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ELECTRON DISCHARGE TUBE

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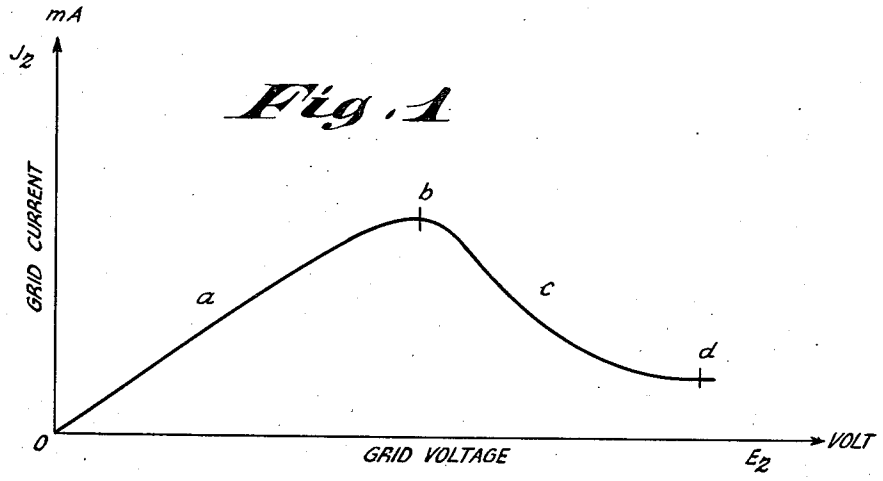


Fig. 1

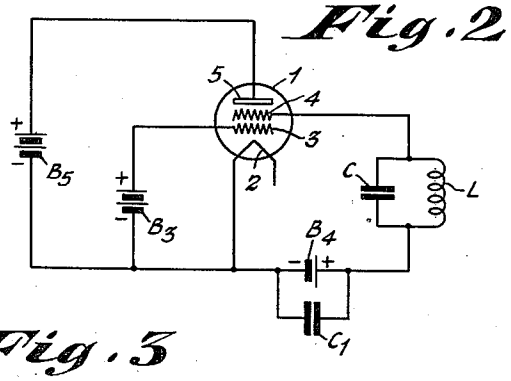


Fig. 2

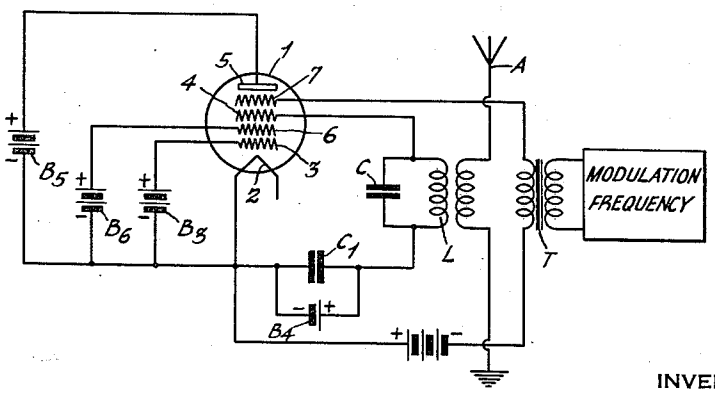


Fig. 3

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ELECTRON DISCHARGE TUBE

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6 Claims. (Cl. 250—36)

The present invention relates, in general, to a thermionic device and more particularly to a thermionic tube containing a cathode of high emissivity, a plate or anode and two or more auxiliary electrodes.

The primary object of the present invention is to provide a negative resistance in a tube only by the action of space charge and without any feed back by external coupling means and without utilizing secondary emission. Other objects and features will be apparent as the specification is perused in connection with the accompanying drawing, in which, Fig. 1 shows a characteristic curve of a grid of a tube made according to the invention, Fig. 2 is a schematic circuit diagram of a tube according to my invention connected to generate oscillations, and Fig. 3 is a schematic circuit diagram of a tube according to my invention used as a modulation oscillator.

