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S. M. BELESKAS

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REACTANCE TUBE AND MODULATOR CIRCUIT

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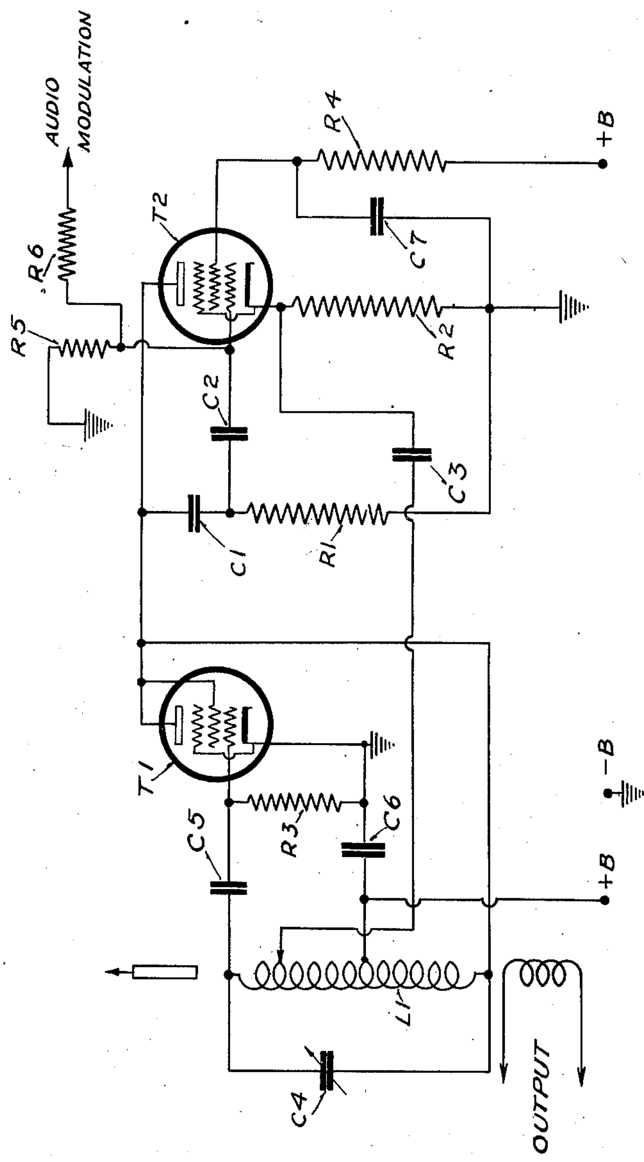

INVENTOR.
STANLEY M. BELESKAS

BY H. S. Grover

ATTORNEY

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REACTANCE TUBE AND MODULATOR CIRCUIT

Stanley M. Beleskas, Oaklyn, N. J., assignor to Radio Corporation of America, a corporation of Delaware

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This application concerns tube reactances and the same as applied as the tuning element in an electrical circuit.

An object of this invention is a tube reactance, the reactive value of which may be changed in accordance with control potentials such as used in an automatic frequency control circuit or potentials representative of signals, through a range considerably greater than has been possible heretofore.

A further object of this invention is a tube reactance as described in the preceding paragraph in a modulation circuit with the tube reactance arranged to be modulated by signals through a range much greater than has been possible heretofore.

An additional object of my invention is a tube reactance as described in the preceding paragraphs wherein the tube reactance reactive effects are linearly controlled by the control or signal potentials throughout said greater range and the so controlled tube reactance is a tuning element in a circuit wherein wave energy of carrier wave frequency flows so that the wave energy is free of distortion of the wave form at control or signal potential frequency.

It may be said then that a primary object of my invention is to increase the ability of a reactance tube to control or modulate the timing of wave energy considerably and at the same time to decrease distortion of the wave form by the modulation.

The manner in which the above objects are attained and other objects and the manner in which they are obtained will appear from the detailed description which follows. In this description reference will be made to the attached drawings wherein the single figure illustrates a reactance tube arranged in accordance with my invention to provide a much greater reactance range than has been possible heretofore, and the same connected in a novel manner with a tuned circuit and operated to tune the said circuit through a range considerably greater than possible heretofore.

