Sept. 19, 1944. E. H. WEBER, JR 2,358,610

TELEGRAPH SIGNALING SYSTEM

Filed March 12, 1943

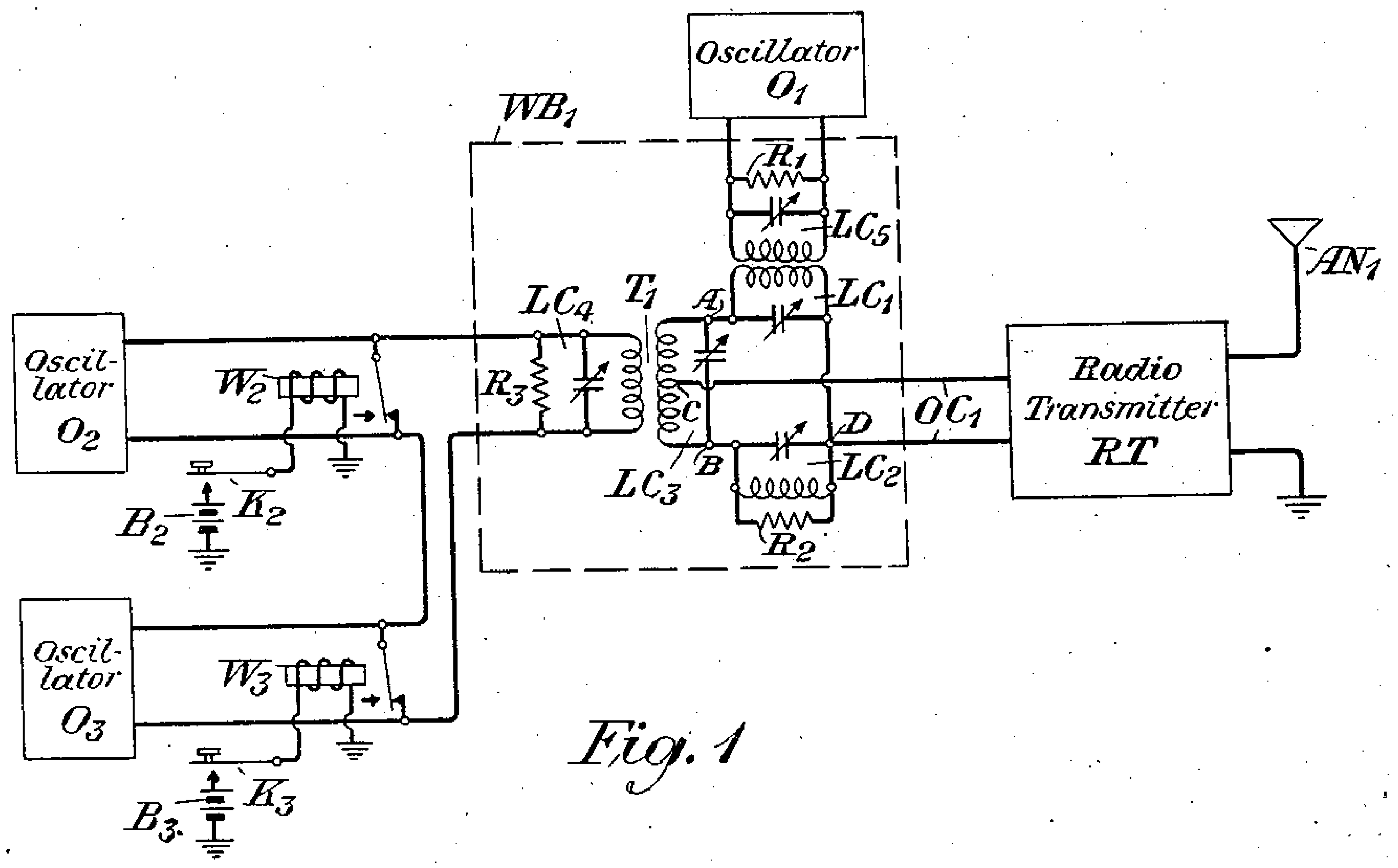


Fig. 1

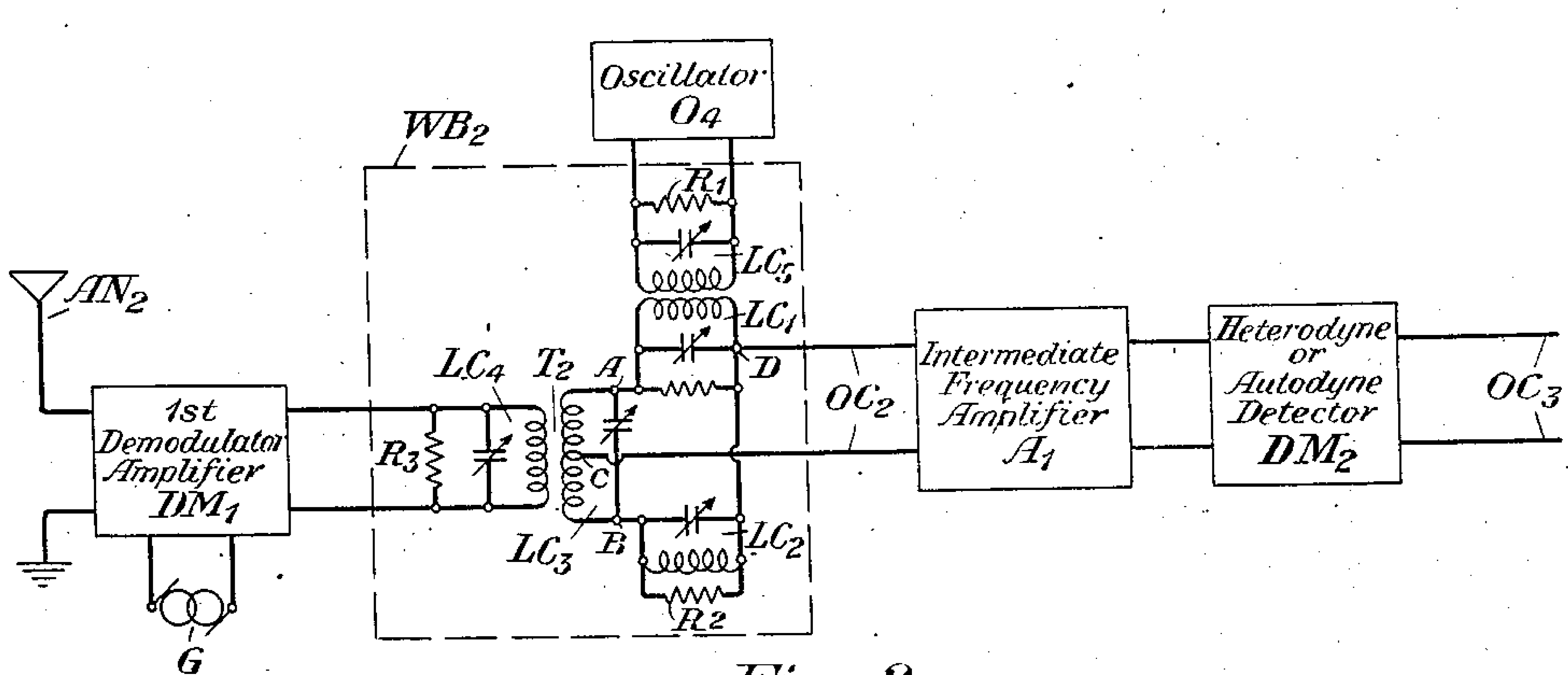


Fig. 2

INVENTOR
E. H. Weber, Jr.
BY Jefferson Ehrlich
ATTORNEY

Patented Sept. 19, 1944

2,358,610

# UNITED STATES PATENT OFFICE

2,358,610

## TELEGRAPH SIGNALING SYSTEM

Edward Henry Weber, Jr., Toms River, N. J., assignor to American Telephone and Telegraph Company, a corporation of New York

Application March 12, 1943, Serial No. 478,882

10 Claims. (Cl. 250—8)

This invention relates to signaling systems. More particularly this invention relates to telegraph systems and especially to carrier or radio telegraph systems.

