

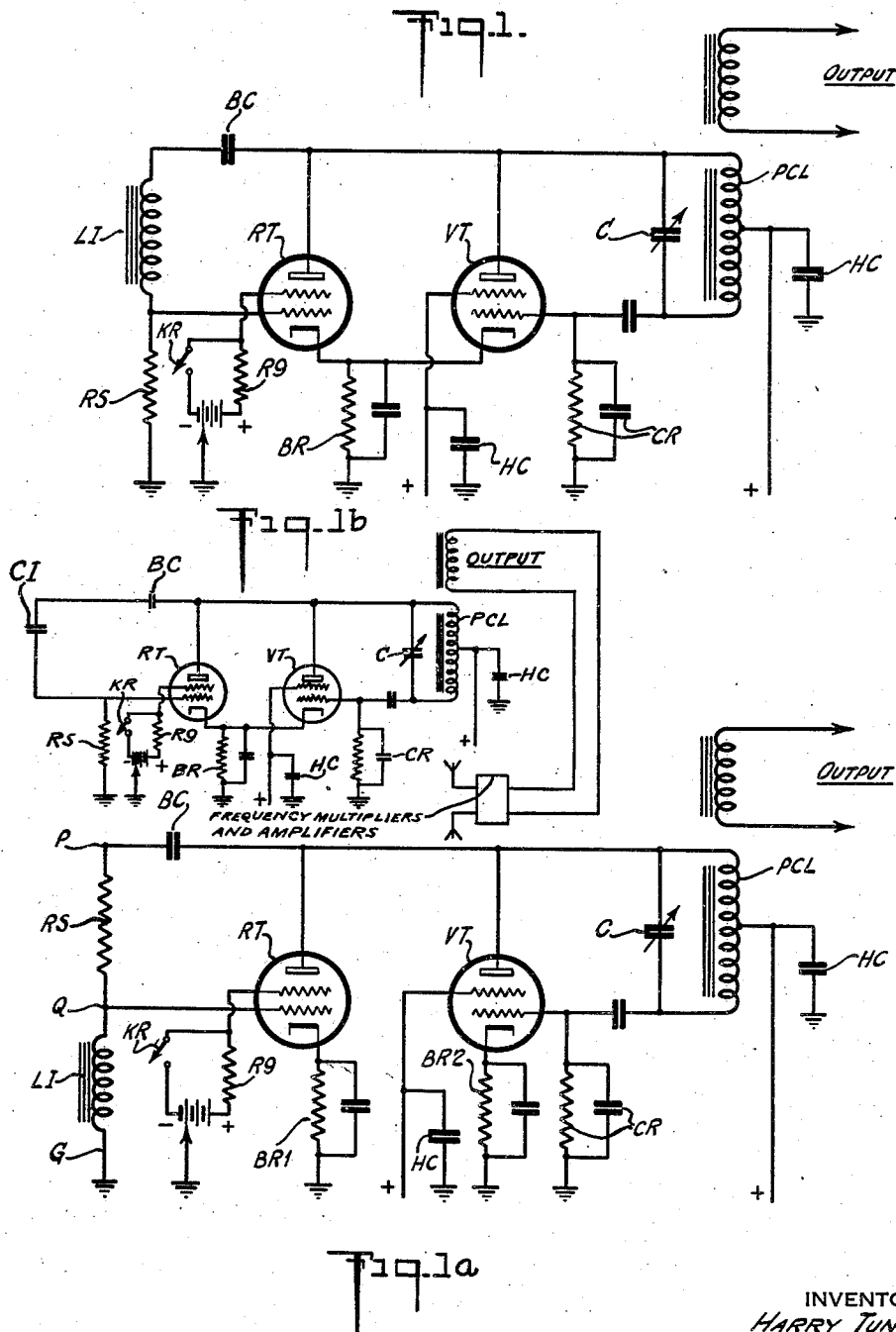
Nov. 27, 1945.