The present invention proceeds from the fact, that in a tube containing a directly or indirectly heated cathode of high emissivity, a plate or anode and one or more auxiliary electrodes situated between the cathode and the anode, the plate current may decrease in spite of increasing the total emission current. This result is attained by suitably proportioning the number and velocity of emitted electrons, both depending upon the voltages applied to the electrodes. Assuming the tube to comprise two grid electrodes, both kept on positive potentials with respect to the cathode, the first grid, i. e. immediately surrounding the cathode, controls the number of electrons or the density of the emission current, whereas the second grid, which is connected to a higher positive potential, accelerates the electrons and determines their velocity. With respect to this feature, the first grid is called hereinafter "density grid", whereas the second grid is referred to as "acceleration grid". If the voltage of the second grid is raised after having adjusted the plate current on a falling portion of its characteristic, the current drawn by the second grid will increase at first, as a space charge is built up between the plate and the second grid. The space charge forms a "cloud" of negative particles and repels additional electrons back to the acceleration grid. By further raising the voltage of the second grid the electrons reach a velocity sufficient to break through the space charge and the plate current increases, whereas the second grid draws less electrons, provided the total emission current remains substantially constant.

In order to obtain this result it is necessary that the actions of the "density grid" and the "acceleration grid" be independent from each other. By raising the voltage E_2 of the second grid no augmentation of the total emission current should occur, the velocity only of the electrons passing through the second grid is to be enhanced. Therefore the influence of the second grid (acceleration grid) through the first grid (density grid) on the electrons between the first grid and the cathode has to be as small as possible (this influence is in German known as "Durchgriff"). This may be obtained by inserting an additional grid electrode between acceleration grid and density grid.

The performance of a tube of the kind described above might be compared with the action of a tube of the well known space charge grid type. Providing the total emission current to remain constant or because of saturation effect, rise of the voltage applied to the space charge grid under certain conditions also may cause decrease of the current drawn by the said space charge grid. The use of tubes of the space charge grid type in order to obtain a negative characteristic on the space charge grid is unfavourable in various respects: filaments of high emissivity, i. e. for example oxide coated cathodes, exhibit no strongly marked saturation point. Small fluctuations of the filament voltage will considerably affect the emission current. Besides, adjusting the emission current has to be effected by varying filament current and usual filament resistances will not allow a regulation as exact and fine as required. On the other hand the control of current density by means of the voltage variation on an additional grid renders quite exact adjustment, which is not affected by fluctuations of the filament current supply. If a cathode is provided, the emissivity of which is sufficient to emit more electrons than required, the density grid will draw a part only of the available electrons. In case of increasing the filament current no higher emission current is allowed to pass through the density grid and in the case of less filament current the emissivity of the cathode will still be sufficient to supply the required emission current. Furthermore the density grid lessens the space charge between acceleration grid and cathode and allows greater electron emission.

Figure 1 shows a characteristic curve of a tube according to the present invention. The plate voltage and the density grid voltage are kept constant throughout after having been adjusted to a suitable positive value. The acceleration

grid voltage E_2 is gradually increased from zero and the current J_2 flowing to the said grid is noted and plotted on the vertical axis. Along the portion *a* of the curve the current J_2 increases in the ordinary way. After the point *b* has been reached, electrons will break through the space charge between plate and acceleration grid and the current J_2 therefore decreases (portion *c*). This goes on until the point *d* is reached. We thus see that increasing the grid voltage E_2 may cause a decrease in the grid current J_2 and a negative resistance in the grid circuit.

By virtue of its negative resistance the device is capable of being used as generator of alternating currents or continuous waves. The negative resistance may be made use of in a receiving set for the purpose of damping reduction or compensation of the resistance losses in the grid circuit. It will be seen from the curve in Figure 1 that, if the potential of the acceleration grid is increased up to a value corresponding to the point *b*, the current, when oscillations are received, will be asymmetric and the device may be used as detector as well as an amplifier.

Figure 2 shows a complete arrangement for generation of oscillations. The tube 1 contains a cathode 2, density grid 3, acceleration grid 4 and the anode or plate 5. The batteries B_3, B_4 and B_5 are intended to give the grids and the plate positive potentials. The filament battery is omitted for the sake of simplicity. All the voltages of course preferably are adjustable. A negative resistance effect is obtained in the circuit of the second grid 4. The grid oscillatory circuit comprises an inductance L and a capacity C, which determine the frequency set up in the device. The battery B_4 is bridged by a fixed condenser C_1 to offer a path of low impedance for the generated current. The adjustment of the voltages B_4 and B_5 may be chosen so that either the plate 5 or the acceleration grid 4 gets the highest positive potential in the tube. In the arrangement shown, I have found the following voltages to produce satisfactory operation: voltage of grid 3=15 volts; voltage of grid 4=20 volts; voltage of plate 5=10 volts.