In the carrier or radio telegraph system of this invention, a local oscillator is connected to a source of carrier telegraph signals so that the frequency of the current of the local oscillator is varied so as to equal the frequency of the received carrier current. The local oscillator and the source of carrier telegraph signals are coupled to each other by a balanced or Wheatstone bridge system. The source of the carrier signals is connected to a diagonal of the bridge while the local oscillator is connected to an arm of the bridge. The signal output circuit is connected to the opposite diagonal of the bridge.

In this system the received carrier current is transmitted through the bridge to the local oscillator and causes the local oscillator to change the frequency of its generated current to equal the frequency of the received carrier current. The two alternating currents are thus brought into synchronism with each other. The signal output circuit then receives the current of the local oscillator modulated by the same signals. The modulated current may thereafter be demodulated in any well known manner to reproduce the original signals. By confining the received modulated carrier current and the signals of output circuit to opposite diagonals of the bridge, the two are made conjugate to each other and they are mutually independent of each other except for the effect referred to.

This invention will be better understood from the more detailed description hereinafter following, when read in connection with the accompanying drawing in which Figure 1 represents one form of radio telegraph transmitting system to which the invention may be applied and Fig. 2 represents a form of radio telegraph receiving system to which the invention may also be applied.

Referring to Fig. 1 of the drawing, a Wheatstone bridge system $WB_1$ is shown interconnecting an oscillator $O_1$ with one or more oscillators $O_2$, $O_3$, etc. The tuned circuit $LC_1$ comprises one of the arms of the bridge, the tuned circuit $LC_2$ comprises another of the arms of the bridge, and the tuned circuit $LC_3$ is divided into two parts which may form the remaining two arms of the bridge. The coil of the tuned circuit $LC_3$ may be the secondary winding of the transformer $T_1$, the primary winding of which is part of a tuned circuit $LC_4$. The latter tuned circuit may be connected to either of the oscillators $O_2$ or $O_3$, as will be described hereinafter.

The tuned circuits $LC_3$ and $LC_4$ are coupled to each other so as to impress the alternating voltage of either of the oscillators $O_2$ or $O_3$, whenever desired, upon the diagonal A—B of the bridge. The oscillator $O_1$ is coupled by the tuned circuit $LC_5$ to the tuned circuit $LC_1$ of the bridge so as to provide an effective connection of the oscillator $O_1$ to one of the arms of the bridge as shown. The output circuit $OC_1$ is connected to the other diagonal C—D of the bridge, this output circuit supplying current to a radio transmitter RT of any well-known type. The radio transmitter RT is connected to an antenna circuit $AN_1$ of well known type for transmission of signals to a distant point.

A local loop including a battery $B_2$, a key $K_2$ and a relay $W_2$ may be employed to control the application of current from the oscillator $O_2$ to the tuned circuit $LC_4$ and the rest of the bridge $WB_1$, to vary the frequency of the oscillator $O_1$, as will later be explained. A similar loop including a battery $B_3$, a key $K_3$ and a relay $W_3$, may be employed to control the application of current from another oscillator $O_3$ through the bridge arrangement to the same oscillator $O_1$ for the same purpose. The relays $W_2$ and $W_3$ are normally released as shown so that neither of the oscillators $O_2$ or $O_3$ will apply current to the bridge arrangement $WB_1$. If one of the keys such as key $K_2$ is depressed, however, the relay $W_2$ will become operated so as to remove the shunt around oscillator $O_2$ provided by the armature and back contact of relay $W_2$. In that event the oscillator $O_2$ may supply current to the bridge $WB_1$ over a circuit which includes the armature and back contact of relay $W_3$ and the tuned circuit $LC_4$. Similarly when the key $K_3$ is depressed the relay $W_3$ will become operated so as to allow the oscillator $O_3$ to transmit current to the tuned circuit $LC_4$ connected to the bridge over a circuit which is completed through the armature and back contact of relay $W_2$.

