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J. D. BOOTH

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MODULATION SYSTEM

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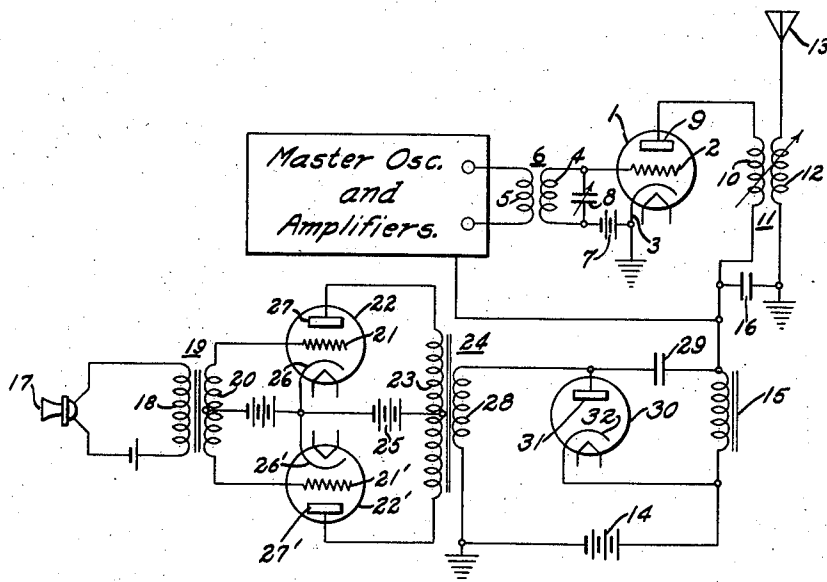


Fig. 1.

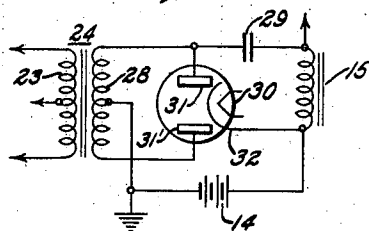


Fig. 2

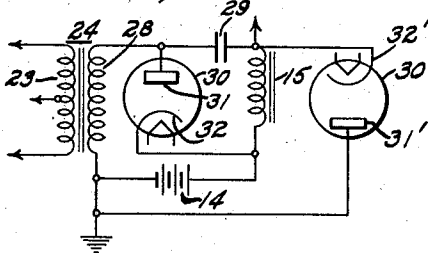


Fig. 3.

WITNESSES:

Leon M. Garman
F. C. Bartholomew

INVENTOR

James D. Booth.

BY

F. W. Lyle,
ATTORNEY

UNITED STATES PATENT OFFICE

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MODULATION SYSTEM

James D. Booth, Longmeadow, Mass., assignor to
Westinghouse Electric & Manufacturing Com-
pany, East Pittsburgh, Pa., a corporation of
Pennsylvania

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9 Claims. (Cl. 179—171.5)

This invention relates to radio transmitters and more particularly to arrangements employing high level modulation.

Radio transmitters generally employ high level or plate modulation for impressing the audio frequency or modulation voltage upon the carrier wave of the transmitter. In this type of modulation, the plate circuit of the final stage of the radio frequency power amplifier is subjected to the modulation voltage which is usually derived from the output of an amplifier. The latter amplifies only the audio frequency currents for the purpose of modulation of the carrier and is generally referred to as the modulation amplifier. In the system to which this invention is particularly directed, a separate supply of operating potentials is provided for the radio frequency amplifier to be modulated and for the modulation frequency amplifier; the coupling between the two plate circuits being obtained by a coupling circuit in which a suitable condenser isolates the direct current potentials of the two power supplies while providing a path for the modulation frequency currents.

It is an established fact that by modulation of a carrier the amplitude thereof will vary in accordance with the amplitude of the modulation wave and at a rate determined by the frequency of the latter. For full modulation when the positive peak of the audio wave reaches its maximum, the peaks of the carrier wave become double the value reached when no modulation is occurring; and when the audio wave reaches a maximum in the negative direction, the carrier wave peaks are reduced to zero. The proportion between the magnitudes of the unmodulated carrier wave and that of the modulation frequency voltage determines the percentage of modulation. Thus the percentage of modulation may be any value between zero to 100 depending upon the amount of audio frequency applied to the modulated stages. If the audio frequency applied thereto is greater than necessary to obtain 100% modulation, an over modulation of the carrier results, causing serious distortion which increases as the over modulation is increased.