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2,389,879

FREQUENCY MODULATION

Original Filed March 27, 1942 2 Sheets-Sheet 1



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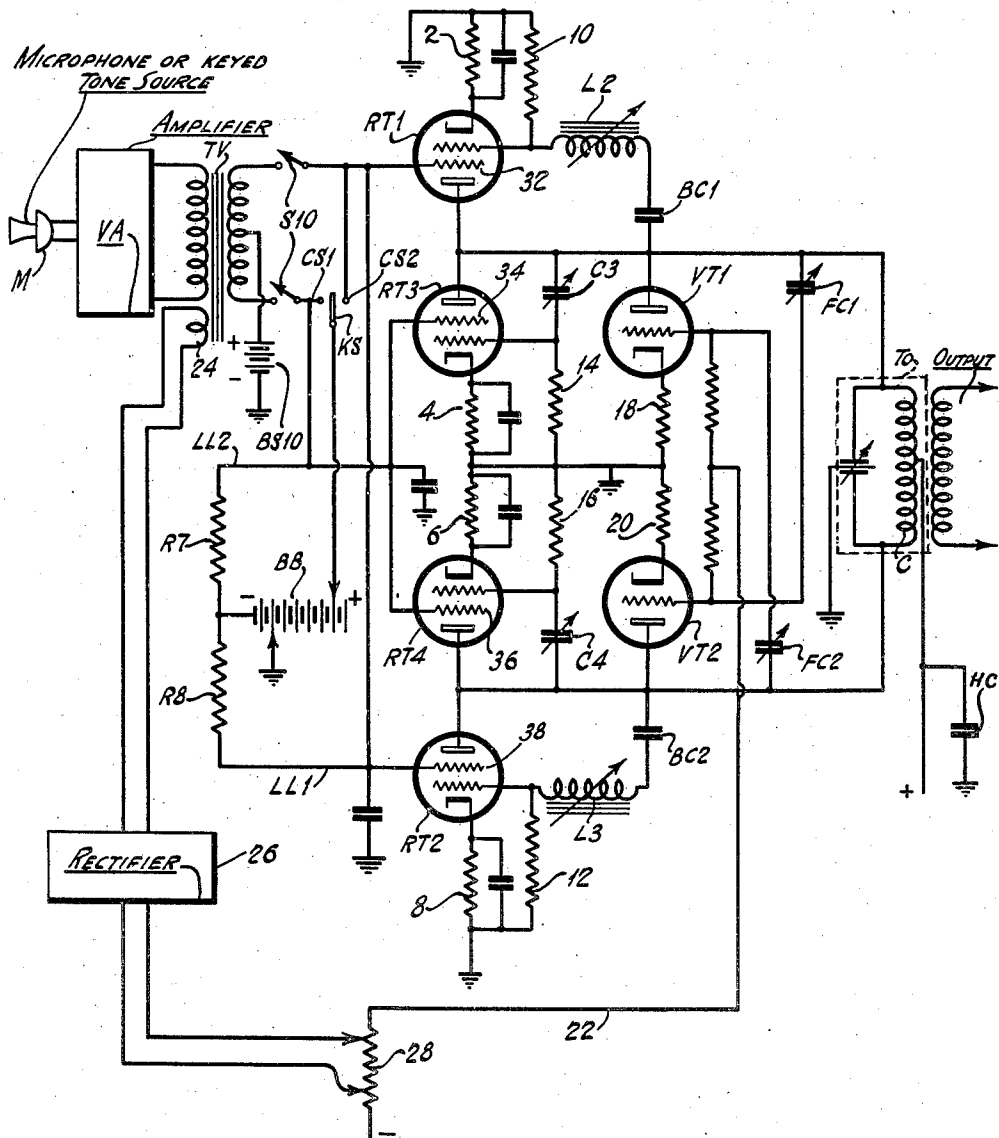
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Fig. 2.



INVENTOR
HARRY TUNICK.
BY *H. Grover*
ATTORNEY

UNITED STATES PATENT OFFICE

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FREQUENCY MODULATION

Harry Tunick, Eye, N. Y., assignor to Radio Corporation of America, a corporation of Delaware

Original application March 27, 1942, Serial No. 436,423. Divided and this application February 9, 1944, Serial No. 521,632

13 Claims. (Cl. 178-66)

This is a division of my copending application Serial No. 436,423, filed March 27, 1942.

My present invention relates to signaling by means of frequency modulated waves. An object of my present invention is to provide improved circuits especially adapted for telegraphic communication by frequency shifted waves. Other objects, advantages and features of my present invention will be self-evident as the more detailed description thereof proceeds.

Briefly, in accordance with one form of my present invention, a quadrature excited reactance tube connected to an oscillation generator is provided with keying circuits whereby the conductivity of the reactance tube is abruptly changed, thereby abruptly shifting the frequency of the oscillator. Such an arrangement is particularly useful for telegraphic signaling by means of frequency shifted waves.

