

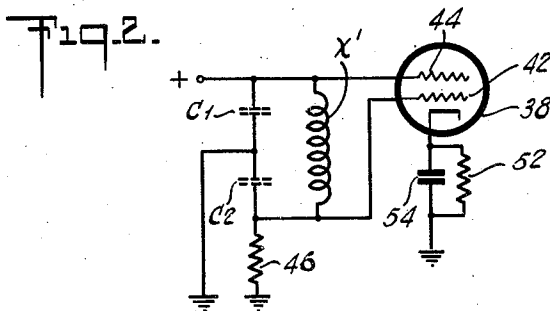
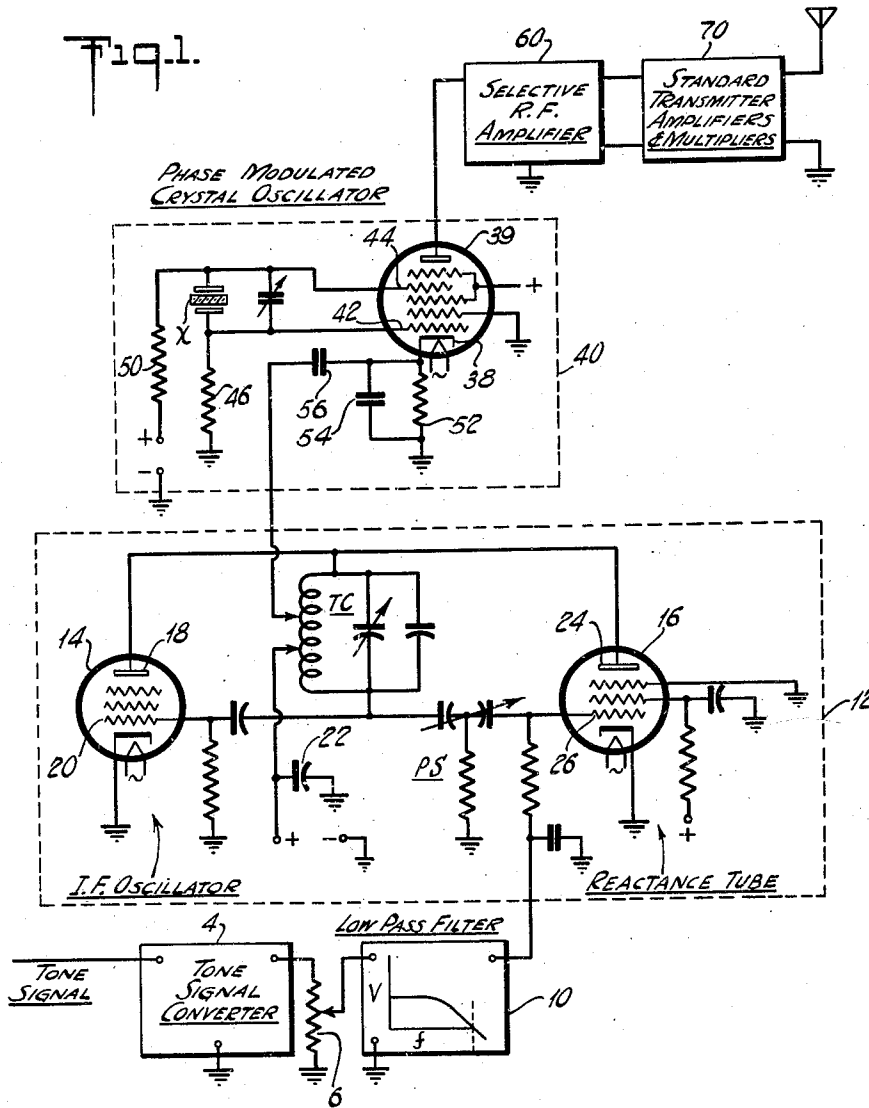
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FREQUENCY SHIFT TELEGRAPHY

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FREQUENCY SHIFT TELEGRAPHY

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1

In this application I disclose a new and improved transmitter for generating and transmitting telegraphy, facsimile and the like signals. My system is further classified by the fact that it involves production of oscillatory energy the frequency of which is shifted between two frequency values in accordance with a potential the value of which is shifted between two values. One frequency and the corresponding potential may represent "mark" in telegraphy or white in facsimile. The other frequency may represent "space" in telegraphy or black in facsimile.

