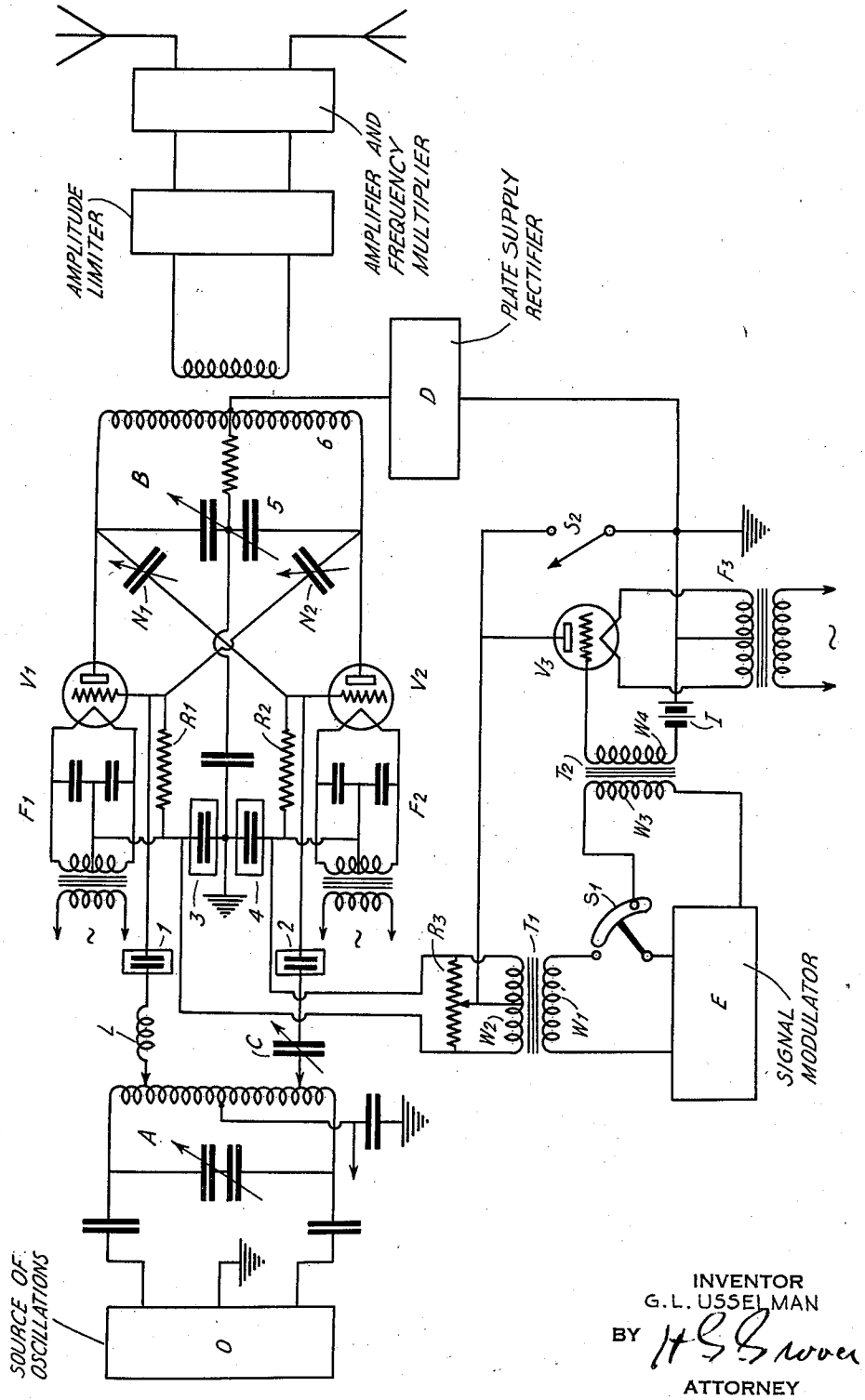
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PHASE MODULATION

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PHASE MODULATION

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This invention relates to a method of and means for impressing phase modulations on radio waves or oscillations for signaling purposes. In particular this invention relates to an improved method of and means for accomplishing phase modulation by the use of a pair of tubes having their input electrodes connected in substantially push-pull relation to a source of carrier waves to be modulated, their cathodes modulated as to potential differentially by the modulating potentials, and their anodes connected in push-pull relation by a common output circuit.

