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FREQUENCY MODULATION SYSTEM WITH CRYSTAL OSCILLATOR

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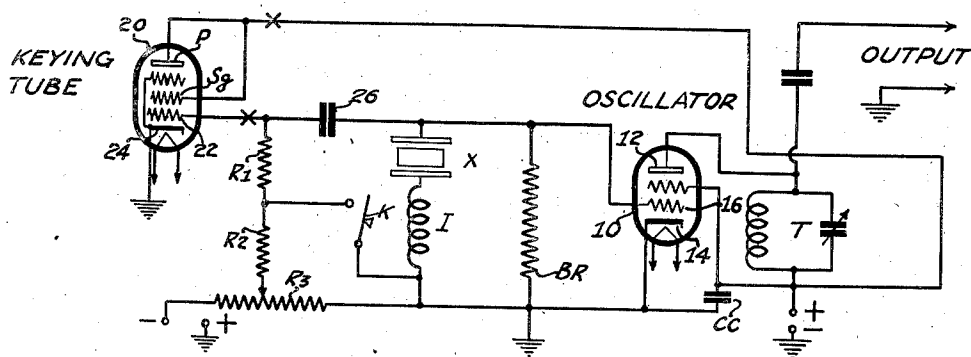


Fig. 1a. Fig. 1.

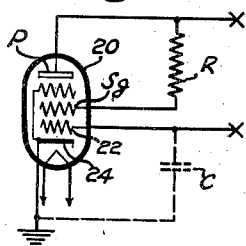


Fig. 1b.

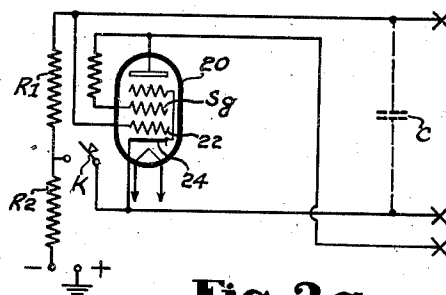


Fig. 2a.

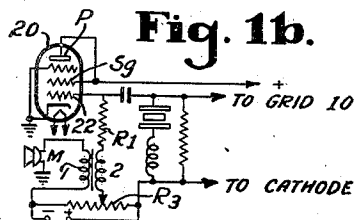


Fig. 2b.

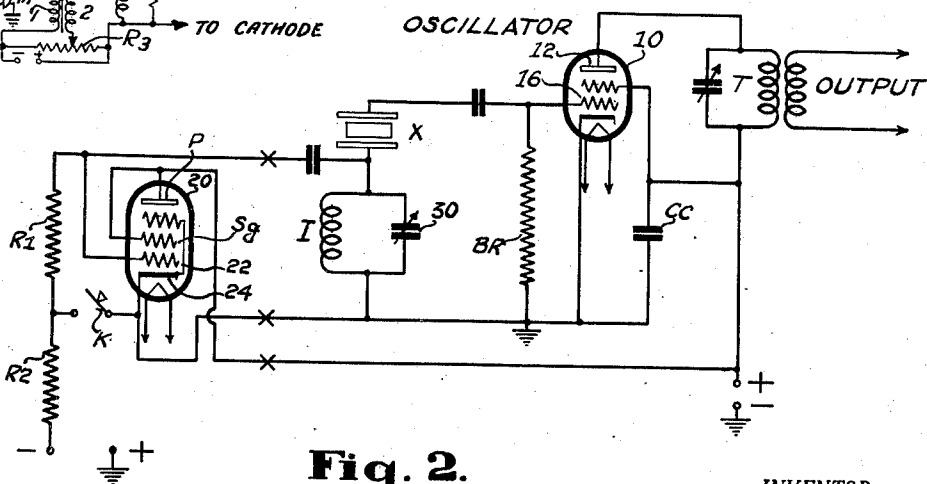


Fig. 2.

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FREQUENCY MODULATION SYSTEM WITH
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8 Claims. (Cl. 250—8)

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This application relates to communication systems of the type wherein wave energy of carrier wave frequency is generated and the frequency shifted in accordance with signals such as voice or square wave, etc. In a particular application the wave energy is keyed or shifted from a first frequency which can be designated as the marking frequency to a second frequency which can be designated as the spacing frequency and vice versa. Systems of this particular type are known in the art as frequency shift keying communication systems or spaced wave systems.

An objective of the present invention is to improve communication systems wherein frequency modulation or frequency-shift signalling is used.

