

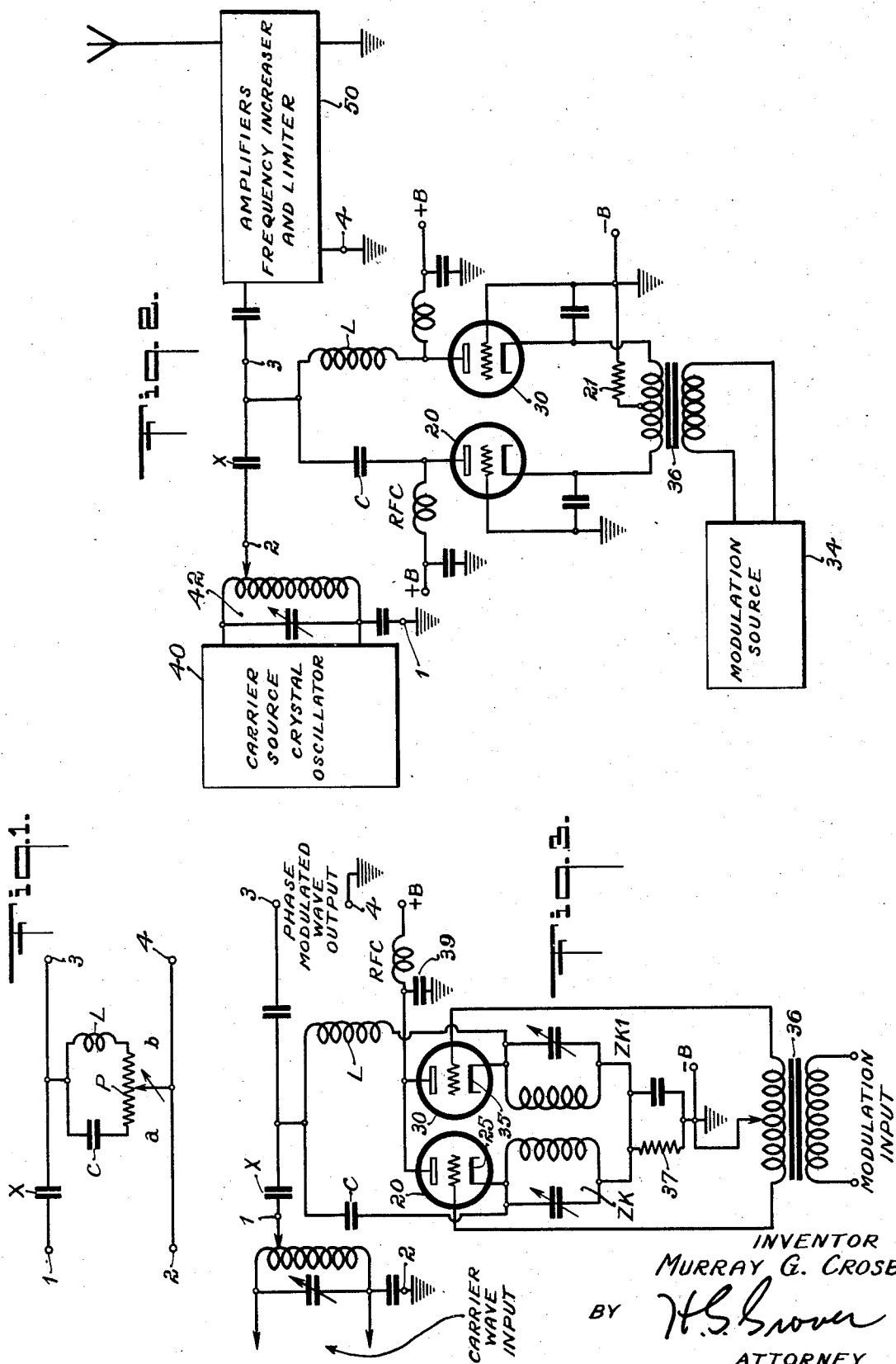
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M. G. CROSBY

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PHASE MODULATOR

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PHASE MODULATOR

Murray G. Crosby, Riverhead, N. Y., assignor to
Radio Corporation of America, a corporation
of Delaware

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This application concerns a new and improved phase modulation system.