In the accompanying drawings:

Figures 1, 1a and 1B are circuit diagrams of oscillators which may be keyed from one frequency to another; and

Figure 2 is a wiring diagram of a radio frequency, frequency modulated transmitter which may be used for keyed tone telegraphy, on and off keying or for telephony.

A form of tone generator which may be used in telegraphic tone transmitting systems is illustrated in Figure 1. Vacuum tube VT is connected as illustrated to produce oscillations of audio frequency, the plate coil PCL being of the powdered iron core type. The reactance tube RT is provided with a phase shifting network consisting of resistor RS and an iron cored phase shifting coil LI. Condenser BC is a by-pass condenser and of low reactance for oscillations generated by oscillator tube VT. Resistor RS is of low resistance relative to the value of reactance of coil LI.

With the key KR open, it will be observed that the oscillator RT of Figure 1 operates at a frequency determined by the tuning of the iron cored inductor PCL shunted by variable condenser C in the plate circuit as modified by the reactance tube RT. With the switch KR closed, RT may be cut off or caused to draw a lesser current, as a result of which vacuum tube VT oscillates at a different frequency. In short, by manipulation of key KR, the conductivity of reactance tube RT is abruptly changed, thereby abruptly shifting the frequency of oscillator VT from one value to another.

If desired, as shown in Figure 1B coil LI of Figure 1 may be replaced by a condenser CI and tube

VT operated as a high frequency oscillator, in which case the output of the oscillator may be radiated with or without frequency multiplication and amplification. When this is done, two discreet frequencies are successively radiated by operation of key KR.

Figure 1A is an arrangement similar in most respects to Figure 1. In Figure 1A, however, the resistance RS is connected between the plate and control grid of reactance tube RT. Also, the resistance of RS is high with respect to the reactance of coil LI connected between the control grid and cathode of tube RT. In other words, the value of the resistance RS is so chosen with respect to the inductive reactance of coil LI that the phase angle of the entire circuit from point P to ground G is practically that of RS. As a result, the voltage at point Q is substantially 90 degrees out of phase or in quadrature with the phase of the voltage across P-G.

Separate cathode return biasing resistors BR1 and BR2 are provided in Figure 1A as distinguished from the common biasing resistor BR of Figure 1. In Figures 1 and 1A condensers HC are by-passing condensers and CR is an additional condenser-grid leak circuit for supplying additional bias on the control grid of the oscillator tube VT.

The transmitting system of Figure 2 consists of the push-pull oscillator tubes VT1 and VT2 provided with a tuned output circuit TO whose coil C may be of the iron core or powdered iron core type. To produce oscillations, feedback condensers FC1 and FC2 are provided. Vacuum tubes VT1 and VT2 may, of course, be of the screen grid or pentode type.

The reactance tubes RT1, RT2 are provided with grid circuits consisting of by-pass condensers BC1 and BC2, phase shifting inductors L2 and L3 which may be provided with adjustable iron or powdered iron cores. The reactance tubes RT3 and RT4 are provided with phase shifting condensers C3 and C4.

By virtue of their connection, as described, reactance tubes RT1 and RT2 produce in shunt to the tuned circuit TO a reactance effect of one sign when they are permitted to become conductive, whereas reactance tubes RT3 and RT4 produce in shunt to the output circuit TO a reactance of the opposite sign, thereby changing the frequency of oscillation up or down, depending upon which of the pairs of tubes are made conductive. The amount of reactance so shunted into circuit and, hence, the extent of the fre-

quency change varies with the conductivity of the reactance tubes.

Resistors 2, 4, 6, 8 are cathode return biasing resistors which may, if desired, be individually shunted with by-pass condensers. Resistors 10 and 12 are of low value relative to the inductive reactance of inductors L2 and L3. Similarly, resistors 14, 16 are of low value relative to the capacitive reactance of condensers C3 and C4.

Resistors 18 and 20 are cathode return biasing resistors for the grids of oscillator tubes VT1 and VT2 which may be used in addition, if desired, to the negative bias inserted through lead 22. Also, if desired, the negative bias impressed through lead 22 may be made sufficiently high so that in the absence of signal at transformer TV, tubes VT1 and VT2 are cut off. When signal is impressed through M, however, a part of the same, amplified by amplifier VA, is picked up by coil 24, rectified by rectifier 26 and fed across resistor 28 in lead 22 in such a direction as to unblock tubes VT1 and VT2.

