

Oct. 16, 1928.

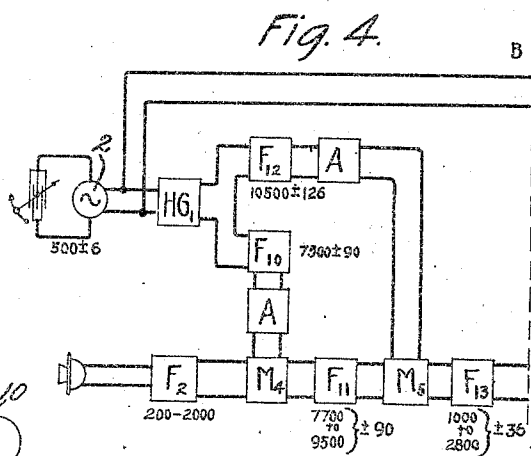
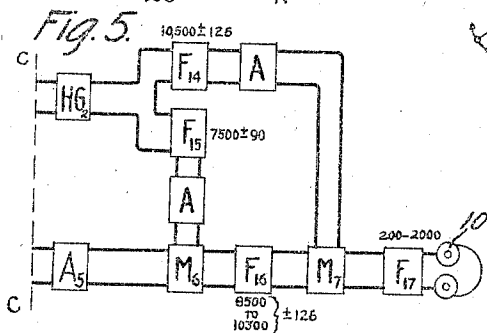
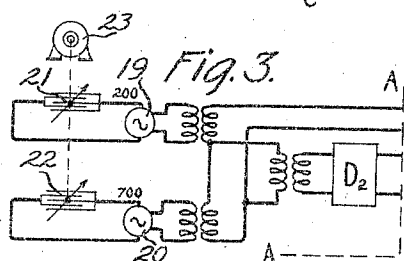
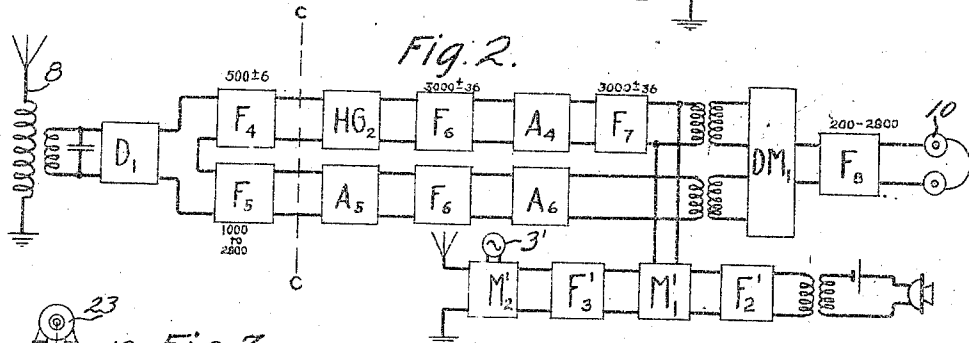
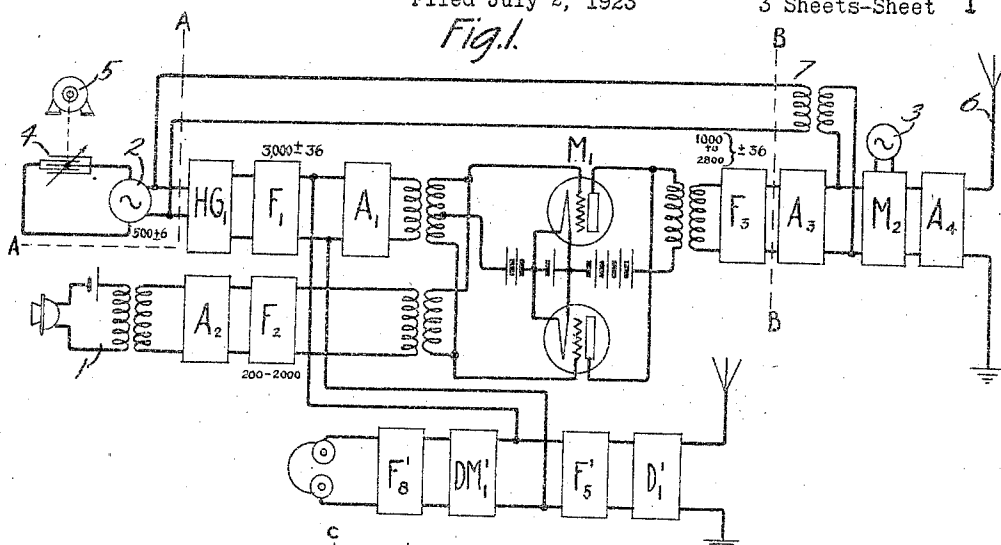
1,687,932

J. F. FARRINGTON

SECRET SIGNALING

Filed July 2, 1923

3 Sheets-Sheet 1



Inventor:
John F. Farrington
by W. G. Giggis Att'y.