In a known type of phase modulation system, oscillations of carrier wave frequency are separated, relatively shifted in phase, differentially modulated in accordance with signals and combined to give resultant phase modulated oscillations.

An object of my invention is improved phase modulation of wave energy in accordance with signals.

In my present simplified and improved system I feed oscillations from a source thereof to a stage such as an amplifier or frequency multiplier by way of a network, including at least two elements the values of which are differentially modulated in accordance with signals to thereby correspondingly phase modulate the oscillations fed to the said stage.

In describing my invention reference will be made to the attached drawing, wherein Fig. 1 is a basic simplified circuit illustrating the network, the manner in which the oscillations are fed thereto, the manner in which the phase shifted oscillations are derived therefrom and the means whereby the network elements are differentially modulated as to value to correspondingly phase modulate the oscillations derived from the network.

Figs. 2 and 3 are modifications of the arrangement of Fig. 1.

In Fig. 1 an alternating current voltage is supplied to the leads marked 1 and 2. X is shown as a condenser but may be a resistance or inductance and in my system X is adjusted to be large as compared to the reactance of condenser C or inductance L. P is a potentiometer resistance the total value of which may be about three times the reactances of C or L. With the adjustable arm of P on the point a there is no phase shift in the voltage supply from terminals 1 and 2 to terminals 3 and 4, if we assume that X is a condenser. This is because the impedance of L and the resistance of P will constitute a relatively negligible impedance across C so that X and condenser C act merely as a capacity potentiometer. With the potentiometer arm moved to point b the impedance of condenser C in series with the resistance of P becomes a relatively negligible impedance across inductance L, so that the current through inductance L will produce therein an inductive drop which leads the current. The phase of the current is determined by X since X is large. The drop across the inductance L can therefore

be made 180° leading when the potentiometer arm is on point b. It will be apparent that for intermediate positions of the potentiometer arm phase shifts from zero to 180° are obtainable.

In the practicable case the full range of 180° is not obtainable because the shunting effect of inductance L in series with resistance P is not negligible across condenser C and likewise the shunting element of condenser C in series with resistance P is not negligible across the inductance L.

It was found experimentally that this phase shifter is capable of providing about 90° phase shift without over 12 db. loss in amplitude of the alternating current from input terminals 1, 2 to output terminals 3, 4, and about a 5 db. amplitude variation with phase change.

It will be apparent that if element X is inductance or capacity in place of resistance the range of phase change will be the same but the phase change at the extreme positions a and b will be different. For example, the phase change range may be from 135° to 180° instead of from 45 to 90.

If oscillations of carrier wave frequency are applied at the terminals 1 and 2 and the arm of potentiometer P is moved in accordance with signals, oscillations modulated in phase in accordance with said signals will appear at the output terminals 3, 4.

In the modification of Fig. 2 the potentiometer resistance P is replaced by the impedance between the anodes and cathodes of two tubes 20 and 30. The grids of these tubes are grounded and the cathodes thereof are raised above ground by biasing resistance 21 and differentially modulated to modulate the carrier phase in accordance with signals from a source 34 fed to a transformer 36 and thence to the cathodes differentially. 40 is a source of oscillations such as, for example, a crystal oscillator and multipliers the output of which is impressed on a circuit 42 tuned to the output frequency. The oscillations are fed from this circuit to the phase shifting network and the phase shifted oscillations are fed to additional circuits in 50, such as amplifiers, frequency increasers and amplitude limiters, and thence to a utilization circuit such as an antenna. The frequency increasers in 50 may be frequency multipliers or heterodynes and mixers.