In modulators of the prior art it has been general practice to apply the modulating potentials to the anodes or control grids or other grid or anode like electrodes. In the present invention by applying the modulating potentials to the cathodes much of the distortion inherently accomplished in modulators known heretofore is eliminated. This advantage and others will be apparent from the specification which follows.

The phase modulator of the present invention may also be readily altered to produce amplitude modulation in place of phase modulation. Moreover, the circuit arrangement of the present invention may be operated to produce phase and amplitude modulation simultaneously.

The normal features of my invention have been pointed out with particularity in the claims appended hereto. The nature of my invention and the manner in which the same is carried out will be better understood from the following detailed description thereof and therefrom when read in connection with the drawing in which the single figure shows for purposes of illustration only a phase modulator circuit arrangement including the features essential to my invention. It will be understood that the arrangement shown may be departed from considerably without departing from the spirit of the present invention.

The phase modulator stage comprises a pair of thermionic tubes V_1 and V_2. The control grids of the tubes V_1 and V_2 are connected as shown by way of phase shifting reactances L and C and stopping condensers 1 and 2 respectively to an inductance in a tuned resonant circuit A which may be coupled to any source of carrier wave oscillations. Preferably the tuned circuit A is connected as shown to a source of oscillations O. The control grids of the tubes V_1 and V_2 are connected to the electrical center of the heating circuits for the cathodes F_1 and F_2 by way of resistances R_1 and R_2 respectively as shown. The anodes of the tubes V_1 and V_2 are connected in push-pull relation to a tuned tank circuit B comprising an inductance 6 and a variable condenser arrangement 5. Condensers 1, 2, 3, and 4 are direct current blocking condensers. Condensers 3 and 4 are connected as shown between the cathode ends of resistances R_1 and R_2 and ground respectively. The electrical centers of the filaments F_1 and F_2 are connected as shown to the terminals of a secondary winding W_2 of a transformer T_1. The primary winding of the transformer T_1 may be connected as shown by a switch S_1 to the source of signal modulations E. A resistor R_3 is connected across the secondary winding of the transformer T_1. The center tap of resistor R_3 and winding W_2 of transformer T_1 is connected to the anode of an additional thermionic tube V_3 and to a contact associated with switch S_2. The electrical center of the cathode F_3 of tube V_3 is connected to ground. The grid of tube V_3 is connected to a biasing source I by way of the secondary winding W_4 of a transformer T_2. The primary winding W_3 of the transformer T_2 is connected to a contact which also cooperates with the switch S_1. The contact member of the switch S_1 is of sufficient length to complete either or both of the primary winding circuits. The switch S_2 when closed short circuits the impedance between the anode and cathode of the tube V_3. The anode potential for the tubes V_1 and V_2 is supplied by way of a plate rectifier D having its positive terminal connected to the electrical center of the inductance 6 and its negative terminal connected to ground and to the electrical center of the cathode F_3 and to the movable contact of switch S_2.

In pointing out the operation of the device it will first be assumed that oscillator O is supplying power at constant frequency to the circuit A. Oscillations will be set up in tank circuit A, the tuning or response of which is determined by the inductance and capacity thereof. Excitation voltage at constant frequency will be supplied from the circuit A through inductance L and condenser C to the grids of tubes V_1 and V_2 respectively in substantially phase opposition or in push-pull fashion. However, the phase of the voltage excitation applied to the grid of modulator tube V_1 will be retarded to some extent by the inductance L while the phase of the voltage excitation applied to the grid of modulator tube V_2 will be advanced to some extent by the capacity C. The amount of retardation and advancement in the phase of the excitation applied to the grids of these tubes may be varied and will depend upon the retarding or inductive value given to the inductance L and the advancing or capaci-

tive value given to the condenser C and also on the value of the resistors R_1 and R_2 respectively. The impedance in each side of the grid circuit should be balanced, then if modulator tubes V_1 and V_2 have the same direct current bias on their control grids, which is the case when no modulation energy is supplied from E, the power supplied by each modulator tube to the circuit B will be equal and the potential oscillations in circuit B will have a constant phase which will coincide with the average phase position of the excitation voltage.