In frequency-shift signalling, carrier energy is keyed in accordance with signals from a first frequency to a second frequency spaced from the first frequency by an appropriate band of frequencies, the extent of which depends on the conditions of operation. The energy is on continuously, being at either one or the other of the two spaced frequencies but is never on both frequencies simultaneously. One frequency may represent mark elements, the other frequency may represent space elements.

It is desirable in the sake of system stability, etc., to use a source of wave energy which is per se of a stable nature, yet is such that the frequency thereof may be shifted readily at a keying rate from the mark to the space frequency and vice versa.

A more detailed object of my invention is an improved frequency shift system, including means for shifting the frequency of operation of a stable oscillator such as, for example, a crystal oscillator.

A further object of my invention is an improved frequency shift system including improved means for shifting the frequency of operation of a crystal oscillator through a relatively wide band of frequencies so that the frequency representing mark and space may be separated a small amount or a large amount, depending on the needs of the particular application at hand.

The manner in which the above objects and others are attained will now be described in detail. In this description reference will be made to the attached drawings wherein Figs. 1 and 2 show two embodiments of my improved frequency shift wave generating and keying system; Figs. 1a and 2a are modifications of the arrangements of Figs. 1 and 2 respectively, while Fig. 1b is a modification of the embodiment of Fig. 1.

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In Fig. 1, 10 is a tube having its anode 12, cathode 14, and control grid 16 coupled in an oscillation generating circuit including a piezoelectric crystal X in series with inductance I between the grid and cathode and a tuned tank circuit T between the anode and cathode. The last connections include a by-pass and direct current blocking condenser CC. Direct current bias for the grid 16 is supplied by a bias resistance BR of appropriate size. Oscillations are generated in tube 10 by virtue of the fact that the tank circuit T is tuned to a frequency slightly higher than the normal frequency of operation of the crystal X so that the tank circuit T presents an inductive reactance to oscillations of the generated frequency. Other types of oscillators, wherein a crystal and inductance in series are used to establish the frequency of operation, may be used.

A variable complex reactance in the form of a tube 20 has its control grid 22 and cathode 24 connected in shunt to the crystal X and inductance I in series. This coupling includes a condenser 26 of low impedance to oscillations of the generated frequency so that the impedance in the tube 20 between electrodes 22 and 24 is effectively in shunt to the crystal X and inductance I. The anode of tube 20 and screen grid are coupled somewhat directly to a source of direct current potential, say, for example, the source supplying the anode 12 of tube 10. The by-pass condenser CC is connected effectively between the anode of tube 20 and the cathode so that the anode of this tube operates at zero or substantially zero radio frequency voltage.

The control grid 22 of the keying tube 20 is connected by resistances R1 and R2 and potentiometer resistance R3 to its cathode. The potentiometer resistance R3 shunts a source of potential while a key shunts resistance R2 and that portion of resistance R3 included in the bias circuit of tube 20. Where voice or similar signals are used a microphone M may be used in place of the key K. The microphone may be connected to the primary winding 1 of a transformer the secondary winding 2 of which is in series with R1. The audio frequency voltage developed across winding 2 is in series with the direct current voltage obtained from R3. The resultant voltage by varying the instantaneous value at the grid of tube 20 produces corresponding variations in the frequency of the oscillations generated in tube 10. The arrangement then is as shown in Fig. 1b.

The purpose of the inductance I is to provide for the crystal oscillator a circuit parameter which can be readily varied the desired extent to

thereby vary the frequency of the oscillation generated. The tube 20 or, more specifically, the variable impedance produced in said tube between the grid 22 and cathode 24 is then provided for varying the magnitude of the combined impedance provided by the tube and impedance I in accordance with the signal. Since the plate P (and screen grid Sg) of this tube is in a circuit of substantially zero radio frequency impedance, that is, connected somewhat directly to the plate source, the tube 20 acts predominantly as a variable resistance across the series circuit including the inductive impedance I. Variation of the tube resistance (impedance) is obtained by varying the grid 22 potential and hence the impedance of the tube 20. The grid potential is changed by opening and closing the key K shunting R2 and a portion of R3. In a practical application, automatic means may be applied for operating the key. In one position, say in the open position, the potential on control grid 22 is more negative than when the key is closed and the tube's impedance then is very high and the impedance affectively shunting the inductance I is very large so that the oscillations generated are of a lower frequency than is the case when the key is closed and the grid potential approaches the cathode potential and the tube is of low impedance. The open position of the key may then represent the marking frequency and when the key is closed the system may be generating oscillations of the space frequency which is higher than the mark frequency.

