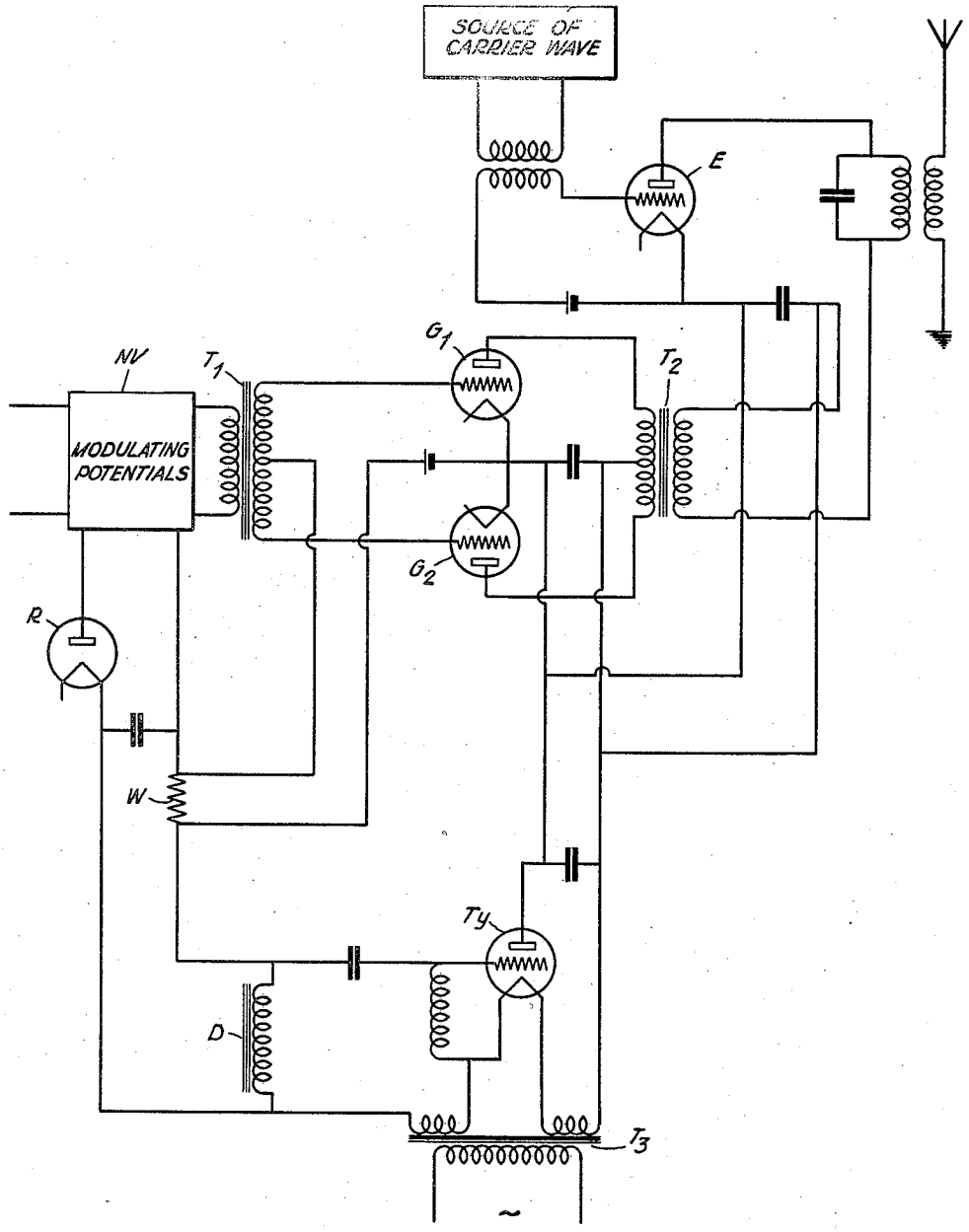
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MODULATION CIRCUIT