In the modification of Fig. 3, I modulate the grid potentials to vary the cathode to ground impedances of the tubes 20 and 30, instead of the plate to cathode impedances, as in Fig. 2. The

cathodes 25 and 35 are connected to ground through bias resistor 37 shunted by a radio frequency by-pass condenser. The anodes are tied together and connected to a source of potential through a radio frequency choke RFC. 39 is a radio frequency by-pass condenser. With tubes 20 and 30 connected as in Fig. 3 about 100 percent degenerative feedback is used and the cathode to ground impedances can be modulated to very low values. Since the cathode to ground impedances go to lower values (of the order of a few hundred ohms), the range of phase variation obtainable by this modification of my system is greater than say the range obtainable in the modification of Fig. 2, wherein the anode to cathode impedances of the tubes 20 and 30 are modulated. In Fig. 3 Zk and Zkl are two circuits used to tune out the cathode capacities of the tubes at the higher carrier frequencies. In this preferred modification the tuned circuits are used as shown to obtain a still wider phase variation obtainable in the phase shifting network. In a modification Zk and Zkl may be replaced by resistances. Resistances are suitable for lower carrier frequencies.

I claim:

1. In a system of the class described, a pair of reactances of opposite sign connected together by an impedance having thereon a movable tap, a connection connecting the free terminals of said reactances together, a second impedance the value of which is large as compared to the value of either of said reactances connected to the terminals of said reactances tied together, connections for applying alternating current of substantially constant frequency to the other terminal of said second impedance and to said movable tap and connections to said movable tap and the terminals of said reactances tied together for deriving alternating current, the phase of which depends upon position of said tap on said impedance.

2. In a modulation system of the nature described, a source of alternating current of substantially constant carrier wave frequency, a utilization circuit, connections one of which includes an impedance coupling said source to said utilization circuit, a first reactance and a first discharge tube impedance in series across said utilization circuit, a second reactance of opposite sign and a second discharge tube impedance in series across said utilization circuit, said first and second reactances being of small value relative to the value of said impedance, and means for modulating the impedances of said tubes differentially in accordance with signals.

3. In a modulation system of the nature described, a source of alternating current of substantially constant carrier wave frequency, a utilization circuit, connections one of which includes an impedance coupling said source to said utilization circuit, a first reactance, and a first discharge tube having its output impedance in series with the first reactance across said connections, a second reactance of opposite sign and a second discharge tube having its output impedance in series with the second reactance across said connections, said first and second reactances being of small value relative to the value

of said impedance, and means for modulating the impedances of said tubes differentially in accordance with signals.

4. In a system of the nature described, a source of oscillations of carrier wave frequency, a utilization circuit, a connection of low impedance to oscillations of the frequency of said source between said source and said utilization circuit, a connection including an impedance between said source and said utilization circuit, a first reactance and a second impedance in shunt to said utilization circuit, a second reactance of opposite sign and a third impedance in shunt to said utilization circuit, a pair of electron discharge tubes each having a cathode, a control grid and an anode, connections including said second and third impedances coupling the cathodes of said tubes to said first connection, a connection tying the anodes to said devices together and to a source of constant potential, and means for modulating the impedances of said tubes differentially in accordance with signals to thereby correspondingly vary the values of said second and third impedances.

5. In a current phase changing system, two input terminals to which alternating current may be applied, a pair of output terminals, a connection of low impedance between one input terminal and one output terminal, a second connection including an impedance coupling the other input terminal to the other output terminal, a first reactance having one terminal coupled to said other output terminal, a second reactance of opposite sign having one terminal coupled to said other output terminal, two differentially variable impedances, one connecting the other terminal of one reactance to said one output terminal, the other differential impedance connecting the other terminal of the other reactance to said one output terminal, said first and second reactances being of small value relative to the value of said first impedance, and means for varying the impedances of said two differentially variable impedances differentially to thereby vary the phase of the current supplied to said output terminals.

6. In a current phase modulating system, a source of alternating current, output terminals, a connection of low impedance to current of the frequency of said source coupling said source to one of said output terminals, a connection including an impedance between said source and the other of said output terminals, a first reactance and a tuned circuit in shunt to said output terminals, a second reactance of opposite sign and a similar tuned circuit in shunt to said output electrodes, a pair of electron discharge devices each having a cathode, a control grid and an anode, a coupling including one of said tuned circuits coupling the cathode of one of said devices to said first connection, a coupling including the other of said tuned circuits coupling the cathode of the other of said devices to said first connection, a connection tying the anodes to said devices together and to said first connection, and means for modulating the impedances of said devices differentially in accordance with signals.

MURRAY G. CROSBY.