The primary object of this invention is to prevent over modulation of the carrier, and to this end means are provided for automatically limiting the magnitude of modulation voltage transfer to the carrier frequency amplifying stage of the transmitter.

As stated before, in amplitude modulation systems the positive peaks of the modulation frequency wave are added to the carrier wave am-

plitude and the negative peaks are subtracted therefrom. In a similar manner when the modulation is applied to the plate circuit of an amplifier stage, the positive voltage peaks will increase the plate voltage supplied to the amplifier tube by an amount equal to the magnitude of the modulation frequency voltage and conversely, the negative peaks will decrease the plate voltage. At 100% modulation the plate voltage will rise to twice its normal value supplied by the plate voltage source at positive half cycles of the modulation frequency and to zero value at the negative half cycle thereof.

A further object of this invention is to prevent the additive or the subtractive transfer of modulation voltage in excess to the magnitude of plate potential supplied irrespective of changes in the value of this potential.

Prior arrangements have attempted to prevent over modulation by a system of balance reached between the modulation voltage and the plate voltage by means of auxiliary control of bias on certain portions of the system. The resultant limiting of modulation peaks was effective only for one pre-set condition, and unbalance occurred as soon as the plate voltage changed in value. In other words, over-modulation was suppressed only at a predetermined value of plate potential, and the system required rebalancing every time the plate supply voltage changed.

The particular feature of this invention is that over-modulation is automatically controlled irrespective of variations in the plate voltage supplied to the carrier amplifier to be modulated without requiring any balancing or setting of controls.

Another advantage resulting from the use of the means herein proposed is that 100% modulation may be maintained automatically at all times as long as the modulation voltage is equal or greater in value than the plate voltage supplied.

Additional objects and advantages will be apparent from the following description of the invention, defined particularly by the appended claims and taken in connection with the accompanying drawing, in which:

Figure 1 illustrates schematically the over-modulation limiter operating on the positive half cycles of the modulation voltage in connection with a plate modulated carrier frequency amplifying stage;

Fig. 2 shows a modification of the limiting portion of Fig. 1 utilizing a double diode tube, the operation of which includes both the positive and

the negative half cycles of the modulation voltage; and

Fig. 3 shows an arrangement similar to Fig. 2 in which two individual diodes perform the same function.

Referring to Fig. 1, the final amplifier stage of the radio transmitter comprises the tube 1, the input circuit of which includes the grid electrode 2 connected to one terminal of the secondary winding 4 of the radio frequency transformer 6. The primary winding 5 thereof is energized by the preceding carrier frequency amplifiers of the transmitter, indicated here merely by a square, inasmuch as the components thereof have no direct bearing on this invention and may be of the conventional type, comprising a master oscillator, a buffer and several other stages of amplification, depending upon the type of service for which the transmitter is designed. Only the final output stages which are to be modulated need be considered, of which the last stage is schematically shown. Continuing the description thereof, the input circuit is completed by the return of the secondary winding to the cathode 3, which is grounded, and in series therewith is a source of grid bias potential shown here for the purpose of illustration by the battery 7. The secondary winding is tuned by the condenser 8 to the carrier frequency to be transmitted.

The filament of any of the tubes in the various figures of the drawing is not completed to its source of heating current in order to simplify the illustration, for it is well known in the art that a suitable source of heating current must be provided in order to operate tubes of the indirectly heated cathode type.

The output circuit of the tube 1 includes the plate or anode 9, the radio frequency load impedance 10, which may be the primary winding of an output transformer 11, the secondary 12 of which supplies the radiator or antenna 13. The return terminal of the winding 10 is connected to the positive terminal of the plate potential source shown here for the purpose of illustration as the battery 14, the negative terminal of which is connected to ground. In series with the plate return lead is a modulation frequency reactance in the form of a choke coil 15. The condenser 16 by-passes the audio frequency energy to ground.

The modulation frequency source is indicated by the output stage of an audio frequency amplifier which is shown as being fed from a microphone 17 coupled to the primary winding 18 of the input transformer 19. The secondary winding 20 thereof excites the grids 21 and 21' of the tubes 22 and 22', respectively. The output circuit of the above tubes is completed to the primary winding 23 of the push-pull output transformer 24 in the conventional manner, the plate potential source indicated by the battery 25 being connected between the junction of the cathodes 26 and 26' and the midpoint of the winding 23, the terminals of which are connected to the plates 27 and 27', respectively. The coupling circuit for the transfer of the modulation frequency voltage comprises the secondary winding 28 of the output transformer 24, one terminal of which is grounded and the other connected to the plate return side of the choke coil 15 through a coupling condenser 29.