Now, if we assume that audio frequency modulations are produced in E and applied through the transformer T_1 by way of switch S_1 to the cathodes F_1, F_2 of tubes V_1 V_2 respectively, the bias applied to the said cathodes will vary in phase opposition and the tubes having the lower bias at any particular instant will supply the most power to the circuit B. Since the radio frequency excitation to the grids of the two tubes V_1 and V_2 respectively has a phase difference, the power supplied to the circuit B by the anodes of the two tubes V_1 and V_2 will have a phase difference. The phase of the oscillations appearing in circuit B will change or approach that of the tube supplying the most power. The amount of phase change in the circuit B will be substantially proportional to the difference in power delivered by the tubes V_1 and V_2 to the circuit B. It is obvious however that there may be no greater phase shift in the circuit B than there is phase difference of excitation applied to the grids of tubes V_1 and V_2 respectively.

When the device is operated as described above, to accomplish phase modulation, the switch S_1 is moved to a position such that the winding W_1 only is energized. The switch S_2 is preferably closed to short circuit the impedance between the anode and cathode of V_3 so that this tube impedance is not included in the anode-cathode direct current circuit of the tubes V_1 V_2.

When the device is to be used as an amplitude modulator the switch S_1 is moved into a position such that the winding W_3 of the transformer T_2 only is energized. Switch S_2 is now open. The anode and cathode impedance of V_3 is now connected in series with the direct current anode-cathode circuit of tubes V_1 V_2. The amplitude modulating potentials are applied from the anode of V_3 in phase or co-phaseally to the cathodes F_1 and F_2. Due to this co-phaseal application of the modulating potentials and substantially anti-phaseal application of the carrier wave potentials to the tubes V_1 V_2, carrier frequency waves of substantially constant phase and of variable amplitude will be produced in the circuit B from which they may be utilized.

A combination of phase and amplitude modulation may be accomplished by moving the switch S_1 in a position such that modulating potentials are supplied to both primary windings W_1 and W_3. In this case the switch S_2 is moved into an open position so that the impedance between the anode and cathode of V_3 is included in the direct current anode circuit of tubes V_1 V_2. Now modulating potentials are applied in push-pull and in phase to the cathodes F_1 and F_2 while carrier wave oscillations are applied in substantially phase opposition by inductances L and C. The output energy in B will be modulated as to phase and as to amplitude simultaneously in accordance with the modulating potentials.

The output circuit B may be tuned to the fundamental frequency or to an harmonic thereof. The circuit B may be coupled to any load circuit but is preferably coupled to a radiating circuit by way of an amplitude limiter or an amplifier or a frequency multiplier or one or more of said devices.

Where necessary, the anode to cathode capacity of tubes V_1 and V_2 may be neutralized as shown by neutralizing condensers N_1 and N_2 as shown. My invention contemplates the use of any known type of tubes. All that is essential is that the tubes include at least the three electrodes. Where screen grid tubes are utilized the neutralizing capacities N_1 N_2 may not be necessary.

In any event, the biasing resistances R_1 and R_2 serve the double purpose of effecting the phase of the radio frequency potentials applied to the control grids and also as a means for supplying biasing potentials to said control grids.

When the device is operated as a phase modulator, the phase modulated energy appears in the tank circuit B but the amplitude modulated component is balanced out.

When the device is operated as an amplitude modulator the amplitude limiter may be dispensed with by any convenient switching means not shown.

What is claimed is:

1. In a modulation system, a pair of electron discharge devices each having an anode, a cathode and a control electrode, a symmetrical circuit adapted to be energized by carrier wave oscillations, phase shifting means connecting different points on said circuit to the control electrodes of said devices, an impedance connected between the control electrode and cathode of each device, a transformer having a primary winding energized by modulating potentials, said transformer having a secondary winding, a connection between a point on the secondary winding of said transformer and a point on one of said impedances, a connection between another point on the secondary winding of said transformer and a point on the other of said impedances, an additional electron discharge device having an anode, a cathode and a control electrode, a circuit including a source of direct current potential and the anode to cathode impedance of said additional electron discharge device connecting the anodes of said pair of tubes to the cathodes of said pair of tubes and a circuit for applying modulating potentials to the control grid and cathode of said additional electron discharge device to produce additional modulation of the carrier wave of a different character in said pair of tubes.