In order to increase the space charge between the plate and the acceleration grid, an additional grid may be inserted between the said electrodes and preferably be kept on negative or zero potential with respect to the filament. In the latter case this additional grid may be connected directly to the cathode within the evacuated vessel or within the tube socket. If not connected directly to the cathode this additional grid may be used for the purpose of modulating the generated oscillations.

Figure 3 illustrates a complete arrangement for generating modulated oscillations. The tube 1 comprises as in Fig. 2 a cathode 2, density grid 3, acceleration grid 4 and plate 5. A grid electrode 6 is provided to make the activities of the grids 3 and 4 independent from each other, whereas an additional grid 7 is designed to intensify the space charge in front of the anode 5. The oscillations are set up in the circuit L, C connected to the acceleration grid 4. The modulation voltages are supplied to the auxiliary electrode 7 by the transformer T. The modulated waves are radiated by the antenna A, which may be coupled to the oscillatory circuit in any usual manner. In the circuit arrangement shown I have found the following voltages to be satisfactory: voltage of grid 3=15 volts; voltage of grid 6=40 volts; voltage of grid 4=100 volts; voltage of plate 5=40 volts and voltage of grid 7=5 volts negative.

As the general arrangement is rather similar to that of a so-called grid dynatron, the following distinctions are referred to: the performance of a dynatron is based on secondary emission. Secondary electrons are liberated from the plate and are drawn away to the positive charged grid. No negative resistance is obtained in the grid circuit, if the grid voltage exceeds the plate voltage or if grid and plate are kept at the same potential. Moreover a dynatron cannot function, if there is a negative biased grid between the plate and the positive charged grid, because the secondary electrons are prevented from flowing to the positive grid.

Although various modifications of the present invention have been described, it is not limited thereto since many changes 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. An oscillation generator comprising a vacuum tube having a cathode, an anode, an acceleration grid located between said cathode and anode, and a density grid located between said cathode and acceleration grid, said density grid being the only control element for controlling the amount of electrons passing to said acceleration grid, means for applying a positive potential to said density grid, means for applying a positive potential to said acceleration grid higher than that of said density grid, an anode circuit substantially free from inductive reactance including means for applying a positive potential to said anode and a tuned circuit connected to said acceleration grid and cathode whereby said tuned circuit oscillates at the desired frequency in the absence of any feedback means external to said tube between said anode circuit and said tuned circuit.

2. The combination defined in the preceding claim in which the positive potential applied to said anode is less than that of said acceleration grid.

3. An oscillation generator comprising an electronic tube having a cathode, an anode, an acceleration grid located between said cathode and anode, a density grid located between said cathode and acceleration grid the potential of said density grid alone regulating the amount of electrons passing therethrough and a third grid located between said anode and acceleration grid, means for applying a positive potential to said density grid, means for applying a positive potential to said anode and acceleration grid higher than that of said density grid, means for applying a potential to said third grid less than said anode potential so as to increase the space charge between the anode and said acceleration grid, and a coil and condenser forming a tuned circuit connected between said acceleration grid and cathode whereby said tuned circuit oscillates at the desired frequency in the absence of any feedback external to said tube between said anode circuit and said tuned circuit.

4. A device of the class described comprising an electron tube having a cathode, an anode, an acceleration grid located between said cathode and anode, a density grid located between said cathode and acceleration grid and a third grid located between said anode and acceleration grid, means for applying a positive potential to said density grid, means for applying a higher posi-

tive potential to said acceleration grid, an anode circuit including means for applying a positive potential thereto less than that of said acceleration grid, a coil and a condenser forming a tuned circuit connected to said acceleration grid and cathode whereby said tuned circuit oscillates at the desired frequency in the absence of any feedback external to said tube between said anode circuit and said tuned circuit and a connection including a source of direct current potential between said cathode and said third grid.

5. An oscillation generator comprising a space discharge tube having a cathode, an anode, an acceleration grid located between said cathode and anode, a density control grid located between said cathode and acceleration grid, means for applying a positive potential to said density control-grid, the potential gradient adjacent said cathode being a function of the potential of said density grid only, and a third grid located between said anode and acceleration grid, means for applying a positive potential to said anode and acceleration grid higher than that of said density control grid, a circuit connecting said third grid and cathode and including an impedance and means for applying a potential to said grid which is negative with reference to said cathode, and an oscillation circuit connected between said acceleration grid and cathode.

6. The combination defined in the preceding claim in which an additional grid is located between said density and acceleration grids and means for applying a positive potential to said additional grid.

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