Dec. 11, 1934. L. THOMPSON 1,983,714

AMPLIFYING TUBE AND METHOD OF OPERATING SAME

Filed May 8, 1930

Fig. 1.

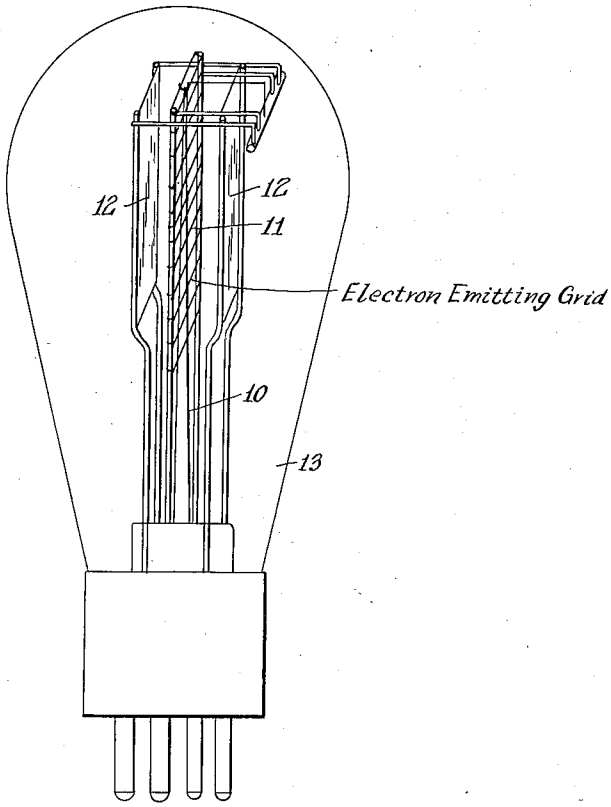
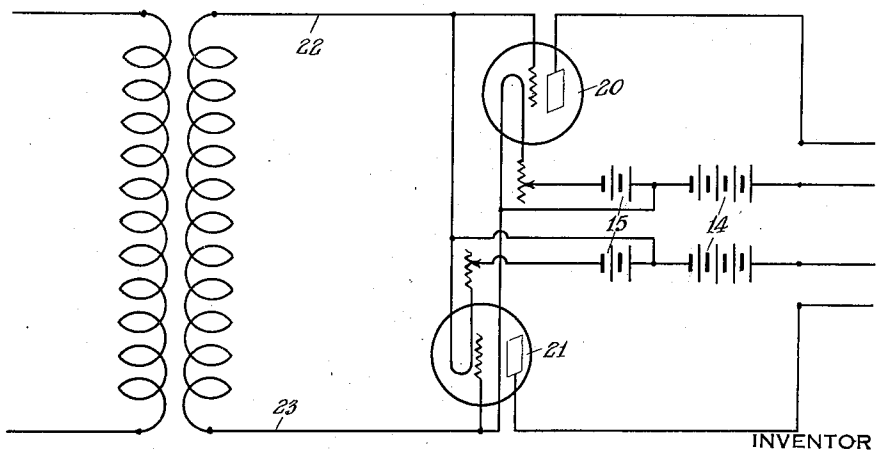


Fig. 2.



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AMPLIFYING TUBE AND METHOD OF OPERATING SAME

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3 Claims. (Cl. 179—171)

The invention relates to thermionic tubes, such as are utilized in electrical amplification systems, and more especially to a tube adapted for amplifying systems of the nature more particularly set forth in my U. S. Letters Patent No. 1,755,938 in which tubes of relatively very high amplification constant are used as power tubes operated at zero or positive grid biases. Under these conditions, substantial electron currents flow in the grid circuit of these tubes, while in the ordinary amplifying systems, negative biases are applied to the grids of the usual, well-known tubes to prevent the flow of electron currents in the grid circuit. Tubes for use in the aforesaid patented system have, therefore, been required to allow relatively large grid-current flow; and, to facilitate the distortionless transmission of signals with this system, it has been required that the relation between grid voltages and grid currents should be as nearly linear as possible.

If a pair of matched tubes, used in the compensated arrangement of the patented system referred to, are operated at zero grid potential, the combined grid circuits will function like a pure resistance if the grid-current grid-voltage curves are linear for the tubes and there is a negligibly small grid current at zero grid.

If there is a curvature in the region of zero grid, and the remainder of the characteristic is linear, the combined curves of the two tubes may be made to overlap to give a continuous straight line, usually by the application of a slight positive bias to each tube.

If but a single one of these tubes is used, a suitable positive bias may be applied so the operating point is in a linear region of this grid-voltage grid-current characteristic, thus also giving a "pure resistance" characteristic for signals not exceeding the linear region.

It is the object of the present invention to provide tubes with adjusted grid-voltage grid-current characteristic as nearly linear as possible and adapted for the flow of relatively large electron currents in their grids, which are therefore to be operated at zero or positive biases.

I have found that tubes may be constructed and operated to respond to the requirements aforesaid, in part through the selection of the proper filament voltage and particularly through the adjustment of secondary electron emission from the grid. Reduction of the voltage of the filament to as low a value as practicable for the necessarily increased filament current for the same filament emission, tends to eliminate curvature in the grid-voltage grid-current characteristic near zero grid potential. By adjustment of the secondary emission from the grid to desired amounts, the net grid current—which is represented by the difference between the primary electrons entering the grid and the secondary electrons leaving said grid—may be reduced to a degree such that the grid-voltage grid-current characteristic may be made very nearly linear.