2. A phase modulating means comprising a pair of electron discharge tubes each having an anode, a cathode and a control grid, a circuit adapted to be energized by oscillations of carrier wave frequency, phase changing means connecting different points on said circuit to the control grids of said tubes, a tuned circuit connected between the anodes and cathodes of said tubes, resistive means connecting the control grid of each tube to the cathode of the respective tube, a source of modulating potentials connected in phase opposition to points on said resistive means and an additional circuit connecting said source of modulating potentials to the anode and cathode electrode of each of the devices.

3. Phase or amplitude modulating means comprising, a pair of thermionic tubes each having an anode, a cathode, and a control electrode, a circuit adapted to be energized by wave energy of

carrier wave frequency, phase shifting means connecting different points on said circuit to the control electrodes of said tubes, a source of modulating potentials, and switching means and circuits for applying modulating potentials from said source in phase opposition to the cathodes of said tubes or in phase to the anodes of said tubes, or both in phase opposition to the cathodes of said tubes and in phase to the anodes of said tubes.

4. In a signalling system, a source of oscillations, a pair of thermionic tubes each having an anode, a cathode and a control electrode, connections between different points on said source of oscillations and the control electrodes of said tubes, a phase shifting reactance in each of said connections, a circuit connecting the anodes of said tubes in push-pull relation, a source of modulating potentials, a biasing and phase shifting impedance connected between the control electrode and cathode of each tube, and transformer means for impressing the modulating potentials from said source in phase opposition on the terminals of said impedances adjacent the cathodes of said tubes, to vary the potential of said cathodes oppositely in accordance with signals to thereby vary the amount of energy supplied by each of said tubes to said circuit.

5. In a phase modulation system, a pair of thermionic tubes each having an anode, a cathode and a control electrode, a symmetrical circuit adapted to be energized by oscillations of high frequency, phase shifting means of unlike character connecting points of high frequency potential on said circuit to the control electrodes of each of said tubes to excite the same in phase displaced relation, a biasing and phase shifting impedance connecting the cathode of each tube to the control electrode of the same tube, neutralizing means coupling the anode of each tube to the control electrode of the other tube, an alternating current circuit connecting the anodes of said tubes in push-pull relation, and a source of modulating potentials connecting the cathodes of said tubes in phase opposition to vary the potential of said cathodes oppositely in accordance with modulating potentials to thereby vary the amount of energy supplied by each of said tubes to said alternating current circuit.

6. In a transmitting system, a source of oscillations of carrier wave frequency, a pair of electron discharge tubes each having an anode, a cathode, and a control electrode, separate circuits connecting said source of oscillations substantially in phase opposition to the control electrodes of each of said tubes, phase shifting means in each of said circuits, a circuit connecting the anodes of said tubes in push-pull relation, a source of modulating potentials, an impedance connected to said source of modulating potentials, connections between different points on said impedance and the cathodes of said tubes to apply modulating potential in phase displaced relation from said impedance to said cathodes, a phase shifting and grid biasing impedance connecting the control electrode of each tube to the cathode of each tube, and a connection including a source of potential between the cathodes of said tubes and the anodes of said tubes.

7. In a signalling system, a source of carrier wave oscillations, a pair of electron discharge tubes each having an anode, a cathode, and a control electrode, circuits for applying oscillations from said source in substantially phase opposition to the control electrodes of said tubes, an alternating current circuit connected to the anodes and cathodes of said tubes, a direct current circuit connected to the grid and cathode of each tube, a circuit for impressing modulating potentials in phase opposition on the cathodes of said tubes, and a circuit for impressing modulating potentials on the anodes of said tubes.

8. In a signalling system, a source of oscillations of carrier wave frequency, a pair of electron discharge tubes each having an anode, a cathode, and a control electrode, phase shifting reactances of different character for applying oscillations from said source to the control electrode of each of said tubes, an output circuit connected to the anodes and cathodes of said tubes, neutralizing means interconnecting the anodes and the control electrodes of said tubes, a circuit for impressing modulating potentials on the anodes of said tubes, and a circuit for impressing modulating potentials in phase opposition on the cathodes of said tubes.

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