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MODULATION CIRCUIT

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One method known in the prior art to increase the efficiency of tube-type transmitters is to vary the amplitude of the high frequency carrier transmitted in proportion to the signal volume or amplitude in such a way that irrespective of variations in the strength of the signal there will be transmitted at all times the minimum requisite carrier wave energy. The mean amplitude of the carrier wave is caused to vary when the mean amplitude of the modulating potentials varies. Heretofore this reduction of the average carrier amplitude, to insure undiminished reception intensity, has been compensated by an increase in the modulation percentage. Increasing the modulation percentage is a defect in the said method because with growing modulation, both at the sending as well as at the receiving end owing to non-linear demodulation characteristics, the distortion factor increases so that the quality of reproduction finally becomes inadmissibly poor.

An object of the present invention is to overcome this defect.

In the present invention for the sake of good voice quality, the mean carrier amplitude is reduced only to such a point that the average modulation, customarily used under normal operation conditions around 20 percent, is not raised to fully 100 percent, but only to, say, 40 to 50 percent. By such partial carrier modulation or control a considerable amount of energy is saved as compared with normal operation predicated upon a constant carrier. However, in order that not only this energy saving may be realized, but a still greater saving, than is feasible in the presence of a 100 percent modulation of the carrier without incidentally occasioning an impairment in quality, may be accomplished in accordance with this invention the method described above and based upon partial carrier modulation is combined in suitable manner with an especial efficient method of plate voltage modulation in which the function of the customary modulator tube is taken over by a push-pull arrangement involving a balanced and steady current drain of minimum value.

One embodiment of the basic idea of this invention is shown in the drawing. The power tube E is modulated by plate potential variations. The efficiency of plate modulation as shown here is well known, to be greater than grid modulation, if it is possible to maintain the energy consumption in the modulator at a low value. The energy consumption is maintained at a low value in accordance with this invention by the use of two tubes G_1 and G_2 operating on the push-pull principle. The grids of the tubes are biased to a point close to the lower knee of their characteristic curve. The signal voltage is impressed on the grids of the tubes by way of the transformed T_1, while by way of the transformer T_2 they influence the plate potential of the power tube E.

In order to insure that the plate potential of the power tube will be fully utilized, we regulate the carrier amplitude by acting upon the plate potential of E. However, simultaneous regulation of the modulator plate potential is desirable in order that the energy consumption of the modulator stage may be minimized, for though it is true that this consumption is greatly reduced by our push-pull arrangement using the high grid biasing potential, it is nevertheless not negligibly low because, if undistorted modulation is to be insured, the working point should not be pushed all the way down to the lower knee of the characteristic curve, because it is not feasible to allow the steady current to drop all the way down to zero. Hence, according to this invention the modulator plate potential is acted upon, while at the same time the grid biasing voltage of the modulator tubes is so regulated that their working point will always be at the optimum value.

The drawing illustrates a simple method adapted to regulate or control by the signal amplitude, the grid bias of the modulator tubes G_1 and G_2 as well as the plate potential applied to the modulators and to the power tube E. From the audio-frequency amplifier NV, which furnishes signal voltage to the modulator, a part of the signal voltage is branched off, then rectified in R and thereupon conducted through the resistance W and the choke coil D. The fall of potential across W is superimposed on the potential of the grid bias source and furnishes the variable grid biasing potential for the modulators G_1, G_2. The variations in saturation of the choke coil D caused by the rectifier current therein excites the control grid of a rectifier Ty and consequently helps to control the amount of plate direct current voltage obtained thereby from the alternating current source connected with T_3. The transformer T_3 and rectifier Ty converts the network alternating current voltage into direct current in the plate circuit of the rectifier and to a lesser extent into direct current in the grid circuit of the rectifier. The plate direct current voltage furnished from the output of the rectifier is thus controlled by the voltage acting at the grid of the rectifier, and the phase and intensity thereof of the said controlling voltage is a function of the saturation of the choke coil D, in other words, of the current

at the output of the rectifier R and thus is a function of the mean signal volume.

