

March 14, 1933.

C. W. HANSELL

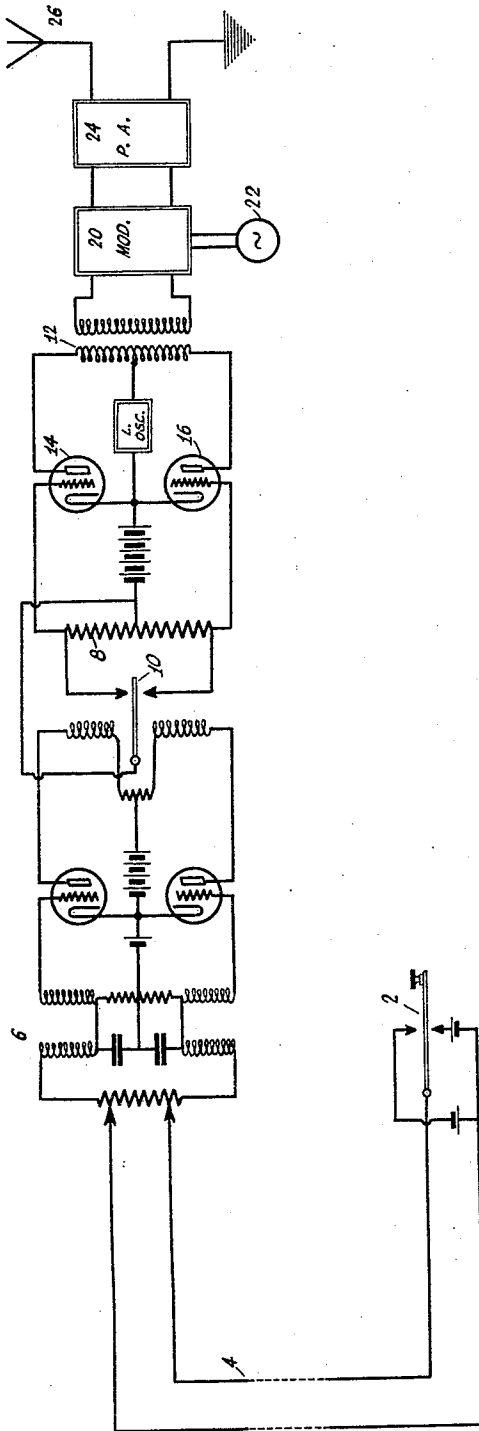
1,901,642

SIGNALING

Filed Dec. 23, 1929

2 Sheets-Sheet 1

Fig. 1



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2 Sheets-Sheet 2

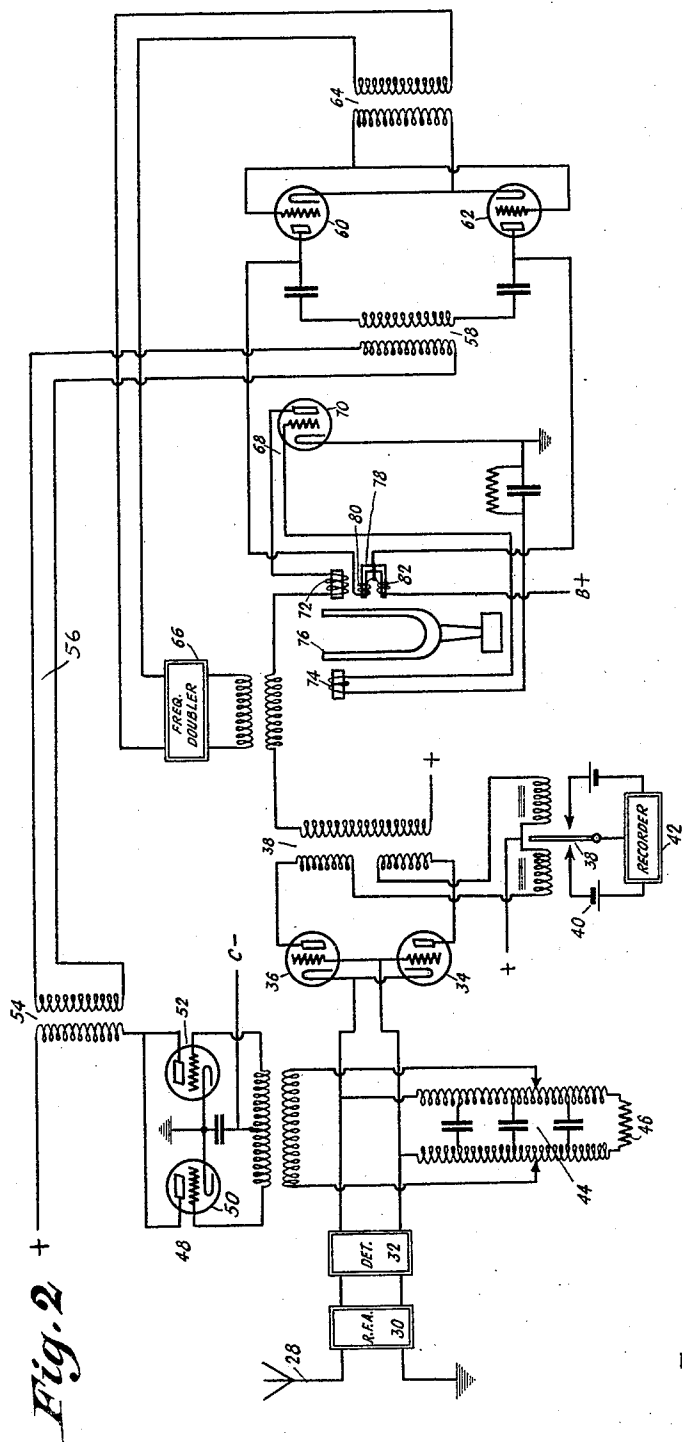
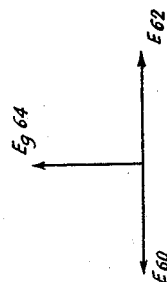


Fig. 3



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SIGNALING

Application filed December 23, 1929. Serial No. 416,053.

In my copending United States patent application Serial Number 230,438, filed November 2, 1927, I have disclosed a signaling system wherein signaling may be carried on by phase shift of a carrier wave, signal transmission at one phase corresponding to, say, dots, and signals corresponding to another phase representing dashes. Absence of signal would, of course, indicate spacing. In this manner, signaling speed can be materially increased.

However, with such a system wherein a carrier wave is phase shifted according to signals to be transmitted, certain defects are present especially when it is attempted to signal at extremely short wave lengths. Not only is it more difficult to maintain apparatus in synchronism, which apparatus is preferable for the operation of the system described in my copending application at higher frequencies; but in addition, certain phenomena often occur during the transmission of short waves which makes it unfeasible to signal by phase shift or by phase reversal. That is, it has been found that the length of path followed by the wave often fluctuates rapidly and this, of course, causes phase shifts in the received energy and precludes the possibility of accurate signaling by this method in many instances.

To overcome the foregoing difficulties and to make signaling by phase reversal possible at very short wave lengths is the main object of the present invention. In order to accomplish this object, modulating energy rather than carrier energy is phase shifted according to signals to be transmitted and then a carrier is modulated with the modulating energy. The combined wave is subsequently transmitted to a receiver.

