June 27, 1939. W. DILLENBURGER 2,163,939

METHOD OF MODULATION

Filed Feb. 24, 1937

Fig. 1.

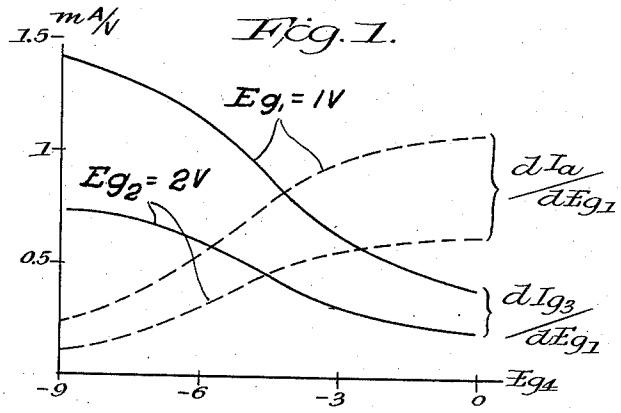


Fig. 2.

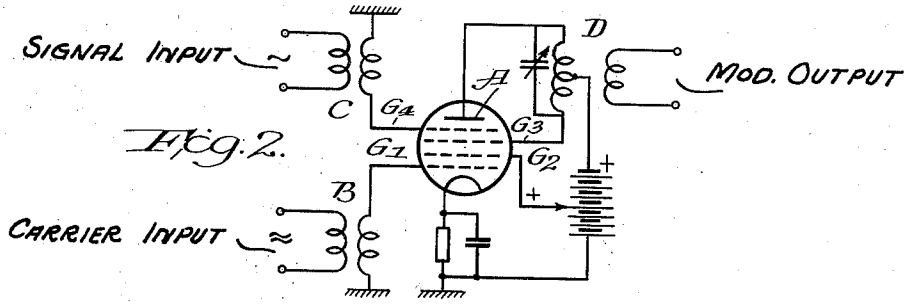


Fig. 3.

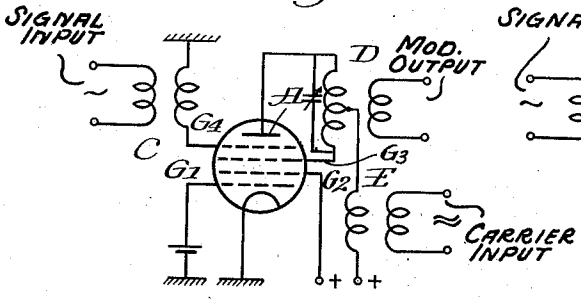
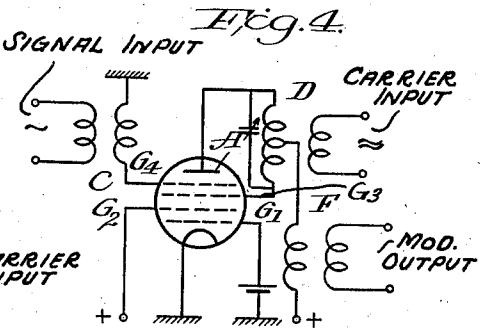


Fig. 4.



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METHOD OF MODULATION

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6 Claims. (Cl. 179—171)

This invention is related to a method of modulation in which a carrier frequency is applied to a multi-grid tube.

It is known to apply a frequency to each of two grids of a multi-grid tube, so that these frequencies are mixed in a multiplicative manner. If such a method would be utilized for the modulation of a carrier frequency the disadvantage would be that a high carrier voltage would be in the anode circuit also at zero modulation. The degree of modulation thereby is always dependent upon the amplitude of the modulation voltage.