The output of Ty depends on the phase relation of the alternating current voltages on its grid and its anode. The phase of the alternating voltage on the anode Ty is substantially fixed. The phase of alternating voltage applied to the grid of Ty is controlled by variations in the inductance of D. The variations in the inductance of D is controlled by the intensity of the rectified signals supplied by R flowing in D. As the rectified current in D increases the inductance of D decreases due to over-saturation, and the voltages on the grid and anode of Ty will approach each other in phase, thereby increasing the output of Ty which supplies plate direct current voltage for tubes G_1, G_2, and E. As the current in the output of R decreases with decrease in signal voltage amplitude, the current through D decreases and the inductance of D increases so that the phase of the voltage on the grid changes and the direct current output of Ty decreases.

The rectifier Ty may be of that type in which irrespective of the value of the anode potential applied no current flows until the grid potential reaches a critical value and then current flows and continues to flow irrespective of the value of the grid potential until the anode potential is removed. It will be understood that the type of rectifier described has been chosen merely by way of example, in fact, the control of the tube direct current potentials by the signal level is accomplishable also by a number of other direct current sources which may include rectifiers of different type, and this in many modified manners.

Having thus described our invention and the operation thereof, what we claim is:

1. A signaling system comprising, a thermionic tube having a control grid adapted to be energized by carrier oscillations and an anode connected with a load circuit and means for modulating the carrier oscillations in said tube at signal frequency comprising, a source of modulating potentials, a pair of modulator tubes having their control grids coupled to said source of modulating potentials and their anodes coupled to the anode in said first named tube, and means for controlling the operation of said modulator tubes and of said thermionic tube in accordance with the mean amplitude of the modulating potentials comprising, a rectifier having its input electrodes coupled to said source of modulating potentials and its output electrodes connected in a circuit including an impedance and a resistance, a circuit connecting the control grids of said modulator tubes with said resistance to utilize the potential drop therethrough for controlling the bias of said modulator tubes, a rectifier for supplying anode potentials for said modulator tubes and said first named tube and a circuit connecting a control grid in said last rectifier to said impedance.

2. A signaling system comprising, a thermionic tube having a control grid adapted to be energized by carrier oscillations and an anode connected with a load circuit, and means for modulating the carrier oscillations in said tube at signal frequency comprising, a source of modulating potentials, a pair of modulator tubes having their control grids coupled to said source of modulating potentials and their anodes coupled to electrodes in said thermionic tube, and means for controlling the operation of said modulator tubes and of said thermionic tube in accordance with the mean amplitude of the modulating potentials comprising a rectifier having its input electrodes coupled to said source of modulating potentials by way of an inductive reactor and a capacity, a source of alternating current to be rectified coupled to the input electrodes of said rectifier, and a circuit coupling the output electrodes of said rectifier to the anodes of said thermionic tube and said pair of modulator tubes.

3. A transmission system including a thermionic tube having output electrodes and having input electrodes coupled to a source of high frequency oscillations, means for modulating the oscillation impressed on said first named tube comprising a modulator tube having its input electrodes coupled to a source of modulating potentials and its output electrodes coupled to an electrode in said first named thermionic tube, and means for controlling the percentage modulation of said oscillations in accordance with changes in the mean amplitude of the modulating potentials comprising a rectifier having its input electrodes coupled to said source of modulating potentials and its output electrodes coupled to the input electrodes of said modulator tube and to the output electrodes of said thermionic tube and to the output electrodes of said modulator tube.

4. In a signaling system, a thermionic tube having a control grid an anode and a cathode, means for energizing said control grid by carrier frequency oscillations to be modulated, a load circuit connected with said anode and cathode, and means for modulating the carrier frequency oscillations in said thermionic tube at signal frequency comprising, a source of modulating potentials, a modulator tube having a control grid an anode and a cathode, a circuit connecting the control grid and cathode of said modulator tube to said source of modulating potentials, a circuit connecting the anode of said modulator tube to the anode of said thermionic tube and means for controlling the operation of said modulator tube comprising a rectifier having an input and an output, a circuit coupling the input of said rectifier to said source of modulating potentials, a circuit coupling the output of said rectifier to the control grid of said modulator tube, a controllable source of direct current charging potentials connected with the anode of said thermionic tube and with the anode of said modulator tube, and a circuit connecting the output of said rectifier to said controllable source of direct current potentials to control the same in accordance with energy in the output of said rectifier.