Where difficulties in obtaining synchronism are due to apparatus difficulties only, I modulate the amplitude of the carrier energy. In short wave transmission, however, unequal fluctuations in carrier and side bands and selective fading make the use of amplitude modulation quite difficult and often impossible. Under these circumstances frequency modulation of the carrier energy is preferred. Thus, when frequency modula-

tion is used, although the carrier may fluctuate in phase, the modulating energy, being of relatively lower frequency, is little affected by the elements which cause phase reversal of high frequency energy in the ether, and hence the phase shifted modulating component of the transmitted wave arrives at the receiver substantially as transmitted.

Preferably as is the case with the system described in my copending application, translation is accomplished by the use of a locally generated wave of energy of a frequency equal to the frequency of the phase displaced transmitted energy. In my copending application crystals are resorted to as a means for generating the local synchronous energy; but, if it were attempted to generate relatively low frequency energy, such as utilized in the present scheme, with crystals, they would of necessity be of extremely large size, difficult to obtain and expensive. Therefore, rather than resort to crystals for controlling the frequency of locally generated energy so as to conform with the phase displaced modulated energy, I make use of an electromechanical resonator other than a crystal to control the frequency of the locally generated energy. In a preferred form of my invention I utilize a tuning fork for electromechanical control, which is sufficiently accurate and inexpensive.