Oct. 16, 1928.

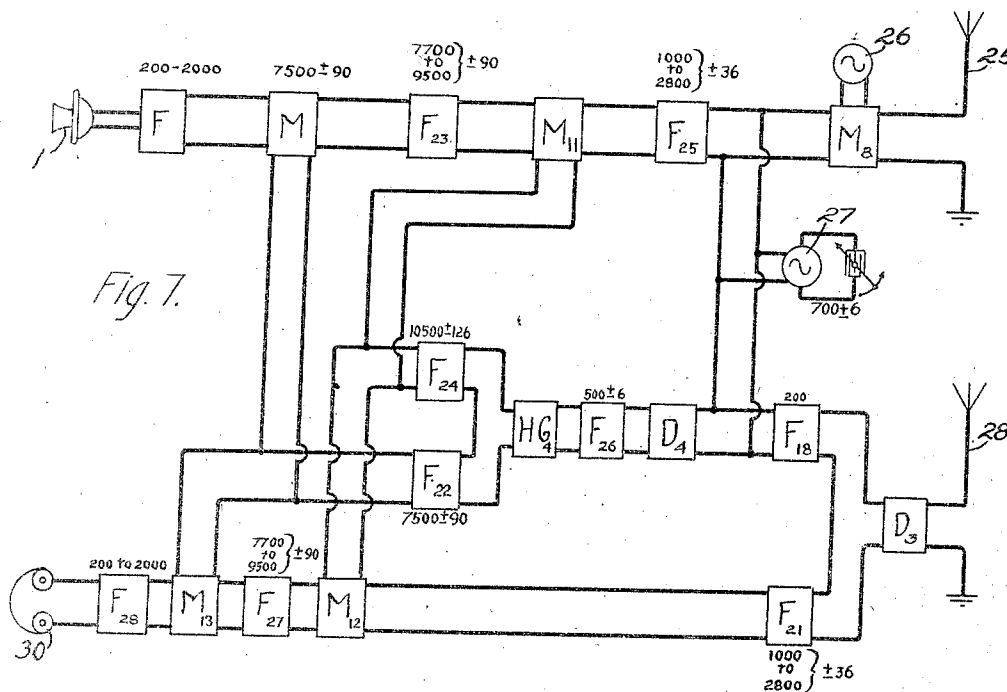
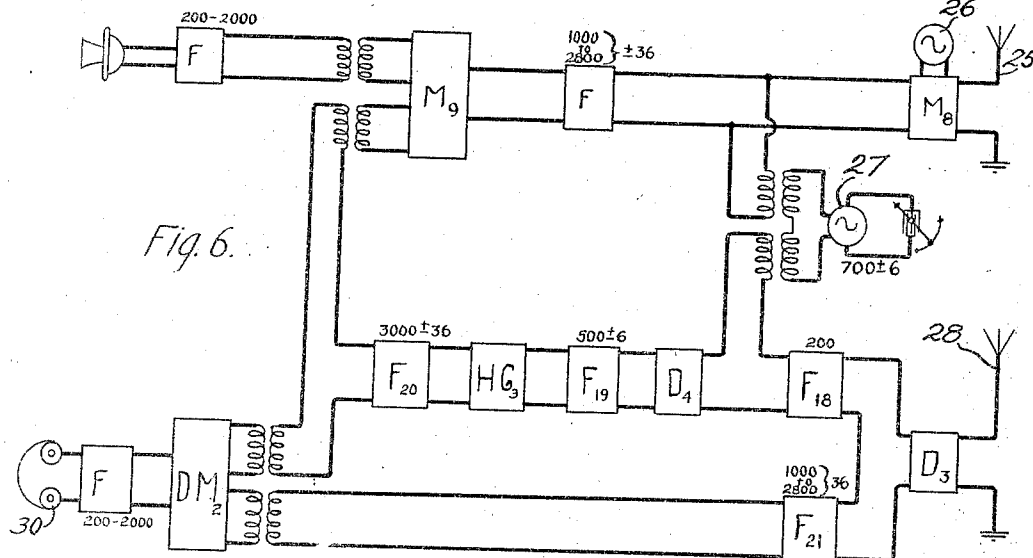
J. F. FARRINGTON

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SECRET SIGNALING

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3 Sheets-Sheet 2



Inventor:
John F. Farrington
W. Griggs Att'y

Oct. 16, 1928.