If a resistance is inserted between the screen grid Sg and the plate circuit then the impedance between the input electrodes is predominantly capacitive, in accordance with the Miller effect well known in the art. In this case the screen grid acts as the plate and the electrode P is grounded for R, F, by condenser CC. The arrangement of Fig. 1 is then modified as illustrated in Fig. 1a. A load in the plate P circuit such as for example a resistance produces the same effect as the resistance R of Fig. 1a. In this case a triode may be used or a screen grid tube may be used with the screen grid tied to the plate or the screen grid may be grounded for R, F.

In these embodiments when the key K is open and the grid 22 negative, the tube gain is lowest and the simulated capacity (tube 20) is smallest so that the generator is operating at a first frequency. When the key K is closed the gain of tube 20 increases so that the simulated capacity increases and the generator operates at a second frequency. If the simulated capacity (tube 20) is small and I is operating at a frequency considerably below its parallel resonant frequency as the simulated capacity increases the frequency of operation decreases then when key K is open the frequency of operation is higher than when key K is closed.

If the simulated capacity is sufficient to tune I to and through parallel resonance then the frequency could decrease as the gain of tube 20 increases until a critical point is reached at which parallel resonance is established and the impedance of the combination becomes very high. Then the system might stop oscillating. With increased gain from this point the system might commence oscillating again with increasing frequency as the tube 20 gain is increased to increase the simulated capacity. In practice and in particular if voice or similar signals are used or purity of wave form is important the system would not be operated in a manner to tune I through parallel resonance.

In a particular application, the oscillator tube 10 of Fig. 1 was a 6G6G type tube. The crystal X is of the oscillator type with a normal frequency of operation of 5 megacycles. BR is 60,000 ohms, R1 is 180,000 ohms, R2 is 50,000 ohms, a potential of 90 volts is applied to the anode 12 and a potential of -10 volts applied to potentiometer resistance R3. Tube 20 is of the 1852 type. Manipulation of the key K changed the potential on the grid 22 from zero to -7 volts, causing a shift in the frequency of the oscillations generated of 1700 cycles.

Where greater frequency shifts are required, the arrangement of Fig. 2 may be used. In this arrangement the oscillation generator is substantially as described hereinbefore. A condenser 30 shunts the inductance I in series with the crystal X. The variable condenser 30 serves to provide large and variable values of reactance in series with the crystal X and hence to adjust the circuit to optimum conditions. This adjustable condenser 30 facilitates operation of the reactance in series with the crystal on the desired part of its reactance versus frequency characteristic so that the keying tube has optimum effect on the frequency shift of the system. The bias circuit and key K for tube 20 may be set to provide the desired capacity variation (tube 20) and as a consequence, the desired frequency shift of the generated oscillations. The condenser 30 may then be adjusted to obtain operation of the generator system at the desired frequency.

Keying is accomplished substantially as discussed hereinbefore by means of key K shunting resistance R2. The input electrodes of the keying tube shunts only inductance I and condenser 30 in parallel. When the keying tube 20 has its plate and screen grid unloaded as in Fig. 2 the tube input is predominantly resistive in character and the resistance is in shunt to I. When the screen grid is loaded as in Fig. 2a, tube 20 presents a capacity input which is a function of the tube gain and hence of the bias on the tube grid 22, as described in detail hereinbefore in connection with Fig. 1. When the key K is closed, the control grid 22 is less negative so that the gain of the tube increases as does the capacity produced between the grid and cathode (Fig. 2a) and added in shunt to the inductance I. This lowers the frequency of operation of the generator as described hereinbefore. With a capacity input (Fig. 2a) increasing the negative bias on the tube reduces the gain of the tube and the size of the capacity shunting I. This increases the frequency of operation.

When the anode is unloaded as in Figure 2 then operation is as described in detail above in connection with Figure 1. When the key K is open the tube 20 impedance is high and the generator operates at a lower frequency than when the key K is closed and the tube 20 impedance is low.

In a practical embodiment an oscillation generator arranged as illustrated in Figure 2 used a crystal X operating at 5 megacycles. A shift of 14,000 cycles was obtained by varying the bias voltage on grid 22 from 0 to -17 volts.