The system so far described conforms in all its details with the commonly employed form of high level or plate circuit modulation. The novel feature of the invention resides in the

particular connection and utilization of a unilateral current conductive device in the form of a diode tube 30, the anode 31 of which is connected to the high potential terminal of the winding 28 and the cathode 32 thereof to the positive terminal of the plate potential source 14. In this manner, the space current path of the diode 30 is effectively connected in parallel with the reactance 15 in so far as modulation frequency currents are concerned, the condenser 29 being of relatively low impedance for such currents.

Referring to the operation of the system, it will be seen that the modulation voltage to be transferred across the reactance 15 appears between the terminals of the secondary winding 28; that is, between ground and the high potential side thereof. This voltage is impressed across the reactance 15 through the condenser 29, and consequently when in the cyclic variation the plate terminal of the reactance 15 becomes positive, the voltage developed thereacross is in additive relation to the voltage supplied by the battery 14, and when reversal of cycle occurs, the voltage is subtractive therefrom. Evidently, when the two voltages are equal in magnitude, the effective plate voltage for the tube 1 is doubled at one half cycle of the modulation voltage and reduced to zero at the next half cycle thereof. Under this condition, 100% modulation is reached. It is to be noted that until such condition is obtained and at such condition of operation, the diode 30 remains non-conductive and has an infinitely high impedance. The reason for this is that its cathode 32 is always biased positive with respect to its anode 31 by the plate potential source 14. Hence as long as the modulation voltage is not greater than the voltage of the source 14 to counteract this bias, the diode forms no conductive path. However, should the modulation voltage exceed the value of the voltage supplied by the battery 14, which may be the case by loud talking, for instance, it the microphone 17, the bias on the cathode 32 will not counterbalance the voltage on the anode 31, and the tube 30 will draw current forming a conductive path effectively in parallel with the reactance 15. In this manner, the excess voltage results in a current by-passing the reactance and the energy is dissipated within the tube 30, whereas the modulation voltage remains of the value required for not more than 100% modulation.

The diode rectifier 30 is always polarized by the source 14 in such manner that the cathode thereof is biased positive with respect to its anode. To be conductive, the modulation voltage at positive peaks must overcome the polarizing voltage. Hence the positive peaks greater in magnitude are resolved into a current finding a conductive path around the choke 15, and an additive voltage transfer is automatically limited to voltages not surpassing in magnitude the plate potential source irrespective of any changes in the latter. By this is meant that if the plate voltage source 14 decreases in value to say half its normal voltage, the bias on the cathode 32 of the diode 30 decreases also in proportion, and its conductivity is automatically adjusted to limit modulation frequency peaks to the existing value of plate potential.

Fig. 2 illustrates the modification of the coupling circuit wherein the limiting diode tube 30 is of the type having two plate anodes 31 and 31' connected in such manner that duo-lateral con-

ductivity is obtained provided that the modulation voltage peaks exceed the value of the plate potential source 14. In this case, both the positive and the negative peaks are resolved into currents finding a conductive path, and the subtractive transfer tending to lower the plate potential in a negative sense below the zero value is also limited and cannot be less than zero. In order to obtain operation of the tube in the manner stated, the output transformer 24 is provided with a mid-tapped secondary winding 28, each half of which is so proportioned in number of turns that the voltage across each secondary section is equal in magnitude to the voltage output of the single secondary winding of the transformer 24 shown in Fig. 1.

In order to obtain dual operation limiting voltage transfer in the coupling circuit with the arrangement shown in Fig. 1, two diodes 30 and 30' may be connected in the manner shown in Fig. 3 in opposing relation of conductivity. As will be seen, the operation is identical with the one shown in Fig. 2 except that two tubes are used, the diode 30 being conductive at positive peaks surpassing the value of the source 14, and the other diode 30' at negative peaks exceeding the same value.

I claim as my invention:

1. In a circuit for modulating high frequency carrier amplifying stages, including electron discharge devices, a source of operating potentials for said devices, a modulation frequency source, a coupling circuit therefor impressing said modulation frequency upon said stages and means for preventing overmodulation in said stages comprising a thermionic device included in said coupling circuit and polarized by said source of potential for limiting the magnitude of modulation voltage transfer in said circuit.