In the drawings the tuned circuit including inductance L1 and condenser C4 in which the reactive effect is produced is shown as being the tank circuit of an oscillation generator including tube T1. It will be understood that the circuit C4, L1 may be a coupling circuit between two tube stages or a tube input circuit or output circuit.

Oscillatory energy is developed in the circuit L1, C4 by virtue of the fact that one end of C4 is coupled to the control grid of tube T1, the other

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end of circuit L1, C4 is connected to the anode of tube T1, while a point on the inductance L1 is coupled by coupling and direct current blocking condenser C6 to the cathode of tube T1. The connections of tube T1 provide an oscillation generator of the Hartley type with the cathode grounded and the arrangement being operative when direct current potentials are applied to produce oscillatory energy of a frequency determined by inductance L1 and condenser C4.

The reactance tube T2 has its anode coupled to one end of the tank circuit L1, C4, and the anode of tube T1. A phase shifting circuit C1, R1 is coupled between the anode of tube T2 and the resistance R2 in the cathode return circuit. Note that the resistance R2 is unbypassed for alternating current of the generated frequency. A point on the phase shifting circuit between C1 and R1 is coupled by coupling and blocking condenser C2 to the control grid of T2.

A grid leak resistance R3 is connected between the control grid and ground and the cathode of tube T1. The direct current circuit for the anode and screen grid of tube T1 and for the anode of tube T2 has a section of the inductance L1 in common. Screen grid potential for the tube T2 is supplied by way of resistance R4 and the screen grid of tube T2 is grounded for radio frequency potentials by condenser C7.

In the phase shifting circuit C1, R1 the impedance of R1 is made small as compared to the reactance of the capacity C1, so that the phase of the alternating current flowing in this connection is determined by the capacitive reactance of C1 and the potential drop across R1 takes the phase of the current and leads the anode or plate voltage on tube T2 by about 90°. Thus the amplified current in the tube T2 to the anode of tube T2 leads the anode voltage by about 90° and a capacitive reactive effect is produced in the tube T2. Thus the current in the tube T2 supplied to the tank circuit L1, C4 leads the generated current in the tank circuit L1, C4 by about 90° and the tube T2 simulates a capacitive reactance in parallel with the tank circuit 20.

A point on the inductance L1 at the end thereof connected to the control grid of tube T1 is coupled back to the cathode of tube T2 by blocking and coupling condenser C3. Out of phase radio frequency voltage is in this manner applied to the cathode of tube T2. Thus the cathode is of high radio frequency potential and this radio frequency potential is 180° (about) out of phase with respect to the radio frequency potential on the anode of tube T2. The amount of voltage fed back is adjusted for best results by the coupling tap to inductance L1. The amplitude of this voltage is not critical.

By controlling the transconductance of tube T2 the reactive effect is controlled to thereby correspondingly control the tuning of circuit L1, C4. This control may be in accordance with potentials characteristic of signals or of slow deviations in the frequency of wave energy. In other words, the tuned circuits L1, C4 may be in the oscillation generator of a modulation system or may be the local oscillator in a heterodyne receiver. In the first case the timing of the generated oscillations are modulated by signals and in the latter case the frequency of the generated oscillations is stabilized by control potentials.

The phase shifting network in the reactance tube circuit may take any one of numerous forms. For example, C1 may be replaced by an inductance in which case the circuit may be arranged to simulate an inductive reactance in place of a capacitive reactance as in the embodiment of the single figure. The effective inductive reactance also tunes the circuit L1, C4. The essential feature in any arrangement is that there is a phase quadrature (substantially) relation between the grid and anode voltages at T2 and a substantially 180° phase relation between the anode and cathode voltages at T2. The phase shifter shown is merely illustrative of my invention.