I claim:

1. In a signalling system to be used with an oscillation generator having a frequency controlling circuit including a crystal and an inductance in series and with a tube having a cathode, a control grid and an anode, means for modulating the frequency of the oscillations generated in accordance with signals including a supple-

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mental frequency controlling means comprising a circuit having a cathode terminal and a grid terminal for coupling the space within said tube between the control grid and cathode in shunt to said inductance, a coupling having an anode terminal and a cathode terminal for coupling the anode to the cathode of said device, a bias circuit including resistance and having a control grid terminal and a cathode terminal for connecting the control grid to the cathode of said device and means for varying the value of said resistance in accordance with signals.

2. In a signalling system to be used with an oscillation generator having a frequency controlling circuit including a crystal and an inductance in series and with a tube having a cathode, a control grid and an anode, means for modulating the frequency of the oscillations generated in accordance with signals including a supplemental frequency controlling means comprising a circuit having a cathode terminal and a grid terminal for coupling the space within said tube between the control grid and cathode in shunt to said crystal and inductance in series, a coupling of low impedance having an anode terminal and a cathode terminal for coupling the anode to the cathode of said device, a bias circuit including resistance and having a control grid terminal and a cathode terminal for connecting the control grid to the cathode of said device and means for varying the value of said resistance in accordance with signals.

3. In a signalling system to be used with an oscillation generator having a frequency controlling circuit including a crystal and an inductance in series and with a tube having an anode, a control grid and a cathode, means for modulating the frequency of the oscillations generated in accordance with signals including a supplemental tuning element composed of the space between the grid and cathode of said tube and connections for coupling the control grid and cathode of the tube in shunt to said inductance, a low impedance and a source of direct current in a circuit having an anode terminal and a cathode terminal for coupling the anode to the cathode, series resistances in a circuit having a control grid terminal and a cathode terminal for coupling the control grid to the cathode and a key in shunt to a part at least of said resistance.

4. In a signalling system using an oscillation generator having in an oscillation circuit a crystal and an inductance in series, means for keying the frequency of the oscillations generated between two values in accordance with signals comprising an electron discharging device having a control grid, a cathode and an anode, connections coupling the impedance between the control grid and cathode of the device in shunt to said inductance, a low impedance circuit coupling the anode to the cathode of said device, a bias circuit including resistance connecting the control grid to the cathode of said device and a key in shunt to a portion of said resistance.

5. In a signalling system using an oscillation generator having as a frequency controlling circuit a crystal and an inductance in series, means for shifting the frequency of the oscillations generated between two values in accordance with signals comprising an electron discharging device having a control grid, a cathode, an anode and a screen grid, connections coupling the impedance between the control grid and cathode of the device in shunt to said inductance, a load impedance coupling the screen grid of said device to a

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potential source positive relative to the potential of the cathode, a low impedance circuit between the anode and cathode, a resistance and a source of potential coupling the cathode of the device to the control grid of the device, and a key shunting part of said resistance.

6. In a signalling system to be used with an oscillation generator having a frequency controlling circuit including a crystal and an inductance in series and with a tube having a cathode, a control grid and an anode, means for modulating the frequency of the oscillations generated in accordance with signals including a supplemental frequency controlling means comprising a circuit having a cathode terminal and a grid terminal for coupling the space within said tube between the control grid and cathode in shunt to said inductance, a coupling having an anode terminal and a cathode terminal for coupling the anode to the cathode of said device, a biasing circuit for said tube including resistance and a source of direct current potential and having a control grid terminal and a cathode terminal for connecting the control grid to the cathode of said device, and means for varying the potential supplied by said circuit between said control grid and cathode terminals in accordance with signals.

7. In a signalling system to be used with an oscillation generator having a frequency controlling circuit including a crystal and an inductance in series and with a tube having a cathode, a control grid and an anode, means for modulating the frequency of the oscillations generated in accordance with signals including a supplemental frequency controlling means comprising a circuit having a cathode terminal and a grid terminal for coupling the space within said tube between the control grid and cathode in shunt to said inductance, a coupling having an anode terminal and a cathode terminal for coupling the anode to the cathode of said device, a biasing circuit for said tube including a resistance and impedance in series and having a control grid terminal and a cathode terminal for connecting the control grid to the cathode of said device, and means for varying the potential across said impedance in accordance with signals.

8. In a signalling system using an oscillation generator having in an oscillation circuit a crystal and an inductance in series, means for varying the frequency of the oscillations generated in accordance with signals comprising an electron discharging device having a control grid, a cathode and an anode, connections coupling the impedance between the control grid and cathode of the device in shunt to said crystal and inductance in series, a low impedance circuit coupling the anode to the cathode of said device, a bias circuit including a resistance and an impedance in series connecting the control grid to the cathode of said device, and means for varying the potential across said impedance in accordance with signals.

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