one grid is provided without any connection to another electrode or voltage source; such a grid is charged by the electrons to a negative potential, which depends upon the insulation resistance of the grid and the density and velocity of the electron stream. If several such insulated or free grids are arranged one behind another, cavities are formed by the meshes of the grids, whereby building up the space charge is favored. Furthermore the additional grid or grids may be connected to the cathode or a negative potential. Then the desired value of internal resistance  $R_i$  is adjusted by varying the negative bias of the additional grid.

Further details regarding the tube as well as the circuit diagram may be taken from the accompanying drawing, wherein Figure 1 represents the wiring diagram of an amplifier for alternating voltages according to the present invention and Figures 2 and 3 illustrate modified forms of the invention.

In Fig. 1 the input coil 1, which may be connected to the aerial of a receiving station or to the plate circuit of a preceding amplifier stage, induces the input voltage in the grid circuit, comprising the coil 2 and the condenser 3. The evacuated envelope 4 contains a filament 5, which may be replaced by an indirectly heated cathode, a control grid 6, a screen grid 7, a perforated anode 8, an additional grid 9 and the auxiliary electrode 10; the latter may consist of a metal sheet or a fine-meshed wire netting. The filament voltage is supplied by a battery 11. The negative bias of the control grid 6 is taken from

a battery 12 and the plate battery is illustrated by 14. The plate circuit contains a resonant circuit 19, 20, which is coupled to the output coil 21. Bypass-condensers 17, 18 offer paths of low impedance for the alternating currents. The plate battery 14 is tapped on the points 15 and 16, to which the auxiliary electrode 10 and the screen grid 7 respectively are joined. The additional grid 9 is negatively charged from the tap 13 of the grid battery 12. Preferably the tapping points 13 and 15 are variable in order to allow the proper adjustment of the internal resistance of the tube.

It is understood, that the grid 9 may also be omitted or without any battery connection, as already stated, thereby resulting in a free floating grid. The latter arrangement is shown in Fig. 3, the auxiliary grid 9 being shown as not having a lead-in conductor connection thereto. Otherwise the circuit connections may be the same as in Fig. 1.

In order to simplify the wiring and to save lead-in wires it is proposed to connect the auxiliary electrode to the screen grid and/or the additional grid 9 to the cathode. The connections may be made either within the envelope or within the socket of the tube. One embodiment of such tube is shown in Fig. 2 wherein both connections are made. 30 is the evacuated envelope containing the indirectly heated cathode 31 and the heater 32. The grid 33 is the control electrode, 34 the screen grid, 35 a perforated anode, 36 an additional grid and 37 the auxiliary electrode. The cathode 31 is linked to the grid 36 by a wire 39 and the lead 38 connects the auxiliary electrode 37 to the screen grid 34. The circuit connections are otherwise the same as in Fig. 1.

Although several modifications of the present invention have been described, it is not limited thereto since many changes may suggest themselves to those skilled in the art.

Having now described my invention, what I claim as new and desire to secure by Letters Patent of the United States, is:

1. A thermionic device comprising a cathode and a perforated anode, a plurality of grid electrodes interposed between said cathode and anode, one of said grid electrodes having a signal potential applied thereto, and means positioned on that side of the anode remote from the cathode for producing a negative space charge externally of the anode comprising at least one auxiliary electrode which is maintained at a constant potential irrespective of the signal potential.

2. A thermionic device comprising a cathode and a perforated anode, a signal control grid and a screening grid interposed between said cathode and anode, said control grid having a signal potential applied thereto, and means positioned on that side of the anode remote from the cathode for producing a negative space charge externally of the anode comprising an auxiliary grid electrode which is maintained at a negative constant operating potential with respect to the cathode irrespective of the signal potential.

3. A thermionic device comprising a cathode and a perforated anode, a signal control grid and a screening grid interposed between said cathode and anode, and means positioned on that side of the anode remote from the cathode for producing a negative space charge externally of the anode comprising an auxiliary electrode

which is maintained at a negative constant operating potential with respect to the cathode and a second auxiliary electrode which is maintained at a positive constant operating potential, said last named electrode being positioned on that side of the first auxiliary electrode which is remote from the cathode.

4. A thermionic device comprising an evacuated envelope, a cathode and a perforated anode mounted therein, a grid electrode positioned adjacent the cathode and a second grid electrode positioned adjacent the anode, both said grid electrodes being interposed in the space between said cathode and anode, and a pair of electrodes mounted on that side of the anode remote from the cathode, one being directly connected to the cathode and the other being directly connected to said second grid electrode which is adjacent the anode.

5. A thermionic device comprising an evacuated envelope, an indirectly heated cathode and a perforated anode mounted therein, a signal control grid positioned adjacent the cathode and a screening grid positioned adjacent the anode, both said grids being interposed in the space between said cathode and anode, and a pair of auxiliary electrodes mounted on that side of the anode remote from the cathode, the one immediately adjacent the anode being in the form of a grid and directly connected within the envelope to the cathode and the other electrode being in the form of a plate and directly connected within the envelope to the screening grid.

6. In combination, a thermionic tube having a cathode, a control grid, a perforated anode and an auxiliary plate electrode positioned within the tube in the order named, an input circuit connected between the control grid and cathode, an output circuit including a source of potential connected between the perforated anode and cathode, and a direct electrical connection from an intermediate point on said source of potential to the auxiliary plate electrode.

7. In combination, a thermionic tube having a cathode, a control grid, a screen grid, an anode and a pair of auxiliary electrodes positioned within the tube in the order named, an input circuit connected between the control grid and cathode, an output circuit including a source of potential connected between the anode and cathode, and direct electrical connections from intermediate points on said source of potential to the screen grid and to one of the auxiliary electrodes, and a negative potential with respect to the cathode applied to the second auxiliary electrode.

8. In combination, a thermionic tube having a cathode, a control grid, a screen grid, a perforated anode and a pair of auxiliary electrodes positioned within the tube in the order named, an input circuit connected between the control grid and cathode, an output circuit connected between the anode and cathode, said output circuit including a source of potential with its maximum potential applied to the anode, and direct adjustable connections from the screen grid and the second auxiliary electrode to points on said potential source of lesser potential, and a constant potential with respect to the cathode applied to the first auxiliary electrode.

9. In combination, a thermionic tube having a cathode, a control grid, a screen grid, a perforated anode and a pair of auxiliary electrodes positioned within the tube in the order named, an input circuit connected between the control

5 grid and cathode, an output circuit connected between the anode and cathode, said output circuit including a source of potential with its maximum potential applied to the anode, direct adjustable connections from the screen grid and the second auxiliary electrode to points on said

potential source of lesser potential, a source of biasing potential included in the input circuit, and a direct adjustable connection from the first auxiliary electrode to the biasing potential source.

GÜNTHER JOBST.