It is preferred, however, to omit coil 24, rectifier 26, resistor 28 and permit tubes VT1 and VT2 to oscillate at full power by proper choice of bias through lead 22, even in the absence of signal at microphone M. This, it will be recognized, is the usual way of operating an F. M. transmitter.

Normally, the reactance tubes RT1, RT2, RT3 and RT4 of Figure 2 are biased to cut-off by their screen grids 32, 34, 36 and 38 which are biased to cut-off by battery or other voltage source BB supplying voltage through leads LL1 and LL2. Manipulation of the key KS to the left contact CS1 causes tubes RT3 and RT4 to become abruptly conductive, whereas moving the key KS to the other contacts CS2 causes tubes RT1 and RT2 to become suddenly conductive while simultaneously causing the abrupt blocking of the previously unblocked tubes RT3 and RT4. Short-circuiting of the biasing battery or source BB during the keying operation is prevented by the action of resistors R7, R8 which act in a way similar to the resistor R9 of Figure 1.

By way of further explanation, it will be found that reactance tubes RT1 and RT2 act as variable inductances. As the conductivity of these tubes is increased, the effective inductance in shunt to the circuit TO is increased, thereby lessening the total inductance of circuit TO causing an increase in frequency. Reactance tubes RT3 and RT4 act as capacitors effectively in shunt to the tuned circuit TO. Hence, when the conductivity of tubes RT3 and RT4 is increased, the effective capacity of circuit TO is increased, thereby decreasing the frequency of the waves fed to the output circuit.

For voice modulation of the transmitting system of Figure 2, switch KS is left open in its mid position as shown and switch S10 is closed, enabling voice currents generated by pick-up microphone M and amplified by the voice amplifier VA to be impressed through transformer TV in phase opposition upon the screen grids of the pairs of tubes RT1, RT2 and RT3, RT4. If desired, an additional biasing source BS10 may be provided and connected, as shown, to partially unblock the reactance tubes when the transmitter is used for transmission of speech or other undulatory waves supplied to the transformer TV.

Tone oscillators, as explained in my United States Patent No. 2,282,102, may be used for transmission over the transmitter of Figure 2,

in which case keyed tones are fed into the primary of transformer TV and switch S10 is closed, but switch KS is left in its open mid-position. The output of the transmitter of Figure 2 may be fed, regardless of the type of modulation used (speech or keyed tones), to frequency multipliers and amplifiers before radiation over a transmitting antenna.

Having thus described my invention, what I claim is:

1. In combination, an oscillation generator, a reactance tube having an anode, a cathode and a control electrode connected thereto for changing the frequency of oscillation of said oscillation generator, a reactance circuit for supplying quadrature voltages to the control electrode of said reactance tube from said oscillation generator, and a keying circuit for abruptly changing the conductivity of said reactance tube from one value when the key is open to another value when the key is closed.

2. In combination, an oscillation generator, a pair of reactance tubes each having an anode, a cathode and a control electrode, means for feeding quadrature voltages of opposite sign to the control grids of said reactance tubes, and a keying circuit for rendering one of said reactance tubes conductive while rendering the other non-conductive and vice versa whereby waves generated by said generator are abruptly changed in frequency from one value to another.

3. In combination, an oscillation generator, a reactance tube having an anode, a cathode and a control electrode connected thereto for changing the frequency of oscillation of said oscillation generator, a reactance circuit for supplying quadrature voltages to the control electrode of said reactance tube from said oscillation generator, a source of uni-directional potential having one terminal connected to the cathode of said reactance tube, and a key for connecting, at will, a control electrode of said reactance tube to either of two points of different potential on said source.

4. In combination, a resonant electrical circuit, a reactance tube having an anode, a cathode and a control electrode connected thereto for changing the effective resonant frequency of said circuit, a reactance circuit for supplying quadrature voltages to the control electrode of said reactance tube from said resonant circuit, a source of uni-directional potential having one terminal connected to the cathode of said reactance tube, and a key for connecting, at will, a control electrode of said reactance tube to either of two points of different electrical potential on said source.

5. In combination, a resonant electrical circuit, a pair of reactance tubes each having an anode, a cathode and a control electrode, means for feeding quadrature voltages of opposite sign to the control grids of said reactance tubes, and a keying circuit for rendering one of said reactance tubes conductive while rendering the other non-conductive and vice versa.

