May 26, 1936. J. PLEBANSKI 2,041,951

MODULATING SYSTEM

Filed July 21, 1934

FIG. 1

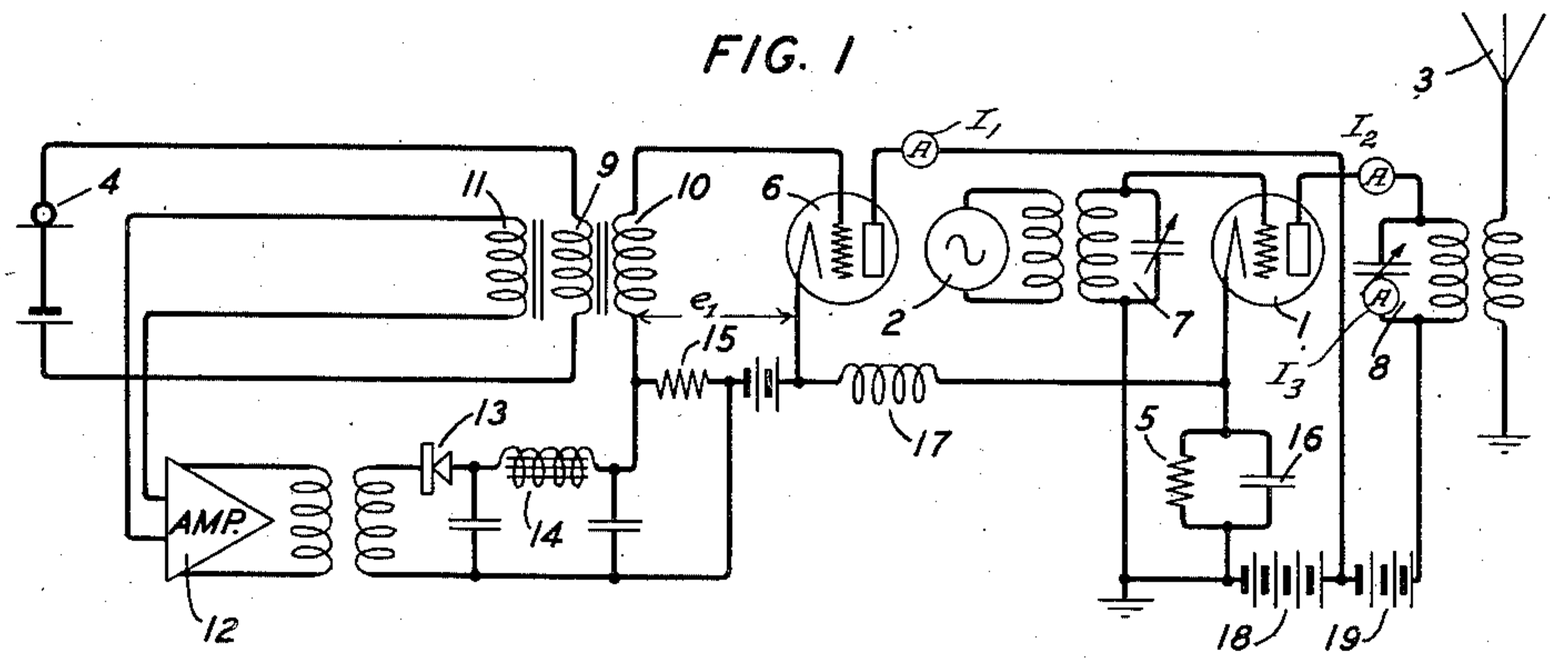
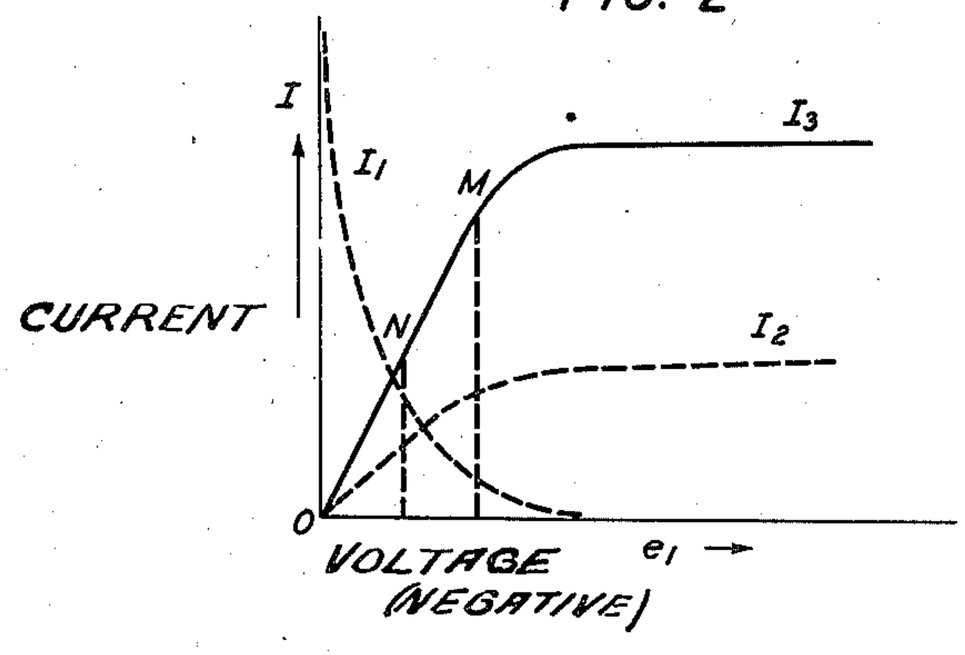


