

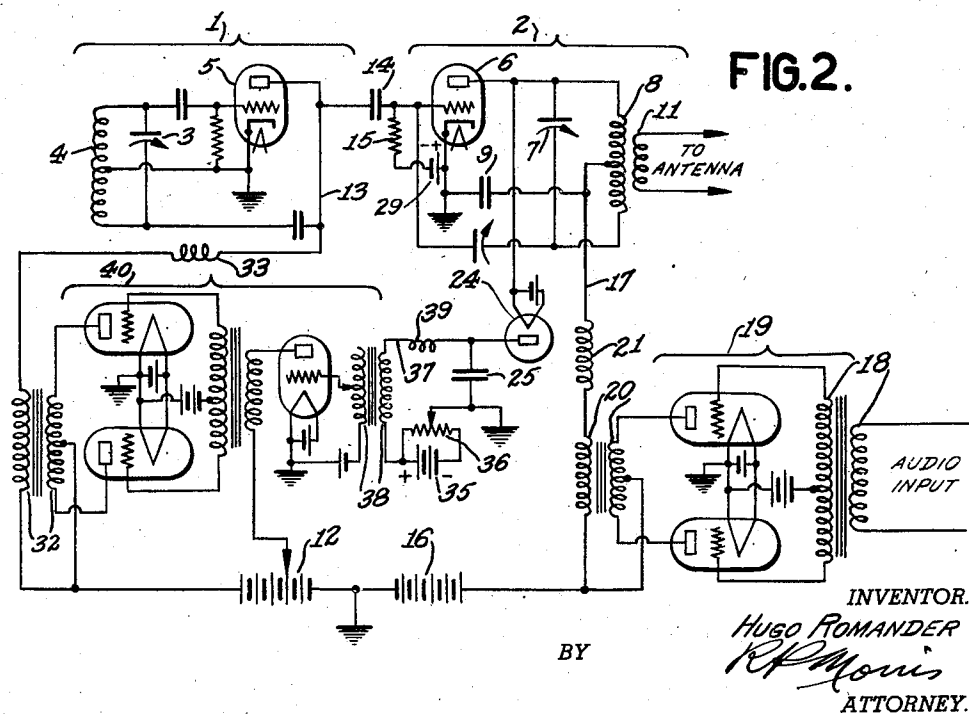
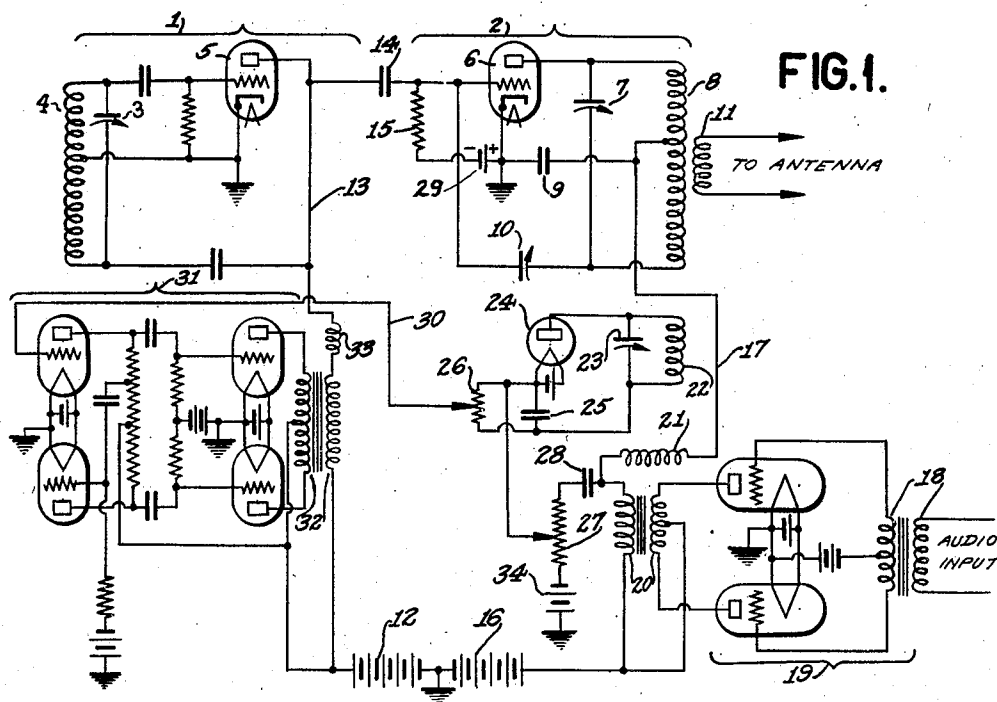
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MODULATOR DISTORTION CORRECTION

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MODULATOR DISTORTION CORRECTION

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This invention relates to modulating systems and more particularly to the reduction of distortion, hum and other undesired modulation in the modulated wave produced by such systems.