5. In a signaling system a thermionic tube having an anode, a cathode and a control grid, a circuit for applying carrier waves to be modulated to the control grid and cathode of said thermionic tube, a utilization circuit connected with the anode and cathode of said thermionic tube, a source of modulating potentials, a modulator tube having an anode a cathode and a control grid, a circuit connecting the control grid and cathode of said modulator tube to said source of modulating potentials, a circuit connecting the anode and cathode of said modulator tube to the anode and cathode of said thermionic tube, a source of controllable direct current potential comprising a rectifier having input and output electrodes, a circuit coupling the output electrodes of said rectifier to the anodes of both of said tubes, a circuit connecting the input electrodes of said rectifier to a source of alternating current potential, a second rectifier having an input coupled to said source of modulating po-

tentials, said second rectifier having an output, a circuit including an impedance coupling the output of said second rectifier to the control grid and cathode of said modulator tube, and a circuit connecting the output of said second rectifier to said first named rectifier to control the impedance thereof.

6. In a signaling system an electron discharge tube having an anode, a cathode and a control grid, a circuit for applying waves to be modulated to the control grid and cathode of said tube, a utilization circuit coupled to the anode and cathode of said tube, a modulator tube having an anode, a cathode and a control grid, a source of modulating potential connected with the control grid and cathode of said modulator tube, a circuit coupling the anode of said modulator tube to the anode of said electron discharge tube, a variable source of direct current potential connected with the anodes of both of said tubes, and a rectifier circuit coupling said source of modulating potentials to the control grid of said modulator tube and to said variable source of direct current potential to simultaneously vary the potential on the control grid of said modulator tube and the potential on the anode of said modulator tube and the anode of said discharge tube, in accordance with variations in the amplitude of the modulating potentials from said source.

7. In a signalling system, an electron discharge device having a control grid, a cathode and an anode, said control grid being connected with an alternating current circuit, means for impressing oscillations to be modulated on said alternating current circuit, an alternating current output circuit connected with the anode of said tube in which modulated potentials are set up, a pair of modulator tubes each having input and output electrodes, a circuit impressing modulating potentials in push-pull relation on the input electrodes of said modulator tubes, a circuit coupling the output electrodes of said modulator tubes to the anode and cathode of said first electron discharge device, a source of direct current potential of variable intensity, a circuit connecting said source of direct current potential between the anode and cathode of said discharge device, a rectifier having input electrodes on which modulating potentials may be impressed, said rectifier having output electrodes and means coupling the output electrodes of said rectifier to said variable source of direct current potential to control the intensity thereof in accordance with the mean amplitude of the modulating potentials.

8. In a signalling system, an electron discharge device having an anode, a cathode and a control grid, an alternating current circuit connected with said control grid for impressing oscillations of carrier wave frequency thereon, an alternating current circuit connected with the anode of said device, a pair of modulator tubes each having a control grid, a cathode and an anode, a circuit for impressing modulating potentials in push-pull relation on the control grids of said modulator tubes, a circuit coupling the anode electrodes of said modulator tubes in push-pull relation, said last named circuit being coupled to the anode and cathode of said device, a source of direct current potential of variable intensity, a circuit connecting said source of direct current potential of variable intensity between the anode and cathode of said first named device, a rectifier having input electrodes, means for impressing modulating potentials on the input electrodes of said rectifiers, said rectifier having output electrodes connected in a circuit including current smoothing elements, and means for coupling said rectifier output circuit to said source of direct current potentials of variable intensity to control the intensity thereof in accordance with the mean amplitude of the modulating potentials to thereby control the amplitude of the modulated potentials appearing in the output circuit of said device in accordance with the mean amplitude of said controlling potentials.