Of the many transmitting stations in use today few are adapted for transmission of signals by the method known in the art as frequency shift signalling. The main object of my invention is to provide a satisfactory frequency shift system which may be used in many existing transmitters merely by replacing the crystal oscillator used in said transmitters by my adapter.

In describing my invention in detail reference will be made to the attached drawings wherein Figure 1 illustrates partly by block diagram and partly by circuit element and circuit element connections a frequency shift signalling system arranged in accordance with my invention and Figure 2 illustrates the basic circuit of the crystal controlled oscillator including tube 39 of unit 40.

The signals may be represented by keyed tone, pulses of which appear on "mark", the intervals between pulses being used to represent "space." These signals may be generated at the transmitter or as in applicant's assignee's systems at a remote station, in which case they are sent over land lines to the transmitter station. The tone signals are fed to a tone signal converter 4 of a conventional type at hand in the systems to be converted to frequency shift signalling. The converter is essentially a tone amplifier, a full wave rectifier and rectified tone amplifier and is so arranged with respect to the output resistor 6, of a potentiometer, that a high negative potential is produced at the ungrounded end of the resistor 6 when a tone pulse of proper magnitude representing "mark" appears on the line. This potential might be of the order of -200 volts. In the absence of mark pulses, i. e., on "space," the potential is about 0. The direct current pulses reduced in amplitude as desired by the potentiometer resistor 6 are fed to a low pass filter 10 wherein the unwanted side frequencies, resulting from rectification of the keyed oscillations of tone frequency, are removed to reduce the width of the bands occupied by the transmitted signal, which is shifted from one fre-

2

quency representing space to another frequency representing mark.

Unit 12 includes an oscillator including a tube 14 and a reactance modulator including a reactance tube 16. The oscillator per se is not claimed to be novel and comprises a tuned circuit TC between the anode 18 and grid 20 of tube 14 with a voltage nodal point on the inductance of the tuned circuit coupled by a direct current blocking and alternating current coupling condenser 22 to ground and thence to the grounded cathode. Oscillation generation takes place by virtue of the fact that the oscillations at the anode 18 and grid 20 are of opposed phase to cause regeneration to take place in the amplifier tube. The oscillator is unstable in the sense that its frequency of operation may be varied by varying the tuning of the circuit TC. This I do by including the reactive effect of the tube 16 in shunt to a part at least of the circuit TC and by varying the reactance simulated by tube 16 in accordance with the direct current potential output of the filter 10 which represents the signal.

The anode 24 of the tube 16 is coupled to the anode of tube 18 so the generated voltages on the anodes of tubes 14 and 16 are of like phase. The control grid 26 of tube 16 is coupled to the other end of the tank circuit TC by a two stage phase shifter PS which makes the voltage on the control grid 26 in quadrature relation with the voltage on the anode 24. The two stage phase shifter may be substantially as described in Usselman U. S. Patent #2,342,708 issued Feb. 29, 1944. The cathode of the tube 16 is coupled to ground and a point on the inductance of circuit TC is connected to ground by capacitor 22 thereby including the reactance developed in tube 16 in the tank circuit TC. Since the grid 26 voltage is in quadrature with the anode 24 voltage and the current amplified in the tube 16 is in phase with the grid voltage the tube 16 simulates a reactive effect included in the tank TC circuit. The magnitude of the reactive effect depends on the tube gain or conductance and the latter depends on the signal potential on the control grid 26. This potential changes between zero at "space" and a negative potential at "mark" so the frequency of the oscillation generator shifts from a first frequency at "space" to a higher frequency at "mark". In order to facilitate selection of the desired side band and exclusion of undesired side band and carrier at the transmitter input, in the embodiment being described, it is assumed that the oscillator including tube 18 operates at say about 400 kc.