Under normal conditions, when the keys $K_2$ and $K_3$ are released, the oscillator $O_1$ will supply current through tuned circuit $LC_5$ to the arm $LC_1$ of the bridge and this current will flow in the output circuit $OC_1$ to the radio transmitter RT. The radio transmitter RT may be employed to modulate this current upon the current of a radio frequency wave in a well known manner for the transmission of the modulated current through the antenna circuit $AN_1$ to a distant point. The oscillator $O_1$ may, for example, be a not too stable generator of sinusoidal current of any well known type. The circuit of oscillator $O_1$ also may include some kind of keying device for controlling the current of oscillator $O_1$ in accordance with signals (the keying device not being shown though of well known type).

When key $K_2$, for example, is depressed, the oscillator $O_2$ will apply voltage to the diagonal A—B of the bridge $WB_1$ to cause the current of oscillator $O_2$ to flow serially at any instant through the circuits $LC_1$, $LC_2$ and $LC_3$ and therefore through all four arms of the bridge. The voltage thus generated will send current through the output circuit $OC_1$ in one direction and at the same time the voltage generated across the tuned circuit $LC_2$ by the same current of oscillator $O_2$ will cause current to flow through the output circuit $OC_1$ in the opposite direction. As the opposing currents in the output circuit $OC_1$ are of equal magnitude the resultant current through the output circuit $OC_1$ due to the current supplied by the oscillator $O_2$ will be practically a nullity.

While oscillator $O_2$ is supplying current to the bridge $WB_1$ in response to the closure of key $K_2$, the voltage generated by this current across the tuned circuit $LC_1$ of the bridge will also be applied to the oscillator $O_1$. This voltage will act to lock the oscillator $O_1$ in step with the oscillator $O_2$ so that the waves of the two oscillators will be in synchronism with each other. The current of the oscillator $O_1$ will therefore be changed in frequency to be substantially equal to the frequency of the current supplied by oscillator $O_2$, but the waves of the two oscillators may differ in phase. The current of the oscillator $O_1$, being supplied to the arm $LC_1$ of the bridge, will then be transmitted to the output circuit $OC_1$ of the bridge but the frequency of this current in the output circuit $OC_1$ will be equal to that of the current of oscillator $O_2$. The bridge circuit shown and described herein is also shown and described in applicant's copending application, entitled "Signaling apparatus," Serial No. 478,881, filed of even date.

It will be observed that the oscillator $O_2$ and the output circuit $OC_1$ are connected in conjugate relationship with each other so that substantially none of the current of oscillator $O_2$ will traverse the output circuit $OC_1$. The oscillator $O_1$, however, will alone supply current to the output circuit $OC_1$. Although the frequency of the oscillator $O_1$ continuously follows the frequency of oscillator $O_2$, the current supplied by oscillator $O_1$ to the output circuit $OC_1$ will have a substantially constant amplitude for all practical purposes.

After key $K_2$ is released, key $K_3$ may be thereafter depressed. In that case the oscillator $O_3$ will then supply current to the bridge $WB_1$ in a similar manner. This will cause oscillator $O_1$ to adopt a frequency which is equal to that of oscillator $O_3$. The current of oscillator $O_1$—now of a frequency which is equal to that of oscillator $O_3$—will supply current of this frequency to the output circuit $OC_1$ and to the radio transmitter RT for transmission to a distant point.