FIG. 2



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Patented May 26, 1936 2,041,951

UNITED STATES PATENT OFFICE

2,041,951

MODULATING SYSTEM

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Application July 21, 1934, Serial No. 736,403
In Poland August 17, 1933

7 Claims. (Cl. 179—171)

This invention relates to modulating systems and more particularly to means for controlling the transmission characteristics of such systems.

The main object of the invention is to obtain a high degree of proportionality between the modulated high frequency current output and the signal input of a modulating system, thus permitting a high degree of modulation, substantially 100 per cent, to be used without the introduction of noticeable distortion.

In accordance with the invention, a modulating tube and an amplifying tube are so associated with a coupling impedance that the latter is common to the plate circuit of the amplifying tube and to the plate circuit and grid circuit of the modulating tube. The plate current in the modulating tube then falls whenever the plate current in the amplifying tube rises, and vice versa. The type of modulation employed is a grid bias modulation with automatic compensation, as the bias for the modulating tube depends not only upon the current in the amplifying tube but also upon the current in the modulating tube. Such a system shows a straight line dependence between the high frequency current output and the potential applied between the grid and cathode of the amplifying tube. It is especially noticeable that bending of the curve such as is usually found at low values of applied potential is here nearly absent. Therefore the system may be adjusted initially to an operating point in the center of the linear range and a 100 per cent. modulation can be effected by operating between zero output and the upper limit of linear response, with a distortion factor that is exceedingly low.

The invention will be more fully understood from the following detailed description in conjunction with the accompanying drawing, in which Fig. 1 shows an embodiment of the invention in a radio transmitting system, and Fig. 2 shows current voltage relations in various portions of the system of Fig. 1.

In Fig. 1, the reference character 1 designates a modulating tube inserted between a carrier source 2 and an antenna system 3. A signal source 4 is connected to a coupling resistance 5 through an amplifying tube 6. The coupling resistance 5 is common to the plate circuit of the tube 6 and to the plate circuit and the grid circuit of the tube 1. The carrier source 2 is coupled to the grid of the tube 1 by means of a tuned input circuit 7. The plate of the tube 1 has a tuned output circuit 8 by which it is associated with the antenna system 3. The signal source 4 is coupled to the grid of the tube 6 through a pair of windings 9 and 10, which are part of a transformer having a third winding 11 connected to an amplifier 12. This amplifier is joined to a rectifier 13 and a low-pass filter 14, the output end of the latter being bridged across a resistance 15 in the grid circuit of the tube 6. The coupling resistance 5 is by-passed by a condenser 16. The cathodes of the tubes are connected together by a high frequency choke coil 17. Suitable anode voltages are provided for the tubes by means of batteries 18 and 19.