The frequency shifted oscillations are supplied to the cathode 38 of a crystal controlled oscillator tube 39 in unit 40. The oscillator comprises a crystal X between its control or first grid 42 and its electropositive grid 44. The grid 42 of the oscillator tube is grounded by a biasing resistor 46. The oscillator anode grid 44 is connected to the positive terminal of a direct current source by a resistor 50. The cathode 38 is connected to ground by a cathode return resistor 52 shunted by a bypass condenser 54. The oscillator circuit is as illustrated in Figure 2 wherein C1 represents the capacity between the anode grid 44 and ground, C2 represents the capacity between the control grid 42 and ground and X' represents the inductance of the crystal. The similarity between this oscillator and oscillators of the Colpitts type will be apparent. When mechanical and electrical vibration of the crystal takes place oscillations are generated in the circuit and the generated voltages on the anode grid 44 and grid 42 are of opposed phase so that regeneration takes place to sustain oscillation in the system.

The frequency shifted oscillations of adjustable amplitude (by moving the tap on the inductance of TC) are taken from the tank circuit TC and fed by coupling, and direct current blocking capacitor 56 to the cathode 38 of the oscillator tube 39 to phase and or amplitude modulate the high frequency oscillations generated by this tube and circuit. This modulation takes place, as described more in detail in Goldstine U. S. Patent #2,067,081 and #2,067,082 both dated January 5, 1937. The capacitor 54 is of sufficient capacity to bypass alternating currents of the frequency of the oscillations generated in the oscillator 40. This capacitor is small enough however to present a high impedance to alternating voltages of the frequency of the oscillations generated and shifted in frequency in unit 12. The cathode 38 potential is modulated by the applied oscillations to vary the impedance between the grid and cathode to correspondingly vary the grid to cathode current. The crystal voltage is working into the grid to cathode capacity and the resistive component caused by the grid to cathode direct current and the variation of potential and current results in a phase shift which is proportional to the variation of the said resistive component. This phase modulates the current to the oscillator anode 44 and the output of the tube appears on the anode 58 which is electronically coupled to the oscillation generator. There may be some amplitude modulation of the high frequency oscillations generated in the unit 40 but both amplitude and phase modulation or either is useful in my improved system as will appear more in detail hereinafter.

The upper side band is selected by the radio frequency amplifier 60 which comprises one or more amplifying stages coupled in cascade by selective circuits. The upper side band is amplified and supplied as excitation to standard or conventional transmitter equipment 70 comprising amplifiers and multipliers such as are at hand in the usual transmitting station. The excitation from the selective radio frequency amplifiers in 60 replaces the crystal controlled exciter in the usual or conventional transmitter system.

In operation, the keyed tone is rectified in unit 4 to provide across resistor 6 a direct current component which changes in magnitude in accordance with the keyed tone. The magnitude of the variable direct current potential supplied to the reactance tube 16 may be adjusted by

potentiometer resistor 6. The low pass filter 10 is so arranged as to pass a band of frequencies including the desired side frequencies. As an example, this keying speed might be assumed to be around 250 words per minute so that the direct current component of the rectified tone might vary between "mark" and "space" magnitudes at a rate such that it may correspond to a wave of 100 cycles per second. Then the low pass filter 10 might pass only the first to fifth harmonics of the 100 cycle wave. The purpose of this filter is to eliminate the undesired side frequencies and thus reduce the band width of the frequency multiplied transmitted wave. In doing this the filter rounds off the corners of the keyed wave passed by the filter circuit so that key thumps or shock excitation are reduced to thereby reduce the number of side frequencies in the finally transmitted wave.

The reactance tube modulator 16 operates in a well known manner to shift the frequency of the oscillations generated in tube 14 in accordance with the keyed tone input at 4. The oscillator 14 might operate at about 400 k. c. so that when rectified tone is applied to the reactance tube the frequency of the oscillator might shift from 399.96875 k. c. for "space" to 400.03125 k. c. for "mark." This would give a frequency shift of $62\frac{1}{2}$ cycles per second.

More shift or less shift may be obtained by adjustment of potentiometer resistance 6 and or by other adjustment of the range of variation of the reactance presented by tube 16 or of the ratio of this reactance to the fixed reactance in the circuit TC. The amount of shift desired depends of course on the multiplication factor of the transmitter. These figures assume that the transmitter 70 has a multiplication factor of 8 and that about 500 cycles frequency shift from "mark" (transmitted) frequency to "space" (transmitted) frequency is desired. The adjustment of potentiometer 6 and the parameters of the reactance tube modulated oscillator in unit 12 are such as to allow for up to 1200 cycles shift with a transmitter multiplication factor of 4.