Thus it will be observed that the key $K_2$ may be operated to transmit signal pulses of current to the output circuit $OC_1$ and to the radio transmitter RT, the current emanating from oscillator $O_1$ but being of the frequency of oscillator $O_2$. When key $K_3$ is operated in accordance with signals, pulses of current will be transmitted through the output circuit $OC_1$ to the radio transmitter RT, this current similarly emanating from the oscillator $O_1$ but being of the frequency of oscillator $O_3$. Hence the oscillator $O_1$ is caused to oscillate either at its own frequency unaffected by any external conditions or it may be caused to operate at either the frequencies of the oscillators $O_2$ or $O_3$. Thus the radio transmitter RT will transmit signals of different frequencies in accordance with telegraph signals.

The resistors $R_1$, $R_2$ and $R_3$ may be added to the circuit if desired in order that the bridge may have equal impedances for currents of all frequencies which may be transmitted therethrough. If the arms of the bridge are all tuned to the same frequency and if selected to exhibit like characteristics, the bridge will remain balanced under all conditions of its operation.

Although oscillators $O_2$ and $O_3$ and their respective control apparatus $W_2$—$K_2$ and $W_3$—$K_3$ are shown in Fig. 1 in proximity to the bridge arrangement $WB_1$, they may be located at points considerably distant from the bridge arrangement $WB_1$. The lines between oscillators $O_2$ and $O_3$ may be so long as to have induced therein considerable noise and other interference. The arrangement of Fig. 1 may be employed to effectively eliminate such noise and other interference so that the radio transmitter RT may transmit the current of oscillator $O_1$ unaffected by the noise or interference.

Oscillators $O_1$ and $O_2$ have been described as generators of current of different frequencies. These oscillators may have the same frequencies if so desired. Moreover, all three oscillators may be designed to generate currents having frequencies of the same value, although this is by no means essential to the system. Whenever oscillator $O_1$ is employed to produce current of a frequency which is different from the frequencies of oscillators $O_2$ and $O_3$, the oscillator $O_1$ may return to its normal frequency upon release of keys $K_2$ and $K_3$.

Fig. 2 illustrates a radio telegraph receiving system which may include an antenna circuit $AN_2$, a first demodulator-amplifier $DM_1$ to which a generator or oscillator G may be connected for demodulating received radio waves into intermediate frequencies in a well known manner; a Wheatstone bridge arrangement $WB_2$ which is similar to the Wheatstone bridge $WB_1$ of Fig. 1 for receiving the currents of the intermediate frequencies; an oscillator $O_4$ which is to supply current of a frequency equal to that of the received carrier current; an amplifier $A_1$ which is connected to the output circuit $OC_2$ of the bridge $WB_2$; a demodulator $DM_2$ which may be of a heterodyne or an autodyne type; and an output circuit $OC_3$ for receiving the demodulated currents in, for example, the audio frequency range. The oscillator $O_4$ may be adjusted to produce current of a frequency of, for example, 501 k. c., which is applied through tuned circuit $LC_5$ to one of the arms $LC_1$ of the bridge, as already explained. This will cause current emanating from oscillator $O_4$ to flow through the output circuit $OC_2$. The current of oscillator $O_4$ will be amplified by amplifier $A_1$ and then demodulated by the demodulator $DM_2$ so as to produce a zero frequency beating component. Under these conditions the output circuit $OC_3$ will receive no audible tone.

When the antenna $AN_2$ receives a radio frequency wave interrupted in accordance with telegraph signals, the intermediate frequency components of the received radio wave obtained from the demodulator $DM_1$—which may be of a frequency of 500 k. c.—will be applied to the diagonal A—B of the bridge $WB_2$. This current will reach the oscillator $O_4$ as already explained and cause the oscillator $O_4$ to change its frequency so as to be synchronous with the frequency of the carrier wave supplied by the demodulator $DM_1$. Thus the oscillator $O_4$ may now be caused to produce oscillations of a frequency of, for example, 500 k. c. The current of this frequency will be transmitted through the output circuit $OC_2$ and through the amplifier $A_1$ to demodulator $DM_2$. Demodulator $DM_2$ may, for example, produce its own current of 501 k. c. for demodulating the intermediate frequency current of 500 k. c., thereby producing a beat note of 1,000 cycles. This audible frequency component will be received in the output circuit $OC_3$.