In an embodiment tested the oscillation generator T1 is operated at 4 megacycles. C1 and R1 only were used, and C4 had a value of 56 m. m. f. A deviation of plus and minus 30 kilocycles was obtained. C3 was then added and C4 was increased to 120 m. m. f. and the maximum deviation then became plus and minus 70 kilocycles. If the condenser C4 was made smaller, say, for example, 56 m. m f., a much greater deviation would be obtained. When tested a meter covering only 150 kilocycles total was available and when C4 was increased to 120 m. m. f. the deviation was 150 kilocycles.

I am not entirely sure why the great improvement in deviation range results from the arrangement shown. I believe, however, that the results obtained are due in part at least to the fact that in my arrangement the resistive component in the reactance tube is completely wiped out by the voltage fed back to the cathode through C3. Obviously, the resulting pure reactance simulated in tube T2 would have a greater tuning range.

Furthermore, the tube reactance T2 is in shunt to a part of the grid end of L1 in series with the anode end of L1, so that the range should be greater than the conventional case where the tube reactance shunts the anode end only of L1.

I claim:

1. In a tube reactance of the type wherein a tube has an electron receiving electrode and a cathode connected across a pair of terminals at which alternating voltage of radio frequency appears and the tube has an electron flow control electrode excited by said alternating voltage substantially in phase quadrature with respect to the alternating voltage on the electron receiving electrode so that a reactive effect is developed in said tube of a value which may be varied by varying the tube transconductance and means for extending the range through which the reactive effect may be varied including, a radio frequency connection to the cathode for exciting the cathode of said tube by said alternating voltage approximately in phase opposition with respect to the phase of the alternating voltage on the electron receiving electrode.

2. In a circuit tuner of the type wherein a tube reactance has an electron receiving electrode and a cathode connected to a reactive circuit wherein alternating voltage of carrier wave frequency appears and the tube has an electron flow control electrode excited by said alternating voltage substantially in phase quadrature with the alternating voltage on the electron receiving electrode so that a reactive effect is developed in said tube and reflected in said reactive circuit, said reactive effect being of a value which may be varied by varying the tube transconductance and means for extending the range through which the reactive effect may be varied including, a carrier wave frequency connection to the cathode for exciting the cathode of said tube by said alternating voltage approximately in phase opposition with respect to the phase of the alternating voltage on the electron receiving electrode.

3. In a circuit tuner of the type wherein a tube reactance has an electron receiving electrode and a cathode connected across a tunable circuit across which alternating voltage appears, so that voltage of radio frequency of a first phase is set up on said electron receiving electrode, and the tube has an electron flow control electrode coupled to said circuit by a phase shifting network so that the said electron flow control electrode is excited by said alternating voltage substantially in phase quadrature with the said alternating voltage of said first phase so that a reactive effect is developed in said tube of a value which may be varied by varying the tube transconductance and means for extending the said range through which the reactive effect may be varied including a radio frequency coupling between said tuned circuit and the cathode of said tube for exciting the cathode of said tube by alternating voltage approximately in phase opposition with respect to the phase of the alternating voltage of said first phase set up on said electron receiving electrode.

4. In a timing modulation system of the type wherein a tube reactance has an electron receiving electrode and a cathode connected across a tuned circuit wherein alternating voltage of radio frequency appears and the tube has an electron flow control electrode excited by said alternating voltage substantially in phase quadrature with the alternating voltage on the electron receiving electrode so that a reactive effect is developed in said tube and the transconductance of the tube is controlled by signals to control the tube reactance and thereby control the tuning of said circuit and the timing of the alternating current, and means for extending the said range through which said reactance is controlled including a radio frequency connection from the tuned circuit to the cathode for exciting the cathode of said tube by said alternating voltage approximately in phase opposition with respect to the phase of the alternating voltage on the electron receiving electrode.