6. In combination, an oscillation generator, a reactance tube having an anode, a cathode, a control electrode, and an auxiliary grid, means for subjecting the electrodes of said tube to suitable operating potentials, said tube being connected to said generator for changing the frequency of oscillation of said oscillation generator, a reactance circuit connected to the generator and to said control electrode for supplying quadrature voltages to the control electrode of said reactance tube from said oscillation generator, a source of uni-directional potential having one terminal con-

nected to the cathode of said reactance tube, a resistance connected to another point on said source and to said auxiliary grid, and a key connected to the auxiliary grid side of said resistance for effectively connecting said auxiliary grid to still another point or terminal on said source of uni-directional potential.

7. In combination, an oscillation generator, a reactance tube having an anode, a cathode, a control electrode and a screen grid, circuits for subjecting the electrodes of said reactance tube to suitable operating potentials, said tube being connected to said generator for changing the frequency of oscillation thereof, a reactance circuit for supplying quadrature voltages to the control electrode of said reactance tube from said oscillation generator, and a keying circuit connected to said screen grid for abruptly changing the voltage on said screen grid with respect to the cathode from one value when the keying circuit is open to another value when the keying circuit is closed.

8. In combination, an oscillation generator, a pair of reactance tubes each having an anode, a cathode, a control electrode and an auxiliary grid, means subjecting the electrodes of said reactance tubes to suitable operating potentials, means for feeding quadrature voltages of opposite sign and derived from the generator to the control grids of said reactance tubes, and a keying circuit connected to said auxiliary grids for rendering one of said reactance tubes conductive while rendering the other non-conductive and vice versa.

9. In combination, a resonant electrical circuit, a reactance tube having an anode, a cathode and a control electrode connected thereto for changing the effective resonant frequency of said circuit, a reactance circuit for supplying quadrature voltages to the control electrode of said reactance tube from said resonant circuit, a source of uni-directional potential having one terminal connected to the cathode of said reactance tube, a resistance connecting another terminal of said source to another electrode of said reactance tube, and a key for effectively connecting, at will, the electrode end of said resistance to still another terminal on said source of potential.

10. In combination, a resonant electrical circuit, a pair of reactance tubes each having an anode, a cathode and a control electrode, means for feeding quadrature voltages of opposite sign derived from said circuit to the control grids of said reactance tubes, and a keying circuit including a plurality of resistors and a single source of potential for rendering at will one of said reactance tubes conductive while rendering the other non-conductive and vice versa.

11. In combination, an oscillation generator comprising an electron discharge system having an anode, a cathode and a grid, a frequency controlling system having inductance and capacity

connected to said electrodes for determining the frequency of operation of said generator, a reactance tube having an anode, a cathode and a control grid, means connecting the cathode of the reactance tube and the cathode of the generator directly together, a common cathode return resistor for said cathodes, means for connecting the plate of the reactance tube to the anode of said generator, means for subjecting the control grid of the reactance tube to a quadrature voltage with respect to the voltage on the plate of said reactance tube, and means for varying the gain of said reactance tube.

12. In combination, an oscillation generator having an electron discharge system including an anode, a cathode and a control grid, a circuit having inductance and capacity connected to said electrodes, means for subjecting said electrodes to suitable operating potentials whereby oscillations are regeneratively set up in said circuit having inductance and capacity, a reactance tube comprising an anode, a cathode and a grid, means connecting the anode of said reactance tube to said circuit having inductance and capacity, means for deriving from and subjecting the control grid of said reactance tube to a quadrature voltage with respect to the voltage at the point in said circuit having inductance and capacity to which the plate of said reactance tube is connected, a source of potential having an intermediate point connected to the cathode of said reactance tube, a resistor connecting another point on said source of potential to a grid electrode within said reactance tube, and a key for connecting the grid end of said resistor at will to still another point on said source of potential.

13. In combination, an oscillation generator comprising a tube having an anode, a cathode and a grid, a circuit having inductance and capacity connected to the electrodes of said tube, means for subjecting the electrodes of said tube to suitable operating potentials whereby oscillations are regeneratively set up in said circuit having inductance and capacity, a reactance tube having an anode, a cathode, a grid, and an auxiliary grid, connection from the anode of said reactance tube to said circuit having inductance and capacity, a circuit connected to the anode and control grid of said reactance tube for subjecting the control grid to a quadrature potential with respect to the potential on the anode of said reactance tube, a source of potential having an intermediate point connected to said cathode of said reactance tube, a resistor connecting another point on said source of uni-directional potential to said auxiliary grid, and a key for connecting the auxiliary grid end of said resistor to, at will, still another point on said source of uni-directional potential.

HARRY TUNICK.