As the frequency of the modulating wave may vary, it is desirable that the wave locally generated at the receiver be synchronized in frequency therewith and to accomplish this by electromechanical control is a further object of the present invention. Briefly this is carried out by varying a mechanical stress or a pull on the electromechanical vibrator whereby its frequency is altered in the correct direction. Of course, in doing this I also make use of a phenomenon that I have referred to in my copending application, namely, that when a wave is phase reversed 180 degrees its second harmonic is not altered in phase.

More fully by utilizing alternating potentials 180 degrees apart derived by frequency doubling the demodulated signal wave at the receiver in connection with a locally gener-

ated, frequency-doubled wave 90 degrees away from the waves separated by 180 degrees, a current flow can be obtained in a direction such that it will indicate the phase shift caused by change in frequency of the locally generated wave relative to the incoming demodulated wave. The current is then used to correct, by altering the stress on an electromechanical frequency controlling device, the frequency of the locally generated wave so that it is maintained in synchronism with the incoming demodulated wave.

In the accompanying drawings which are to be taken only by way of illustration of my invention,

Figure 1 indicates diagrammatically transmitting apparatus for transmitting a carrier wave modulated with modulating energy phase displaced according to signals to be transmitted,

Figure 2 indicates receiving apparatus for translating the wave transmitted by the apparatus shown in Figure 1, and

Figure 3 is given to aid in the explanation of the operation of Figure 2.

Turning to Figure 1, by means of keying apparatus 2, currents of opposite polarity are sent over a land line 4 to a quick acting relay 6 which, by means of a double acting armature 10, controls the potential drop due to the flow of current through each of the two halves of a resistance 8. This potential variation due to the relay acts differentially on the modulator tubes 14, 16, which, in turn, act to reverse the phase of the output from transformer 12. The relay apparatus 6, 10 is more fully described and claimed in my copending application Serial Number 230,439 filed November 2, 1927.

With the armature 10 in its mid, uncontacting position, no modulating energy appears in the output transformer 12 coupled to electron discharge devices 14, 16 because of the symmetrical connection thereof. However, when, say, contact 10 moves in its upper position tube 14 draws a larger current than tube 16 and allows modulating energy of one phase to appear in the secondary of transformer 12. In its lower position tube 16 draws more current than 14 and modulating energy from source 18 appears in the output circuit 12 relatively phase reversed. Either of the phase reversed positions may be utilized to indicate dots or dashes and, when armature 10 is allowed to remain in its mid position, the absence of energy from local oscillator 18 in output circuit 12 will indicate a space.

Modulating energy, phase displaced according to signals to be transmitted, appearing in the secondary of transformer 12 is then fed into a modulator 20 supplied with carrier energy from a source 22. The output of modulator 20 is fed into a power amplifier 24 and radiated by a suitable antenna 26.

It is to be understood, of course, that radiation from antenna 26 may be made to be either a single side band, both side bands or both side bands and the carrier. Or, any combination thereof as produced by amplitude modulation may be radiated as desired, the requisites necessary being either filters in the case where certain side bands are to be suppressed, or in the case when the carrier is to be suppressed, a carrier suppression modulator may be used at 20. Or, if desired, a filter may be connected to the output thereof for eliminating the carrier energy from the power amplifier 24. Preferably, for short wave transmission, the modulator 20 should react upon source 22 to carry its frequency in accordance with the modulating energy from 12 in a manner similar to that shown in my Patent No. 1,787,979.

At the receiver (see Figure 2) a portion of the transmitted energy is collected upon an antenna 28, amplified by means of an amplifier 30, and demodulated by means of a detector 32.

A portion of the demodulated energy is fed in parallel or cophasially to the input circuits of electron discharge devices 34, 36, whose anodes are connected serially or in phase opposition relative to the primary of transformer 38 supplying locally generated energy of constant phase and like frequency relative to the demodulated wave.