5. In a tube reactance, a tank circuit wherein oscillatory energy is developed, an electron discharge tube having an electron receiving electrode, an electron flow control electrode and a cathode, a coupling between the electron receiving electrode of said tube and a point on said tank circuit whereat an oscillatory voltage of a first phase appears, a phase shifting network coupling the tank circuit to the electron flow control electrode of the tube to apply thereto an os-

cillatory voltage displaced in phase about 90° with respect to the phase of said first voltage, and an oscillatory voltage coupling from the tank circuit to the cathode for applying to said cathode of said tube an oscillatory voltage of a phase which is approximately opposed to the phase of said first voltage whereby a reactive effect is produced in said tube.

6. In a tube reactance, a tank circuit wherein oscillatory energy of radio frequency is developed, an electron discharge tube having an electron receiving electrode, an electron flow control electrode and a cathode, a radio frequency coupling between the electron receiving electrode of said tube and said tank circuit to set up on said electron receiving electrode a voltage of the frequency of the oscillatory energy and of a first phase, a radio frequency coupling to the electron flow control electrode to apply thereto a voltage of the frequency of the oscillatory energy which is displaced in phase about 90° with respect to the phase of said first voltage, and a radio frequency coupling from the tank circuit to the cathode for applying to said cathode of said tube a voltage of the frequency of the oscillatory energy which is of a phase which is approximately opposed to the phase of said first voltage, whereby a reactive effect is produced in said tube.

7. In a tube reactance a tank circuit wherein radio frequency oscillations are developed, a connection between a point intermediate the terminals of said tank circuit and ground or equivalent radio frequency potential the arrangement being such that the radio frequency oscillations in said tank circuit on opposite sides of said point are of opposed polarity, an electron discharge device having an electron receiving electrode, an electron flow control electrode and a cathode, a coupling between the electron receiving electrode of said tube and a point on said tank circuit at one side of said intermediate point to set up on said electron receiving electrode radio frequency oscillations of a first phase, a phase shifting network coupling the electron receiving electrode of the tube to the electron flow control electrode of the tube to apply thereto radio frequency oscillations displaced in phase about 90° with respect to the phase of said first oscillations of said first phase, an impedance to voltages of the frequency of said oscillations coupling the cathode of said tube to said point of ground or equivalent radio frequency potential, and a coupling between the cathode of the tube and a point on said tank circuit at the other side of said intermediate point for applying to said cathode of said tube radio frequency oscillations of a phase which is approximately opposed with respect to the phase of said radio frequency oscillations set up on the electron receiving electrode of the tube.

8. In a circuit tuner a tank circuit including an inductance, with a point intermediate its terminals grounded, wherein oscillations are developed, an electron discharge tube having an electron receiving electrode, an electron flow control electrode and a cathode, a resistance connecting said cathode to ground, a coupling between the electron receiving electrode of said tube and a point on said inductance at one side of said intermediate point to apply oscillations of a first phase to said electron receiving electrode, a phase shifting network coupling the tank circuit to the electron flow control electrode of the tube to apply thereto oscillations displaced in phase about 90° with respect to the phase of said oscillations of said first phase, and a connection between the cathode of the tube and a point on said inductance at the other side of said intermediate point for applying to the cathode of said tube oscillations of a phase which is approximately opposed to the phase of said oscillations of said first phase.

9. In a timing modulation system, a tuned circuit wherein oscillations are developed, said tuned circuit having a point intermediate its terminals grounded so that the oscillations on opposite sides of said point are of opposed phase, an electron discharge tube having an electron receiving electrode, an electron flow control electrode and a cathode, an impedance to voltages of the frequency of said oscillations coupling said cathode to ground, a coupling between the electron receiving electrode of said tube and a point on said tank circuit at one side of said first point so that oscillations of a first phase are set up on said electron receiving electrode, a phase shifting network coupling the tank circuit to the electron flow control electrode of the tube to apply thereto oscillations displaced in phase about 90° with respect to the phase of said oscillations set up on said electron receiving electrode, a coupling between the cathode of said tube and a point on said tank circuit at the other side of said first point to set up on said cathode oscillations of a phase which is approximately opposed to the phase of said oscillations set up on said electron receiving electrode, and connections to the electrodes of said tube for modulating the transconductance thereof in accordance with signals.

STANLEY M. BELESKAS.

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