9. A system as recited in claim 8 wherein a biasing impedance is coupled between the control grid and cathodes of said modulator tubes and wherein said biasing impedance is connected in the circuit connected with the output electrodes of said rectifier.

10. A signalling system as recited in claim 8 wherein said source of direct current potential of variable intensity is also connected with the anodes and cathodes of said modulator tubes.

11. A signalling system as recited in claim 8 wherein a biasing impedance is connected between the control grids and cathodes of said modulator tubes and is connected with the circuit connected with the output electrodes of said rectifier and wherein said direct current source of variable intensity is connected with the anodes and cathodes of said modulator tubes.

12. In a transmission system, a source of wave energy to be modulated, an amplifier tube having input and output electrodes, means for impressing wave energy from said source on the input electrodes of said amplifier, an output circuit coupled to said output electrodes, a source of modulating potentials, means for impressing modulating potentials from said source of modulating potentials on an electrode in said amplifier tube to modulate therein the wave energy when said tube electrodes are energized, and means for energizing the electrodes of said tube and for controlling the degree of modulation of said wave energy accomplished in said tube including a rectifier tube having a control grid, an anode, and a cathode, a source of alternating current, circuit means for impressing alternating current from said source on the anode of said rectifier circuit, means including a reactor for impressing alternating current from said source on the control grid of said rectifier, a circuit coupling the anode and cathode of said rectifier to an electrode in said amplifier, and an additional means for producing current flow in said reactor the intensity of which is controlled in accordance with the amplitude of the modulating potentials of said source of modulating potentials.

13. In a transmission system, a source of wave energy to be modulated, an amplifier tube having input electrodes and output electrodes, means for impressing wave energy from said source to the input electrodes of said amplifier, an output circuit coupled to said output electrodes, a source of modulating potentials, a circuit coupling said source of modulating potentials to a pair of electrodes in said tube to modulate in said tube the wave energy when direct current potentials are applied to the anode of said tube, and means for applying direct current potentials to the anode of said tube and for controlling the value of said potentials in accordance with the mean amplitude of the modulating potentials including a rectifier tube having a control grid, an anode, and a cathode, a source of alternating cur-

rent, circuits for impressing alternating current from said source on the grid and cathode and on the anode and cathode of said rectifier tube, means for impressing rectified alternating current from the anode and cathode of said rectifier on a pair of electrodes of said amplifier tube, and a control circuit including a rectifier coupling said source of modulating potentials to said one of said last named circuits for controlling the relative phase of the alternating current impressed on the grid and on the anode of said rectifier tube in accordance with the amplitude of said modulating potentials.

14. A system as recited in claim 13 wherein an additional electron discharge tube has its input electrodes coupled to said source of modulating potentials and its output electrodes coupled to the said pair of electrodes in said amplifier tube and wherein the output electrodes of said rectifier are coupled to an electrode in said discharge tube to control the operation thereof in accordance with the mean amplitudes of said modulating potentials.

15. In a signalling system, a tube amplifier having input electrodes excited by wave energy to be modulated and output electrodes coupled to a load circuit, a source of modulating potentials coupled to electrodes in said tube to modulate therein said wave energy, a source of alternating current, a rectifier tube having input electrodes including a control grid and a cathode, and output electrodes including an anode and said cathode, said rectifier tube being of the type in which, irrespective of the value of the anode potential applied no current flows until the control grid potential reaches a critical value and then current flows and continues to flow irrespective of the value of the grid potential until the anode potential is removed, a direct current circuit coupling the anode and cathode of said rectifier tube to electrodes of said tube to control the operation thereof, alternating current circuits for applying alternating current from said alternating current source to the anode and to the control grid of said rectifier tube, and means coupling the control grid of said rectifier to said source of modulating potentials to control the phase relation of the potentials applied to the anode and control grid of said rectifier in accordance with the mean amplitude of said modulating potentials to thereby control the degree of modulation of the wave energy in said tube.

16. A system as recited in claim 15 wherein an additional amplifier tube is interposed between said source of modulating potentials and electrodes in said first named tube and in which an electrode in said additional tube is connected to the output electrodes of said rectifier to control the operation of said additional tube in accordance with the mean amplitude of said modulating potentials.