It will, therefore, be clear that when the demodulated or low frequency component of the incoming wave is combined in phase with the energy supplied by transformer 38 to tube 36, there will be a predominant flow of current in tube 36 which will cause armature 38 to move in one direction, applying currents of one polarity from source 40 to a suitable translating or recording device 42; and, when the phase of the modulating component of the collected energy is reversed, tube 34 will predominate in the drawing of anode current, causing armature 38 to be moved in a reversed direction, applying energy of a different polarity to recording device 42. In the absence of signal energy, the armature 38 will remain in its mid position whereby the translating device 42 will indicate a space.

In order to obtain the necessary translating energy, of like frequency and constant phase relative to the demodulated energy, at 38, a portion of the demodulated energy from the output of detector 32 is taken from a phase adjuster 44 suitably terminated by an impedance 46, and applied to the input side of a frequency doubler 48, which, because of the parallel connection of the anodes and the serial connection of the grids of tubes 50, 52 comprising it, has appearing in the output side thereof a second harmonic of the demodulated energy. Despite phase reversals of the fundamental, the harmonic

energy remains relatively constant in phase.

The energy of doubled frequency is fed through transformer 54, lines 56, and transformer 58 to the serially connected or phase opposed anodes of electron discharge devices 60, 62 having their input circuits connected in parallel or cophasially. To the input circuits of tubes 60, 62 through transformer 64, is fed energy from frequency doubler 66 which is supplied with energy from a local generator of waves 68 arranged to generate as nearly as possible energy of a frequency equal to that of the demodulated received wave.

By virtue of the foregoing connections, and by suitable adjustment of the taps on phase adjuster 44, with frequency doubler 66 supplying energy of the same frequency as that supplied by frequency doubler 48, the instantaneous potentials applied to the anodes and control electrodes of tubes 60, 62 may be made as indicated in Figure 3 where E_{g64} indicates control electrode potentials applied to tubes 60, 62 and E_{60} , E_{62} , indicate respectively anode potentials of tubes 60, 62. With such an arrangement it will be seen that the unidirectional components of the currents appearing in the anode circuits 60, 62 are identical. In the event that there is a relative change in frequency of the potentials applied to the input and output circuits of tubes 60, 62, there will be a phase shift of the control electrode potentials relative to the anode potentials of tubes 60, 62 which in turn will cause one or the other of the two tubes to draw a greater unidirectional component than the other. For a very complete discussion of the operation of this apparatus reference is made to my copending application Serial Number 230,214, filed November 1, 1927 on automatic tuning.

The foregoing principle is relied upon for correcting the frequency of the local generator of waves. The local generator 68 comprises a vacuum tube 70 regeneratively connected through electromagnets 72, 74 acting upon tuning fork 76 which, of course, controls the frequency of oscillation of source 68. By means of a permanent U magnet 78, having coils 80, 82 wound about each leg thereof, the pull on one leg of tuning fork 76 may be varied and hence the frequency of vibration of tuning fork 76 may be varied. Hence, by connecting coils 80, 82 in the anode circuits of tubes 60, 62 respectively, the pull of the magnet may be altered according to the unidirectional flow of current in each tube. In this way, depending upon the phase shift caused by a change in frequency of the local oscillator relative to the demodulated signal wave, the differential anode currents of tubes 60, 62 alters the pull on tuning fork 76 in a direction such that its frequency is pulled into step with the demodulated wave.

Many changes, of course, will readily suggest themselves to those skilled in the art. For example, the input and output circuits of tubes 36, 34 and tubes 60, 62 may be reversed without altering the principles underlying my invention. It is, therefore, to be understood that the scope of this invention is to be limited not by what has been shown but solely by the breadth of the appended claims.

Having thus described my invention what I claim is:—

1. The method of signaling which includes transmitting carrier energy modulated with signal phase displaced, low frequency energy, collecting a portion of the transmitted carrier energy, synchronizing locally generated energy with the low frequency component of the collected energy by utilizing even numbered multiple harmonics of the energies to be synchronized and utilizing the synchronized energy and the low frequency component for translation.

2. The method of signaling which includes transmitting carrier energy modulated with signal phase displaced, low frequency energy, collecting a portion of the transmitted carrier energy, synchronizing locally generated energy with the low frequency component of the collected energy by utilizing a harmonic of the modulating energy that remains cophasial regardless of phase displacements of the modulating energy and utilizing the low frequency energy and synchronized energy for translation.