It will be observed that the demodulator $DM_1$ and the output circuit $OC_2$ are in conjugate relationship with each other with respect to the bridge circuit and hence none of the current of the demodulator $DM_1$ will reach the output circuit $OC_2$. Because of this conjugacy and also because of the one-way path provided by the amplifier $A_1$, none of the current of the demodulator $DM_2$ will be returned to the demodulator $DM_1$. It will be understood that the oscillator $O_4$ may be operated either at its own frequency or at any one of several different frequencies which may be applied to it from the demodulator $DM_1$.

The radio transmitter of Fig. 1 and the radio receiver of Fig. 2 may be operated in independent signaling systems which are unrelated to each other. That is, the radio transmitter of Fig. 1 may be operated in conjunction with any well known radio telegraph receiver and the radio receiver of Fig. 2 may be operated in conjunction with any well known form of radio telegraph transmitter. However, the circuits of Figs. 1 and 2, if desired, may form a complete radio telegraph system, as will be understood by those skilled in the art. Where several different radio frequencies may be received at different times by the receiving antenna $AN_2$ the frequency of oscillator $O_4$ will be changed to match and correspond with the carrier wave received by the antenna $AN_2$ at any instant. The resulting beat note will be of a frequency which corresponds to the particular radio wave received by the system. The output circuit $OC_3$ may include well known selecting devices (not shown) to distinguish a beat note of one frequency from that of another frequency.

In Figs. 1 and 2 the oscillators $O_1$ and $O_4$ are shown connected to tuned circuits $LC_5$ and $LC_1$ of the balanced bridge system. It will be understood that either tuned circuit $LC_5$ or both of these tuned circuits may be incorporated as part of the oscillators $O_1$ and $O_4$, as will be apparent to those skilled in the art. As the oscillators $O_1$ and $O_4$ may be of any one of many different types, their circuits are not shown in detail because the oscillators themselves do not comprise this invention.

Although Fig. 2 has been described as a radio telegraph receiving system, the same general arrangement may be employed for receiving and detecting frequency modulated signals. If Fig. 2 is used in a frequency modulated system, the intermediate carrier frequency obtained from demodulator $DM_1$ will swing over a considerable range in accordance with signals. The oscillator $O_4$ will then be continuously changed in frequency in accordance with the instantaneous values of the intermediate frequency. Thus the oscillator $O_4$ will produce current of a frequency which changes in accordance with the received frequency modulated current.

However, the current of oscillator $O_4$, though responding to the frequency variations of the received carrier wave, will supply current of substantially constant amplitude. Consequently the limiter usually accompanying receiving systems for frequency modulated signals may be omitted. The demodulator $DM_2$ will necessarily comprise any well known type of detector for converting the frequency variations of the current of oscillator $O_4$ into audible signals.

Thus the circuit of Fig. 2 may be employed to drive the oscillator $O_4$ to produce current of a variable frequency to correspond to the frequency variations of received frequency modulated signals. These frequency variations will be detected by the demodulating apparatus $DM_2$ without a limiter. The bridge circuit $WB_2$ will operate with oscillator $O_4$ to substantially reduce noise or other interfering effects.

While this invention has been shown and described in certain particular embodiments merely for the purpose of illustration, it will be understood that the general principles of this invention may be applied to other and widely varied organizations without departing from the spirit of the invention as defined in the appended claims.

What is claimed is:

1. In a signaling system, the combination of a first oscillator, means for interrupting the current of the first oscillator in accordance with signals, a second oscillator of a frequency different from that of the first oscillator, means comprising a balanced bridge circuit coupling said first oscillator with said second oscillator for causing the frequency of the current of the second oscillator to be synchronized with the current of the first oscillator and interrupted by the same signals, and means for deriving the signals from the interrupted current of the second oscillator.