17. A system as recited in claim 15 wherein said last named means includes a rectifier tube having input electrodes coupled to said source of modulating potentials and having output electrodes connected to the alternating current circuit connected with the grid of said rectifier.

18. The method of producing in oscillation producing apparatus, oscillations varied in amplitude in accordance with a signal wave which comprises shifting the phase of and simultaneously rectifying constant frequency alternating current and at the same time variably controlling the phase shifting and the rectification in accordance with said signal wave so as to produce unidirectional current varying in amplitude in accordance with said signal wave, supplying said unidirectional current to the space current path of said oscillation producing apparatus, and separately and simultaneously acting on said oscillation producing apparatus in accordance with said signal wave.

19. A signalling system including a carrier wave source, a source of signals, means for modulating said carrier wave in accordance with said signals, a power supply source of constant freqeuncy alternating potential, means for varying the phase of said potential in accordance with said signals, and means for additionally modulating said carrier wave in accordance with said phase varying of said potential.

20. A signalling system including a source of carrier waves, a source of signals, means for modulating said carrier waves in accordance with said signals, and means for separately modulating said carrier waves in accordance with said signals including rectifier apparatus having grid and plate electrodes, a constant frequency alternating current power supply source connected with said grid and plate electrodes for supplying potentials of similar frequency thereto, and reactance means varying the phase relation between said potentials in accordance with said signals for causing said rectifier apparatus to supply rectified voltage from said alternating current supply source in accordance with said signals.

21. A signalling system including a source of carrier waves, a source of signals, means for modulating said carrier waves in accordance with said signals, a power source of constant frequency alternating current, and means connected with said power source of constant frequency alternating current for separately modulating said carrier waves in accordance with said signals and only at a rate of modulation less than the frequency of said alternating current power source.

22. The method of producing in oscillation producing apparatus, oscillations varied in amplitude in accordance with a signal wave which comprises shifting the phase of and simultaneously rectifying constant frequency alternating current and at the same time variably controlling the phase shifting and the rectification in accordance with a characteristic of said signal wave so as to produce unidirectional current varying in amplitude in accordance with said characteristic of said signal wave, supplying said unidirectional current to the space current path of said oscillation producing apparatus, and separately and simultaneously acting on said oscillation producing apparatus in accordance with a substantially different characteristic of said signal wave.

23. A system including means for producing oscillations, a power supply source of constant frequency alternating potential, said frequency of said supply source potential being substantially less than that of said oscillations, a signal current circuit, means for shifting the phase of said supply source potential in accordance with said signal current, and means for varying said oscillations in accordance with said phase shifting of said supply source potential.

24. A power supply system including a source of signal current, an output circuit, an alternating current power supply circuit, rectifier means connected with said output circuit for supplying unidirectional current from said supply circuit to said output circuit and including a tube having a plurality of electrodes, and means for supplying voltages of similar frequency to said elec-

trodes from said supply circuit, said voltage supplying means including means for shifting the phase of said voltage on one of said electrodes with respect to the phase of said voltage on another of said electrodes in accordance with said signal current for varying the magnitude of said unidirectional current in accordance with said phase shifting and said signal current.

25. A system including means including a space discharge device for producing radio frequency current, a source of signal current, means including a rectifier for producing flow of direct current in accordance with said signal current, a supply source of constant frequency alternating voltage, means including a resistance device and an inductance device having an iron core for changing the phase of said supply source voltage in accordance with said flow of said direct current, and means including another rectifier for supplying rectified voltage from said supply source to said space discharge device in accordance with said changes of phase of said supply source voltage.

26. A signaling system including a source of carrier waves, a source of signals, means for modulating said carrier waves in accordance with said signals, a power source of constant frequency alternating current, and means connected with and modulating said power source of constant frequency alternating current for separately modulating said carrier waves in accordance with said signals, and only at a rate of modulation slower than that of said first mentioned modulating means.

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