3. The method of signaling which includes transmitting carrier energy modulated with signal phase displaced, low frequency energy, collecting a portion of the transmitted carrier energy, synchronizing locally generated energy with the low frequency component of the collected energy by utilizing the second harmonic of the component and the locally generated energy, and translating the combined component and locally generated energy.

4. The method of translating signals transmitted by phase reversing modulating energy which includes doubling the frequency of a portion of received demodulated energy, generating energy locally, doubling the frequency of a portion of the locally generated energy, synchronizing the received and locally generated energies by utilization of the doubled frequencies, and combining the phase of the received demodulated energy of fundamental frequency with that of the local energy of fundamental frequency in order to detect phase reversal of the modulating component of the received energy.

5. The method of signaling which includes generating carrier energy, modulating the carrier with relatively low frequency, signal phase displaced, energy, transmitting the resultant energy; collecting a portion of the transmitted energy, rectifying the energy to

obtain the signal phase displaced component, locally generating energy of a frequency corresponding to the phase displaced component; utilizing the second harmonic of the component and the second harmonic of locally generated energy to synchronize the component and the local energy, combining the synchronized energies, and utilizing the combined energies for translation.

6. In combination, means for transmitting carrier energy modulated with signal phase displaced low frequency energy; means for collecting a portion of the transmitted carrier energy, means for synchronizing locally generated energy with the low frequency component by utilizing the same harmonic of the energies to be synchronized and means for translating the combined locally generated energy and low frequency component.

7. In combination, means for transmitting carrier energy modulated with signal phase displaced low frequency energy; means for collecting a portion of the transmitted carrier energy, means for synchronizing locally generated energy with the low frequency component by utilizing that harmonic of the modulating energy that remains cophasial regardless of phase displacements of the modulating energy, means for combining the locally generated energy and the low frequency component and means for translating the combined energies.

8. In combination, means for transmitting carrier energy modulated with signal phase displaced low frequency energy; means for collecting a portion of the transmitted carrier energy, means for synchronizing locally generated energy with the low frequency component by utilizing the second harmonic of the component and the locally generated energy and means for combining and translating the locally generated energy and low frequency component.

9. In a receiving system for translating signals transmitted by phase reversing modulating energy, means for doubling the frequency of a portion of received demodulated energy, means for generating energy locally, means for doubling the frequency of a portion of the locally generated energy, means for synchronizing the received and locally generated energies by combining the double frequencies, and means for combining the received demodulated energy of fundamental frequency with that of the local energy of fundamental frequency in order to detect phase reversal of the modulating component of the received energy.

10. In combination, means for generating carrier energy, means for modulating the carrier with relatively low frequency signal phase displaced energy, means for transmitting the resultant energy; means for collecting a portion of the transmitted energy, means for rectifying the energy to obtain the

signal phase displaced component, means for locally generating energy of a frequency corresponding to the phase displaced component, means for utilizing the second harmonic of the component and the second harmonic of locally generated energy to synchronize the component and the local energy, means for combining the synchronized energies, and means for utilizing the combined energies for translation.

11. The method of translating signals including a carrier on which phase reversed signal frequencies have been impressed by means of signal demodulating means and translating means comprising a pair of thermionic tubes which includes the steps of, collecting said signal modulated carrier, demodulating said modulated carrier, applying demodulated energy to like electrodes of said pair of electron emission tubes substantially in phase, applying locally generated synchronous energy to different like electrodes of said tubes approximately in opposed phase, and utilizing the difference in the currents in the output circuits of said tubes for producing indications characteristic of the signals impressed on said carrier.

12. In a system for translating signals transmitted by phase reversal of modulating energy on a carrier, means for collecting said modulated carrier, signal demodulating means connected with said collecting means, a pair of thermionic tubes, means for connecting a pair of like electrodes in said tubes to the output circuit of said demodulating means, means for applying locally generated synchronous alternating current energy to another pair of electrodes in said pair of tubes in substantially opposed phase, and translating means connected with the output circuit of said tubes.

CLARENCE W. HANSELL.

CERTIFICATE OF CORRECTION.

Patent No. 1,901,642.

March 14, 1933.

CLARENCE W. HANSELL.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 2, line 81, for "carry" read "vary"; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 15th day of August, A. D. 1933.

M. J. Moore.

(Seal)

Acting Commissioner of Patents.