2. In a signaling system, the combination of an oscillator, means for receiving carrier current modulated in accordance with signals, means comprising a balanced bridge circuit coupling said oscillator with said receiving means for applying the received modulated carrier current to said oscillator to vary the frequency of the current generated by said oscillator to continually equal the frequency of the received carrier current, and means for deriving the signals from the current of said oscillator.

3. In a signaling system, the combination of an oscillator of variable frequency, a source of carrier current modulated by signals, a bridge circuit coupling said source and said oscillator so that the frequency of the current obtained from said oscillator will always equal the frequency of said carrier current, and means for obtaining the current of said oscillator and detecting the signals therefrom.

4. In a telegraph signaling system, the combination of first and second oscillators, the current of said first oscillator being interrupted in accordance with signals, a Wheatstone bridge, means for connecting said first and second oscillators to a diagonal and an arm of the bridge, respectively, means for interrupting the current of the second oscillator in accordance with the same signals, said means including said Wheatstone bridge whereby the current of the

second oscillator is synchronized in frequency with the current of the first oscillator and the current of said second oscillator is interrupted by the same signals, and means connected to the other diagonal of the bridge for deriving the signals from the current of the second oscillator.

5. In a radio telegraph signaling system upon which is impressed carrier current interrupted in accordance with signals, means for deriving the signals from said interrupted carrier current, said means including an oscillator, a Wheatstone bridge to which said oscillator is connected as one arm thereof, means for impressing the received interrupted carrier current upon a diagonal of the bridge, and apparatus connected to the other diagonal of the bridge for demodulating and reproducing the signals.

6. In a telegraph system for reproducing the signals present in the form of interruptions of carrier current, the combination of an oscillator, means responsive to the received interrupted carrier current to change the frequency of the current of said oscillator to equal the frequency of the received carrier current while maintaining the amplitude of the current of said oscillator substantially constant, said means including means whereby the current of said oscillator is modulated in accordance with the same signals, and means for deriving the signals from the modulated current of the oscillator.

7. In a signaling system, the combination of an oscillator, a plurality of separate sources of carrier current each interrupted by telegraph signals, means responsive to any one of the received carrier currents for changing the frequency of the oscillator so as to equal that of the received carrier current and interrupting the current of said oscillator in accordance with said signals, said means comprising a balanced bridge circuit coupling said oscillator to said sources of carrier current, and means for detecting the received signals from the current of said oscillator.

8. In a telegraph system, the combination of a plurality of sources of carrier current of different frequencies, means for interrupting the current of any one of said sources in accordance with telegraph signals, an oscillator, means for changing the frequency of the oscillator to equal the frequency of any one of the received interrupted carrier currents, said latter means comprising a balanced bridge circuit coupling said oscillator to said sources of carrier current, and means for observing the oscillator current interrupted in accordance with the same signals.

9. In a telegraph system, the combination of a plurality of sources of carrier current of different frequencies, means for interrupting the currents of said sources in accordance with signals, an oscillator, a Wheatstone bridge system upon one diagonal of which is impressed the current of any one of said sources interrupted by said signals, the oscillator being connected to an arm of said bridge so as to be locked in step with the carrier current received by said bridge diagonal, and a circuit connected to the other diagonal of the bridge for receiving the current of the oscillator interrupted by said signals.

10. In a telegraph system, the combination of a source of signals in the form of a carrier wave interrupted in accordance with the signals, an oscillator, means coupling said oscillator with said source of signals so that the carrier wave of said source will vary and determine the frequency of the oscillator, said means including means for deriving the current of the oscillator interrupted by the same signals, and means for demodulating the current of the oscillator interrupted by said signals to reproduce said signals.

EDWARD HENRY WEBER, Jr.