For certain reasons, however, a constant degree of modulation, independent of the amplitude of the modulation voltage, is desired. This may be accomplished according to the invention, by distributing the current in a multi-grid tube varying with the carrier frequency between two positive electrodes by means of the modulation voltage. The partial currents are then applied to a coupling element in such a manner that the effects of these currents are partly or entirely compensated in the output. A 100% modulation is then achieved if the coupling element is designed in such a manner that there is no carrier frequency voltage in the output at zero modulation voltage. A differential transformer which is tuned to the carrier frequency may be used as coupling element.

The invention shall be explained with the aid of the drawing.

Figure 1 shows curves of the mutual conductance of the positive electrodes of the tube.

Figures 2, 3 and 4 show modifications of the invention.

The first grid of a hexode is at a constant negative voltage of, for instance, 2 volts. The second grid serves as a screen. The fourth grid distributes the emission current between the anode and the third grid, which both lie at positive potentials. The solid curves of Figure 1 show the mutual conductance dI_{g3}/dE_{g1} of the system incorporating the third grid and the first grid as a function of the voltage on the fourth grid (E_{g4}) for two different values of the bias of the first grid. The upper curve corresponds to a voltage of -1 volt on the first grid; the lower corresponds to a voltage of -2 volts. The mutual conductance dI_a/dE_{g1} of the system incorporating the anode and the first grid as a function of E_{g4}, are shown in the dotted curves. The upper curve again corresponds to a bias of -1 volt on the first grid, whereas the lower curve corresponds to a bias of -2 volts. It may be seen from the graph that both mutual conductances are equal at a certain voltage of the fourth grid. That means that a modulation voltage applied to the fourth grid will vary the currents in the third grid and the anode by the same amount but in opposite polarity. If the currents are applied to a differential transformer with a center tap, no voltage will be induced in the secondary of the transformer.

Figure 2 shows a hexode to the first grid G_1, of which the carrier frequency is applied by means of the transformer B. The grid G_2 is held at a constant positive potential. The modulation voltage is applied to the grid G_4 by means of the transformer C. The emission current varying with the carrier frequency will be distributed by this modulation voltage between the grid G_3 and the anode, which both are at the same positive potential. D indicates a differential transformer preferably tuned to the carrier frequency, to the primary of which the currents from the grid G_3 and the anode A are applied, while the center tap is connected to the anode voltage source. If the biases are chosen in such a manner that both systems, grid G_3-grid G_1 and grid G_3-anode, have the same mutual conductance, no voltage will be induced in the secondary at zero modulation voltage. If the equilibrium of the two partial currents is distributed by a voltage on the grid G_4, a carrier frequency is produced in the secondary of the differential transformer. The amplitude of the carrier frequency voltage is proportional to the amplitude of the modulation voltage.

Instead of the differential transformer, a suitable combination of resistance components may be also used, as coupling element. The resistance components are utilized between stages, in accord with standard practice in resistance coupled amplifiers, with leads to the next stage of amplification being taken at points equidistant from the center tap connection from the anode potential supply to the resistor in circuit between the anode and grid G_3. Operation with different values of the mutual conductance of grid G_3 and anode is also possible. If a 100% modulation is to be obtained in this case, the tube on the coupling element must be unsymmetrical to such an extent that a total compensation occurs in the output at zero modulation voltage. Tube capacities which may cause difficulties at high frequencies may be compensated by suitable neutralizing condensers.

Figure 3 shows another modification of the invention, in which the carrier frequency is applied in the anode circuit by means of a transformer E, while the grid G_1 is held at a constant voltage.

The modulated carrier frequency is again taken off the secondary of a differential transformer D. A 100% modulation is achieved by the same adjustments as in the case of Figure 2.

Figure 4 shows a third modification in which the carrier frequency is applied to the distributor anodes (G_3, A) of the multi-grid tube by means of a coupling device D, and the modulated carrier frequency is taken single ended from the transformer F disposed in the anode circuit. In principle, the same requirements are valid for this case as for the foregoing.

In place of a hexode, other tubes may be also used of course, as long as they allow a distribution of the emission current between two positive electrodes according to the modulation voltage. The third grid of a hexode may be also used as a distributing grid between the second and fourth grid. Finally, tubes built for this special purpose may be also used.