In the operation of the system of Fig. 1, the tube 1 functions as a modulator by virtue of the joint application of carrier and signal waves to its grid from the respective sources 2 and 4. The carrier wave is impressed by way of the tuned circuit 7 while the signal wave is first amplified in the tube 6, the amplified wave passing from the plate of that tube to the coupling resistance 5. The modulation is of the general type disclosed in Van der Bijl Patent No. 1,350,752 of August 24, 1920, the gain of the tube 1 as a carrier amplifier being effectively varied by means of the variable bias impressed upon the grid of the tube through the medium of the resistance 5. The resulting modulated wave in the plate circuit of tube 1 is delivered to the antenna system 3 through the tuned output circuit 8 and radiated.

As in the Van der Bijl system, the tube 1 acts as an amplifier of the signal wave as well as of the carrier, thereby producing a low frequency wave in the plate circuit of the tube 1 which simulates the signal wave more or less closely depending upon the nature of the characteristic relationship between the input voltage and output current of the tube, which may be non-linear.

Fig. 2 shows the currents at various points in the system when a steady negative potential e_1 is applied between the grid and the cathode of the tube 6. I_1 is the plate direct current of tube 6, I_2 is the plate direct current of tube 1, and I_3 is the high frequency output current in the capacitive branch of tuned circuit 8. The current I_1 falls as the impressed potential e_1 increases. At the same time the current I_2 increases. The high frequency output current I_3 increases substantially linearly from O to M. The point N, in the middle of the range OM is a suitable operating point for effecting 100 per cent modulation with very small distortion. It will be noted that when e_1 has a small negative value the current I_1 is large and produces a large negative bias

upon the tube 1 in flowing through the resistance 5. As e_1 is made large, i. e. more negative, the current I_1 decreases and with it the bias on the tube 1, giving an increase of the current I_2.

The invention is readily adaptable to variable carrier systems in which a condition of complete (100 per cent.) modulation is continuously, and automatically maintained irrespective of the signal intensity. As illustrated in Fig. 1, the signal wave is impressed upon the amplifier 12 by means of the coupled windings 9 and 11. The amplified wave is rectified by rectifier 13 and filtered by the low-pass filter 14. The resulting current is impressed upon the resistance 15, giving a variable grid bias for tube 6 which is dependent upon the intensity of the signals arising from the source 4. Through tube 6 and resistance 5, the voltage across the resistance 15 controls the gain of the tube 1 in synchronism with the intensity changes of the signal. When the signal intensity increases, for example, the rectified current also increases, making the grid of tube 6 more negative. This reduces the plate current of tube 6 and consequently reduces the voltage across the resistance 5, making the grid of tube 1 less negative than before and increasing the gain of the latter tube. The carrier voltage effective in the plate circuit of tube 1 is thereby increased, giving greater carrier amplitude to accommodate the increased signal intensity and prevent overmodulation. When the signal intensity decreases, the process is reversed, with the overall result that the carrier amplitude is decreased, permitting complete modulation in spite of the decreased signal intensity. By suitable adjustment of resistances 5 and 15 the system may be made to maintain the modulation substantially constant at any desired percentage of modulation. This regulation is superposed upon and proceeds without interference with the action of the coupling resistance 5 tending to diminish distortion.

I find that efficiency of operation is promoted by using a relatively small tube 6 with a correspondingly low plate supply potential supplied for example from battery 18 alone, but a relatively large tube 1 with higher plate potential as from combined batteries 18 and 19. With suitable tubes and with the potential of the battery 18 one-fifth to one-sixth the potential of the combined batteries an overall efficiency of some 50 per cent may be obtained.