In systems for modulating carrier waves with appreciable power, difficulty is often experienced in obtaining a suitably close agreement between the modulating or signal wave and the resulting envelope of the modulated carrier wave. This lack of agreement may be due to distortion of the modulating wave, or to the introduction into the modulated wave envelope of a hum or other interfering component as from the alternating current supplying energy to the cathode heaters or other parts of the modulating system, or may be due to other causes. Modulating systems have heretofore been proposed for correcting for undesired modulation of the modulated wave by introducing an audio frequency correcting wave into the audio frequency modulating circuit, however this expedient tends objectionably to interfere with the normal construction and operation of the audio frequency modulating circuits and thus leads to further difficulties.

An object of the present invention is to counteract or avoid the difficulties referred to above.

Another object is to correct or compensate effectively and in a simple manner for the distortion or hum in the modulated wave envelope, or for other undesired failure of the envelope to agree precisely with the wave form of the original modulating wave.

Another object is to accomplish one or more of the objectives referred to above without altering the construction or operation of the original audio frequency modulating wave circuit path in the modulating system.

In accordance with the present invention a method of operation and circuits are provided for attaining the above objectives. These and other objects and features of the invention will be understood from the following detailed description in connection with the accompanying drawing of examples illustrative of the invention.

In the drawing, Figs. 1 and 2 show circuit diagrams of modulating systems adapted for carrying out the invention.

In Fig. 1, the modulating system includes the carrier wave source 1 having a modulator-amplifier 2 coupled therewith. The carrier wave source 1 is shown as an oscillator of well known feed back type and may be of any suitable form. The frequency of the carrier wave is controlled

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by adjustment of the variable tuning capacitor 3 in shunt with the inductor 4, constituting together a resonant frequency determining circuit for the oscillator tube 5 of the electron discharge type having an anode, a cathode and a grid. The modulator-amplifier 2, includes the tube 6 of the electron discharge type having an anode, a cathode and a grid. The output or tank circuit 7, 8, tuned to resonance with the carrier wave from source 1, includes the variable tuning capacitor 7 in shunt with the output inductor 8, the cathode of tube 6 being connected by way of the low impedance condenser 9 to an intermediate point of inductor 8 so that neutralization of the amplifier may be obtained by adjustment of the variable capacitor 10 connecting the grid of the tube in well-known manner with the end of inductor 8 remote from the anode of the tube. Inductor 8 constitutes the primary of the output transformer of the modulating system, the secondary 11 of which is connected with an antenna or other suitable load circuit.

Direct current energy is supplied to the carrier wave source 1 over a path which may be traced from the ground through the direct current source 12, and conductor 13 to the anode of tube 5, the cathode of the tube being grounded. The carrier wave from source 1 is transmitted from the anode of tube 5 to the grid of tube 6 through the capacitor 14 of low impedance to the carrier frequency but of high impedance to waves of modulating frequency. Capacitor 14 together with the grid-cathode leak resistance 15 constitute a capacity-resistance coupling between tubes 5 and 6. The direct current energy supply circuit for tube 6 may be traced from the ground through the direct current source 16, conductor 17, and inductor 8 to the anode of the tube, the cathode of the tube being grounded.

A wave of audio or other modulating frequency which is of relatively lower frequency than the carrier wave, is impressed on the primary of input transformer 18, the secondary of which is in the input of the balanced amplifier 19, having an output inductor constituting the primary of transformer 20, the secondary of which is included in conductor 17 supplying direct current energy to the anode of tube 6. The conductor 17 thus serves as a modulating wave input for tube 6. Carrier frequency choke coil 21 of high impedance to waves of carrier frequency and of low impedance to waves of modulating frequency, prevents waves in the carrier frequency range in modulator-amplifier 2 from reaching the transformer 20.

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A secondary inductor 22 is magnetically coupled with the output inductor 8 of modulator-amplifier 2 and has the variable capacitor 23 in shunt therewith for tuning circuit 22, 23 to resonance with the carrier wave from source 1. In series with inductor 22 is connected the demodulator 24 consisting of a diode rectifier tube of the electron discharge type. The capacitor 25 in series between rectifier 24 and inductor 22 is of low impedance to waves in the carrier frequency range and of high impedance to waves of modulating frequency. The potentiometer resistance 26, in shunt with capacitor 25, provides a path for the demodulated wave of modulating frequency. Another potentiometer resistance 27 is connected effectively across the secondary of transformer 20 to provide an adjustable component of the original modulating wave.