The circuit of Figure 2 has the advantage over arrangements where the carrier frequency is applied to the anode circuit, that a lower carrier frequency voltage is sufficient.

The described method allows a modulation with low frequencies down to zero. This is important, for instance, for television transmitters, because very slow variations may be also transmitted by this method, which corresponds to the average light intensity of the picture.

I claim:

1. In combination with a hexode having an anode, a cathode, a control grid disposed adjacent said cathode, a screen grid disposed adjacent said control grid, a third grid disposed between said shielding grid and said anode, and a fourth distributing grid disposed between said third grid and said anode, a modulating circuit, means for applying a carrier current to said control grid, means for positively biasing said shielding grid, an external circuit connecting said third grid and said anode comprising a center tapped tunable differential transformer having said center tap connected to an anode potential supply, means for applying a modulating potential to said distributing grid, and a work circuit arranged to abstract energy from said center tapped differential transformer.

2. In combination with a hexode having an anode, a cathode, a control grid disposed adjacent said cathode, a screen grid disposed adjacent said control grid, a third grid disposed between said shielding grid and said anode, and a fourth distributing grid disposed between said third grid and said anode, a modulating circuit comprising a potential source arranged to positively energize said anode and said third grid and to apply a positive biasing potential to said second grid, means for applying a radio-frequency carrier current to said control grid, means for applying a modulating signal current to said distributing grid, a center tapped differential transformer primary connected between said anode and said third grid and having said anode potential source applied to the center tap thereof, a differential transformer secondary inductively connected to said center tapped primary, and means for tuning said differential transformer.

3. The method of utilizing a hexode having an anode, a cathode, a control grid disposed adjacent said cathode, a screen grid disposed adjacent said control grid, a third grid disposed between said shielding grid and said anode, and a fourth distributing grid disposed between said third grid and said anode, which comprises applying a carrier current to said control grid therein, applying a modulating signal to said distributing grid, maintaining biases on said grids such that the mutual conductance between said third grid and said first grid, and said anode and said first grid, are equal, and differentially coupling the output of said third grid and said anode to a load circuit.

4. The method of modulating a signal current upon a carrier in a hexode having an anode, a cathode, a control grid disposed adjacent said cathode, a screen grid disposed adjacent said control grid, a third grid disposed between said shielding grid and said anode, and a fourth distributing grid disposed between said third grid and said anode, which comprises maintaining the mutual conductance between said third grid and said first grid equal to that between said anode and said first grid, externally connecting said anode and said third grid through a differential output circuit, and applying said modulating signal to said distributing grid to produce an unbalance in said differential output circuit.

5. In combination with a hexode having an anode, a cathode, a control grid disposed adjacent said cathode, a screen grid disposed adjacent said control grid, a third grid disposed between said shielding grid and said anode, and a fourth distributing grid disposed between said third grid and said anode, a modulating circuit comprising means for negatively biasing said control grid, means for positively biasing said shielding grid, a signal input transformer connected to said distributing grid, a center tapped differential transformer primary connected between said third grid and said anode, an output circuit inductively associated with said differential transformer primary and a carrier input circuit connected to said differential transformer primary at said center tap, and means for positively energizing said anode and said third grid through said carrier input circuit.

6. In combination with a hexode having an anode, a cathode, a control grid disposed adjacent said cathode, a screen grid disposed adjacent said control grid, a third grid disposed between said shielding grid and said anode, and a fourth distributing grid disposed between said third grid and said anode, a modulating circuit comprising means for positively energizing said shielding grid. means for negatively biasing said control grid, means for applying a modulating signal to said distributing grid, and a differential transformer primary connected between said anode and said third grid and having a center tap to which the primary of an output transformer may be connected, means for applying a positive potential to said third grid and said anode through said output transformer primary, and means for applying a carrier current to said third grid and said anode equally through said differential transformer.

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