The carrier wave may be substantially excluded from the low frequency portions of the system by means of the high frequency choke coil 17 separating the cathodes of the respective tubes, and the condenser 16 by-passing the resistance 5. Complete separation of the frequencies not always being necessary, the condenser 16 and particularly the coil 17 may be omitted.

What is claimed is:

1. A modulating system comprising a modulating tube and an amplifying tube each having a cathode, an anode and a control grid, a signal source associated with said amplifying tube, a carrier source associated with said modulating tube, and an impedance common to the anode circuit of said amplifying tube and to the anode direct current circuit and the grid circuit of the modulating tube, said impedance being proportioned to provide a substantial coupling of said several circuits, that is selectively responsive to waves in the frequency range comprising the signal wave, whereby modulation is expected while distortion of the modulated wave is diminished.

2. A modulating system comprising a modulating tube and an amplifying tube each having a cathode, an anode and a control grid, a signal source connected to the grid of the amplifying tube, a carrier source associated with the modulating tube, and an impedance common to the anode circuit of the amplifying tube and to the anode direct current circuit and the grid circuit of the modulating tube, said impedance being proportioned to provide a substantial coupling of said several circuits, that is selectively responsive to waves in the frequency range comprising the signal wave whereby modulation is effected while distortion of the modulated wave is diminished.

3. A modulating system comprising a modulating tube and an amplifying tube each having a cathode, an anode and a control grid, a signal source connected to the grid of the amplifying tube, a carrier source connected to the grid of the modulating tube, and an impedance common to the anode circuit of the amplifying tube and to the anode direct current circuit and the grid circuit of the modulating tube, said impedance being proportioned to provide a substantial coupling of said several circuits, that is selectively responsive to waves in the frequency range comprising the signal wave whereby modulation is effected while distortion of the modulated wave is diminished.

4. A modulating system comprising a modulating tube and an amplifying tube each having a cathode, an anode and a control grid, a signal source connected to the grid of the amplifying tube, a carrier source connected to the grid of the modulating tube, and a resistance and condenser combination common to the anode circuit of the amplifying tube and to the anode circuit and the grid circuit of the modulating tube, said resistance and condenser combination being proportioned to provide a substantial coupling of said several circuits that is selectively responsive to waves in the frequency range comprising the signal wave whereby modulation is effected while distortion of the modulated wave is diminished.

5. A modulating system comprising two vacuum tubes each having a cathode, an anode and a grid, a source of modulating current connected to the input circuit of the first tube, a source of carrier waves connected to the input circuit of the second tube, a connection between the cathodes of the respective tubes, said connection being of negligible impedance to modulating currents, a source of anode current supply connected to the two anodes in parallel relation, a resistance connected between the cathode junction and the negative terminal of the supply source and a connection from the grid of the second or carrier tube to the resistance terminal remote from the cathode junction.

6. A modulating system comprising two vacuum tubes each having a cathode, an anode and a grid, a source of modulating current connected to the grid of the first tube, a source of carrier waves connected to the grid of the second tube, a connection between the cathodes of the respective tubes, said connection being of negligible impedance to modulating currents, a source of anode current supply connected to the two anodes in parallel relation, a resistance connected between the cathode junction and the negative terminal of the anode current supply source, a connection from the grid of the second or car-

rier tube to the resistance terminal remote from the cathode junction, and means to prevent feed-back of carrier waves by way of said resistance.

7. A modulating system comprising two vacuum tubes each having a cathode, an anode and a grid, a source of modulating current connected to the grid of the first tube, a source of carrier waves connected to the grid of the second tube, a connection between the cathodes of the respective tubes, said connection being of negligible impedance to modulating currents, a source of anode current supply connected to the two anodes in parallel relation, a resistance connected between the cathode junction and the negative terminal of the anode current source, a connection from the grid of the second or carrier tube to the resistance terminal remote from the cathode junction, and a condenser in shunt relation to said resistance, to prevent feed-back of carrier waves.

JOZEF PLEBANSKI.