2. In a modulation system of the high level type, a carrier frequency amplifier including a vacuum tube having an output circuit, a source of operating potentials supplying current thereto, a modulation frequency source and a circuit interconnecting said output circuit therewith including said source of operating potentials, a thermionic device of unilateral conductivity effectively in parallel with said output circuit and polarized by said source of potentials whereby said device is rendered operative only upon potentials exceeding that of said last mentioned source.

3. In a modulation system of the high level type, a carrier frequency amplifier including a vacuum tube, an output circuit between anode and cathode thereof including an impedance and a source of anode potential, a modulation frequency amplifier, circuit means interconnecting said modulation frequency amplifier and said impedance whereby a modulation frequency voltage is transferred impressively across said impedance additively and subtractively with respect to said anode potential in cyclic variation with frequency and means for limiting the magnitude of said additive transfer automatically upon exceeding the value of said anode potential, comprising a shunt circuit effectively in parallel with said impedance, said last mentioned circuit including an element of variable current conductively operatively associated with and polarized by said source.

4. In a plate circuit modulation system, a carrier frequency vacuum tube amplifier having at least a plate, cathode and control electrodes, an output circuit between said plate electrode and

said cathode including a carrier frequency impedance, a modulation frequency reactance and a source of plate potential in series; a modulation frequency amplifier having an output circuit including an impedance element, a coupling circuit interconnecting said impedance element and said reactance, said circuit including said plate potential source and a capacity in series, and a diode rectifier conductively connected between said impedance element and the plate terminal of said reactance.

5. In a plate circuit modulation system, a carrier frequency vacuum tube amplifier having at least a plate, cathode and control electrodes, an output circuit between said plate electrode and said cathode including a carrier frequency impedance, a modulation frequency reactance and a source of plate potential in series; a modulation frequency amplifier having an output circuit including an impedance element, a coupling circuit interconnecting said impedance element and said reactance, said circuit including said plate potential source and a capacity in series, and a diode rectifier having its anode conductively connected to said impedance element and its cathode to the positive plate terminal of said source.

6. In a plate circuit modulation system, a carrier frequency vacuum tube amplifier, a source of plate voltage therefor, a modulation frequency amplifier, a coupling circuit for the transfer of modulation voltage from one to the other, and means in said circuit for limiting the magnitude of voltage transfer comprising a device of unilateral conductivity, said device being connected in said circuit and polarized by said source to form a current conductive path across said circuit upon application of voltage thereto exceeding a magnitude automatically predetermined by said source.

7. In a modulation system, a carrier frequency vacuum tube amplifier, a source of plate voltage therefor, a modulation frequency amplifier, a coupling circuit for the transfer of modulation voltage from one of said amplifiers to the other, and means in said circuit for limiting the magnitude of voltage transfer comprising a device of duo-lateral conductivity, said device being connected in said circuit and polarized by said source to form a current conductive path across said circuit upon application of voltage thereto exceeding a magnitude automatically predetermined by said source.

8. In a plate circuit modulation system, a carrier frequency vacuum tube amplifier having at least a plate, cathode and control electrodes, an output circuit between said plate electrode and said cathode including a carrier frequency impedance, a modulation frequency reactance and a source of plate potential in series; a modulation frequency amplifier having an output circuit including a transformer with a divided output winding, a coupling circuit interconnecting said output circuit and said reactance, said coupling circuit including said plate potential source and a capacity in series, and a full-wave rectifier having its anode connected to terminals of said divided output winding and its cathode to the positive terminal of said source of potential, the midpoint of said winding being connected to the negative terminal of said source.

9. In a plate circuit modulation system, a carrier frequency vacuum tube amplifier having at least a plate, cathode and control electrodes, an output circuit between said plate electrode and said cathode including a carrier frequency im-

pedance, a modulation frequency reactance and a source of plate potential in series; a modulation frequency amplifier having an output circuit including an impedance element, a coupling circuit interconnecting said impedance element and said reactance, said circuit including said plate potential source and a capacity in series, a diode rectifier having its anode conductively con-

nected to said impedance element and its cathode to the positive plate terminal of said source, and a second diode rectifier having its anode connected to the negative terminal of said source and its cathode to the plate terminal of said reactance. 5

JAMES D. BOOTH.