This frequency shifted wave is fed from the tank circuit TC to the cathode 38 of the crystal oscillator tube to modulate the high frequency oscillations generated therein. This action may be considered modulation or mixing or beating and the modulation may be considered phase or amplitude or both. In any event, the upper side band is selected at 60 for amplification therein. For example, the oscillator in unit 40 may operate at 1100 to 3000 kilocycles, say, for example, 2000 kilocycles, in which case the upper side bands selected in the amplifier and multiplier 60 will be at 2,400.03125 kilocycles for mark and 2,399.96875 kilocycles for space. It is noted that both the carrier and lower side band are sufficiently spaced from the upper side band as to make it easy to eliminate the same from the output and supply as output the upper side band. The frequency multipliers in the standard transmitter 70 may have multiplication factors of 4 or 8. In the event that, for example, a frequency multiplication factor of 8 is chosen the radiated wave is of two discrete frequencies differing by 500 cycles per second. In selecting the frequency of this crystal oscillator in unit 40 the transmitter output frequency and the frequency of the conventional crystal exciter therefor are kept in mind. For example if the transmitter had been used for "on"-"off" telegraphy the crystal oscillator in unit 40 may very well operate at a frequency 400

5

k. c./sec. lower than the original transmitter frequency where the oscillator in unit 12 operates at about 400 k. c. per second.

At the receiver, the two discrete frequencies may be heterodyned down to some low intermediate frequency such as, for example, 50 k. c. for the space wave and 50,500 k. c. for the mark wave. These waves are separated in filtering circuits and demodulated.

I claim:

1. A frequency shift keying unit to be used with a source of direct current potential the magnitude of which varies in accordance with signals, including a first oscillator of variable frequency, modulating means excited by said direct current potential for shifting the frequency of the oscillations generated by said oscillator between two values one representing one signalling condition and the other representing another signalling condition, a high frequency oscillator of the crystal controlled type, means coupling said oscillators together to modulate the phase of the oscillations generated by the high frequency oscillator in accordance with the frequency shifted oscillations generated by said first oscillator, and means to supply as output energy representing one side band only of the modulation output of said high frequency oscillator.

2. A frequency shift keying unit for use with a source of direct current potential the magnitude of which varies in accordance with signals, comprising a filter having an output and having an input excited by said potential, said filter being arranged to pass a band of frequencies including the fundamental and essential side frequencies only, a first oscillator of variable frequency, modulating means coupled to the output of said filter for shifting the frequency of the oscillations generated by said oscillator between two values one representing one signalling condition and the other representing another signalling condition, high frequency oscillator of the crystal controlled type, a means coupling said oscillators together to modulate the phase of the oscillations generated by the crystal oscillator in accordance with the frequency shifted oscillations generated by said first oscillator, and means for selecting energy representing one side band only of the modulation output of said high frequency oscillator.

3. A frequency shift keying unit to be used with a source of direct current potential the magnitude of which varies at a signalling rate, comprising a filter having an output and having an input excited by said potential, said filter be-

6

ing arranged to pass a band of frequencies including the fundamental and essential side frequencies only, a first oscillation generator, modulating means coupled to the output of said filter for modulating the frequency of operation of said generator in accordance with the output of said filter, a second oscillation generator, means coupling said first and second generators together to modulate the phase of operation of said second generator in accordance with the frequency modulated oscillations generated by said first generator, and means for selecting energy representing one side band only of the modulation output of said second generator.

4. A frequency shift keying unit to replace the exciter in a transmitter, comprising a source of direct current potential the magnitude of which varies in accordance with signals, a filter having an output and having an input excited by said potential, said filter being arranged to pass a band of frequencies including the essential side frequencies only, a first oscillation generator of variable frequency, modulating means coupled to the output of said filter for shifting the frequency of the generated oscillations between two values one representing one signaling condition and the other representing another signaling condition, a high frequency oscillation generator of the crystal controlled type including a tube having a cathode operating above a reference alternating current potential and having other electrodes therein connected in an oscillation generating circuit including a crystal for stabilizing the operating frequency of said high frequency generator, means coupling said first generator to the cathode of said tube, a selective circuit tuned to pass the upper sideband only of the modulation output of said high frequency generator, and a coupling between said selective circuit and the transmitter.

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