The mechanism of secondary emission from the grid is as follows. When the grid is negative, there is no electron-grid-current flow or flow of primary electrons into it, since the negative field of the grid tends to repel them; and as the grid approaches equal potential with the filament, the primary electrons are allowed to increase in velocity since the repelling negative field of the grid is being reduced. When the grid becomes positive, primary electrons flow into it and the velocity of these electrons is accelerated by the positive field of the grid. When sufficient positive grid potential is reached to bring the primary electrons which strike the grid to a sufficiently high velocity, they eject secondary electrons from the grid.

If these secondary electrons are ejected with sufficient velocity to carry them into a region where the field of the positive plate is stronger than the field of the positive grid from which they came, they will go to the said plate. These secondary electrons which go to the plate thus represent a current leaving the grid, while the primary electrons represent a current entering the grid, and the net grid current is the difference between the two currents.

The grid-voltage grid-current curve of a tube without secondary emission from the grid usually obeys a law of the nature of:—

$$I_g = KE_g^x$$

Where I_g represents the grid current, E_g the grid voltage, K a constant, and x an exponent which is usually 3/2 to 2.

It is evident that the introduction of a factor which reduces the net grid current in the proper amount will make the relation more nearly linear; and I have found that carefully controlled secondary emission will do this.

The result of too much secondary emission will be so much reduction in the net grid current that the curvature reverses. Actually, it is possible to have the secondary emission factor so high that the net current becomes zero for some positive grid potential, the secondary electron

current leaving the grid being equal then to the primary electron-current entering it.

A main factor governing the amount of secondary emission from the grid is the physical material of the grid surface; and it has been found that the best material for producing the right amount of secondary emission depends largely on the type of tube. For power tubes using 450 volts on the plate, I have found tantalum to give the best results, tantalum being fairly resistant to secondary emission; while for power tubes using 250 volts on the plate, a material giving off secondary electrons with more ease, such as molybdenum, gives good results.

Although copious secondary emission may occur from the grid, it is possible, by separating the plate further therefrom, to make a smaller proportion of the secondary electrons reach the region where the positive field of the plate will prevent them from falling back into the grid. Consequently the degree of separation of grid from plate to get the best results is important, although this factor must be so adjusted as to also determine the desired amplification factor and plate impedance of the tube.

In the drawing, Fig. 1 shows in elevation the novel amplification tube as a triode; and Fig. 2 illustrates the manner of connecting a pair of such triodes in the aforesaid patented amplifying circuit.

In constructing the novel triode, the same is provided with the usual three elements, viz: filament 10, grid 11 and plate 12, all being included and mounted in an evacuated container 13 in the usual and well-known or special manner. The grid 11, however, is of suitable material for the particular type of tube, as, for example, tantalum, for the 450-volt type of tube used; or, molybdenum, for a 250-volt type.

A plate 12, or preferably a pair of plates for affording a strong electrostatic field surrounding the grid, is located the optimum distance from said grid 11, giving the desired amplification constant, plate impedance and secondary-emission control in connection with the grid material used; and a relatively high voltage is arranged to be applied thereto as from the battery 14, for example, 250–450 volts, while the filament heating-current is received from a suitable source of supply as the battery 15 and preferably at potentials ranging from 2 to 3.5 volts.

In accordance with the use to which these tubes are usually to be put, the same are to be matched as to their grid-voltage grid-current characteristics, and two of such tubes 20 and 21 are interconnected in the manner indicated and more fully set forth in my prior Patent No. 1,755,938. In this system and as indicated in Fig. 2, an input circuit represented by the leads 22 and 23 has the former lead connected to the grid of tube 20 and the latter lead to the grid of the tube 21, while the filament of said former tube is also connected to the lead 23 and the filament of the latter tube to the lead 22. The grid currents flowing are thus compensated to produce distortionless transmission of an incoming signal applied to the said input circuit.

I claim:

1. In a thermionic tube having a cathode, a grid of material adapted to emit secondary electrons by impact of electrons from the cathode, and a plate, the method of obtaining distortionless amplification by operating the tube on a linear portion of the grid-voltage grid-current characteristic, which consists in adjusting the positive potential on the grid to such value that the emission of secondary electrons therefrom substantially neutralizes that portion of the primary electrons impinging on the grid from the cathode which causes the non-linear grid-voltage grid-current characteristic.

2. In a thermionic valve, an electron-emitting element, a plate, and an intermediate grid element of tantalum adapted to emit secondary electrons, and means to apply a positive potential to the grid of a magnitude to effect an emission of the secondary electrons sufficient to reduce the grid-current to an extent affording substantially linear grid-voltage grid-current characteristics.

3. In a thermionic valve, an electron-emitting element, a plate, and an intermediate grid element of molybdenum adapted to emit secondary electrons, and means to apply a positive potential to the grid of a magnitude to effect an emission of the secondary electrons sufficient to reduce the grid-current to an extent affording substantially linear grid-voltage grid-current characteristics.

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