A blocking capacitor 28 prevents the passage of direct current from resistance 27 to the secondary of transformer 20 and prevents the high potential from source 16 from reaching resistance 27.

In accordance with the normal operation of the modulating system, a carrier wave from source 1 is transmitted to modulator-amplifier 2 which produces amplified carrier waves in output inductor 8. Modulating waves transmitted through transformer 18 and the input amplifier 19 are impressed upon the energy supply conductor 17 serving as a modulating wave input for modulator-amplifier 2, thus causing the modulator-amplifier to produce an output wave in the tank circuit 7, 8, consisting of the amplified carrier wave modulated substantially in accordance with the modulating wave.

Any distortion, alternating current power hum as that due to alternating current heating (not shown) of the cathodes or any other undesired component introduced by tubes 5 or 6 or their connected circuits, causing the envelope of the modulated wave in tank circuit 7, 8 to differ from the wave form of the original modulating wave, is reproduced in the demodulated wave in potentiometer 26. In order to provide a correction for this undesired distortion, hum, or other interference, a correction circuit conductor 30 is provided which includes a variable portion of each of the potentiometers 26 and 27 connected in series with each other and in phase opposition with respect to the instantaneous values of the modulating and demodulated waves. Conductor 30 connects with the grid of the first stage of amplifier 31 which serves to amplify the correcting wave and supply an amplified correcting wave through the primary of transformer 32, the secondary of which is included in conductor 13 supplying direct current energy to the carrier wave source 1.

Amplifier 31 may be of any well-known form being preferably adapted to amplify without appreciable rotation of the phase of components of the correction wave. A choke coil 33 in conductor 13 is of low impedance to the correction wave and of high impedance to the wave of carrier frequency, so that the carrier wave is isolated from transformer 32. By upward adjustment of the sliding contact on potentiometers 26 and 27, respectively, the amplitude of the demodulating wave and the modulating wave, respectively, in circuit 30, may be increased to any suitable value, while downward adjustment of the sliding contacts reduces the respective amplitudes of these waves.

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Potentiometers 26 and 27 are preferably so adjusted that only the difference component representing the difference in wave form between the original modulating wave and the envelope of the modulated carrier wave, is transmitted in amplified form to the anode of tube 5. The correction wave is applied to source 1 in that one of the two possible phases 180 degrees from each other which opposes the distortion, hum or other interfering component appearing in the envelope of the modulated wave in the output inductor 8 of the modulator-amplifier 2. The amplitude of the correction wave is adjusted by potentiometers 26 and 27 to a suitable value for efficiently correcting for the undesired modulation.

The negative polarizing source 34 is provided in the circuit 30 for the grid of the first stage of amplifier 31.

The circuit of Fig. 2 is similar in its general arrangement and operation to that of Fig. 1, differing therefrom in having a direct connection between the rectifier 24 and the anode of modulator-amplifier 2, the rectifier being effectively in shunt between the cathode and anode of tube 6 and the tank circuit 7, 8, thus avoiding the necessity of a resonant circuit such as circuit 22, 23 in Fig. 1, inductively coupled with the tank circuit 7, 8. The necessity of providing potentiometer 27 in Fig. 1 is, also, avoided since it will be seen that the modulating wave potential is present on the anode of modulator-amplifier 2. It will be seen that the full carrier wave potential of the anode of tube 6 is applied to the cathode of rectifier 24. In this form of circuit, it is necessary to make the direct current potential of the anode circuit of modulator-amplifier 2, exactly equal to the peak carrier wave voltage appearing on the anode, in order to obtain the desired adjustment of the circuit. Under these conditions the peak of the negative half cycle of each cycle of the carrier wave causes the anode current to reduce to zero value. A direct current polarizing source 35, having a potentiometer 36 connected in shunt therewith, is provided in series with rectifier 24 in order to produce a suitable value of space current through the rectifier at those instants when the negative carrier wave peaks are substantially equal and opposite to the average direct current anode potential of tube 6. This means that the potential of the anode of tube 6 will be positive at all times and will vary between zero and twice the potential supplied by conductor 17, thus preventing tube 24 from rectifying except for a small portion of the carrier wave cycle when the anode of tube 6 is less positive than the anode of tube 24. It will be seen that a small amount of current passes through rectifier 24 at each negative peak of the carrier wave and will vary in amplitude in accordance with the difference of wave form between the original modulating wave and the corresponding envelope of the modulated wave, thus producing a correction wave corresponding with that obtained in the Fig. 1 circuit.

According to a preferred operation of the circuits of Figs. 1 and 2, the carrier wave voltage amplitude applied to the grid of modulator-amplifier tube 6 should be of large value, but not so large as to produce saturation of output, that is, not so large as to produce the maximum grid-driven output oscillations in tank circuit 78. The grid excitation is preferably of such value as to permit the slight variations of amplitude of the carrier wave, representing the correction wave as applied to the grid, to produce the neces-

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sary correcting component in the tank circuit to oppose and thus neutralize the effect of the undesired modulation component therein. Moreover, in order to enhance the preferred operation referred to above, it is desirable that the grid of tube 6, receive a component of negative bias potential from a constant voltage source 29, such as a battery, in addition to or in place of any negative bias potential derived from capacitor 14 in conjunction with resistor 15, thus making it possible to obtain readily the desired operating point on the grid-potential anode-current characteristic of tube 6 without appreciable reduction in efficiency of the modulator-amplifier.

Capacitor 25, as in Fig. 1, provides a path for carrier wave current. The conductor 37 in shunt with capacitor 25 includes the primary of transformer 38 adapted to transmit the demodulated waves in modulating frequency range, representing the difference between the modulating wave impressed on the anode of tube 6 by transformer 20 and the demodulated wave produced by rectifier 24. The carrier wave choke coil 39 in series with the primary of transformer 38 prevents the carrier wave from being transmitted to the transformer. As in the case of Fig. 1, the amplifier for transmitting the correction wave to the anode of oscillator 5 may be of any suitable form, the amplifier 40 in Fig. 2 being shown as a transformer coupled multiple stage amplifier, but may be of the same resistance coupled form as that shown for amplifier 31 in Fig. 1.

While the circuit of Fig. 2 is somewhat simpler in certain respects from that of Fig. 1, it will be seen that in Fig. 2, the cathode of rectifier 24 is subjected to the high voltage which may be present on the anode of tube 6. It is therefore necessary to provide more insulation in Fig. 2 and to avoid capacity effects incident to the rectifier circuits connected directly with the anode of tube 6.

It will be noted that in the circuits of Fig. 1 and Fig. 2 the correction wave is applied to the energy supply circuit for the carrier wave source 1 over a path 13 entirely isolated from and independent of the path of conductor 17 for the original modulating wave. The correcting wave, therefore, produces no disturbing effect either on the modulating wave input transformer 20 or the path for the modulating wave through conductor 17. Capacitor 14 which couples tubes 5 and 6, effectively prevents the transmission of the correcting wave to the grid of tube 6.

The results obtained by the operation of the described circuit are comparable with those obtained by the use of negative or inverse feed back which is applicable only to amplifiers adapted for transmitting the same wave from the input to the output thereof. The circuit of the present invention, however, has an advantage over the usual negative feed back arrangement, in avoid-

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ing excitation of the input of the cascade stages 1, 2 by a correcting wave of relatively large amplitude of the kind employed with a negative feed back. The normal operation of the tube circuits is thus maintained with minimum interference from the auxiliary correcting circuits. A further advantage of the present arrangement is that full use may be made of the maximum amplification of tubes 5, 6, or additional stages of amplification (not shown), without reduction of amplification of the type involved in the use of negative feed back circuits.

Various modifications of the method and apparatus disclosed herein may be made without departing from the invention in its broader scope. While the modulating system disclosed by way of example in connection with the invention is of the type employing a carrier wave source coupled with a modulator-amplifier, it will be understood that the invention is applicable, also, to other types of modulating systems. The novel features of the invention are set forth in the appended claims.

What I claim is:

1. A modulating system comprising a modulator-amplifier having an input circuit, a carrier wave source having an output circuit coupled to said input circuit, a rectifier having a cathode coupled to and varying in potential with that of said output circuit, means for maintaining the rectifier anode at a potential substantially the same as the peak carrier wave potential in said output circuit in the absence of distortion so as to demodulate the portion of said carrier wave peak due to distortion, and means for modulating the output wave of said carrier wave source in accordance with the rectifier output wave.

2. A modulating system as set forth in claim 1, in which the carrier wave source includes a vacuum tube, and the means for modulating the output wave of said carrier wave source include means for varying the energy supplied to the anode of said tube.

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