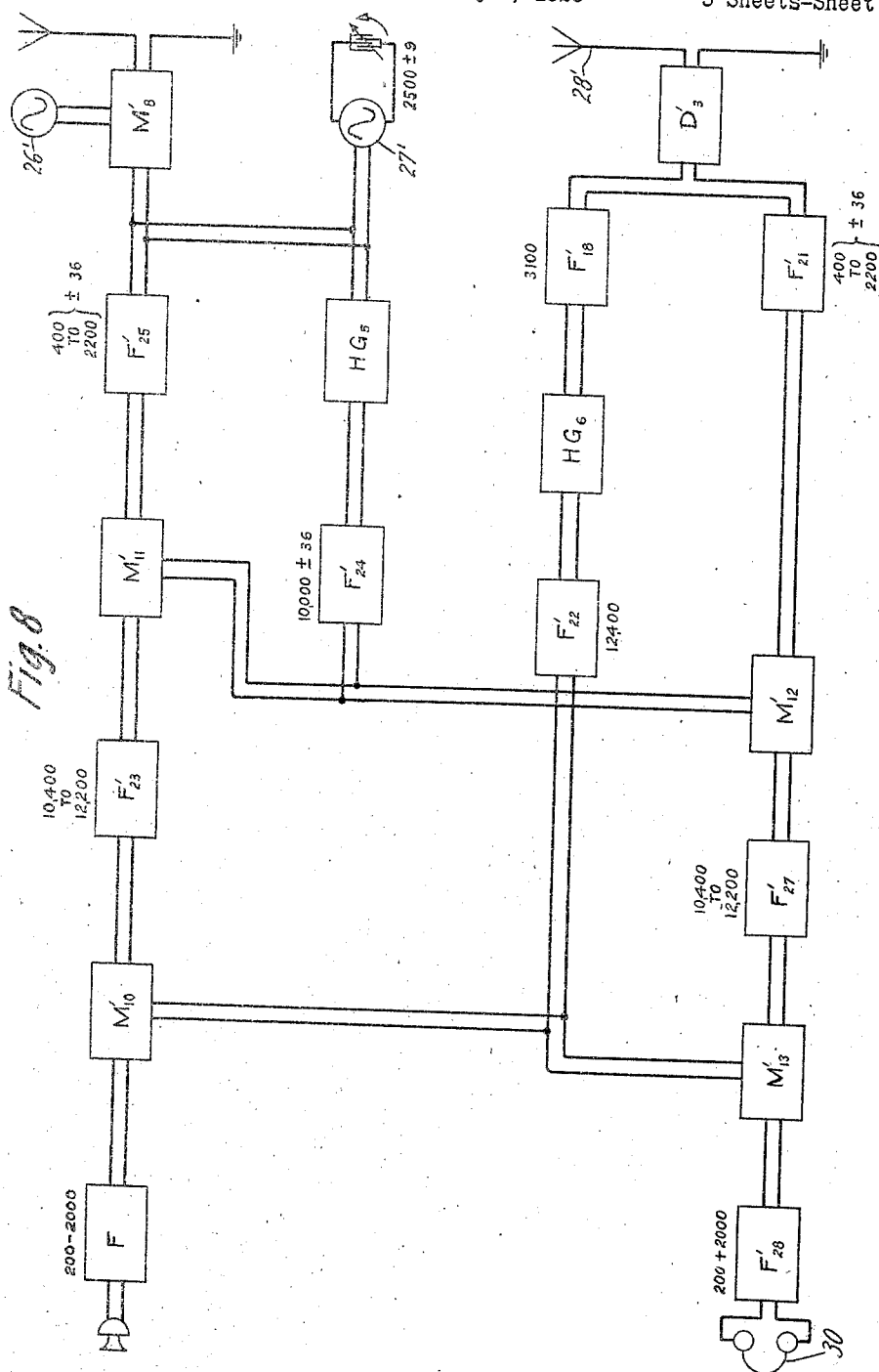
J. F. FARRINGTON

1,687,932

SECRET SIGNALING

Filed July 2, 1923

3 Sheets-Sheet 3



Inventor:
John F. Farrington
by *E. W. Adams* Att'y

Patented Oct. 16, 1928.

1,687,932

UNITED STATES PATENT OFFICE.

JOHN F. FARRINGTON, OF FLUSHING, NEW YORK, ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

SECRET SIGNALING.

Application filed July 2, 1923. Serial No. 648,887.

The present invention relates to signaling and has particularly to do with securing secrecy in the transmission of signals.

An object of the invention is to secure a high degree of secrecy in the transmission of messages by radio or carrier while still enabling the messages to be received at an authorized station with high quality of reproduction.

It has been suggested to secure secrecy by transmitting only waves the frequency components of which have a frequency order different from that of the signal waves, as, for example, waves having a frequency order the inverse of that of the signal waves so that the lowest frequency component of the signal is transmitted as the highest frequency, and the higher frequency components of the signal are transmitted as successively lower frequency components. Such a wave is unintelligible and can only be understood by inverting it so as to restore the normal frequency order of the signal. It has further been proposed to cause the inverted frequency wave to undergo a cyclic frequency variation to prevent the message from being intercepted by use of a local source of oscillations of such a frequency as to give a beat wave of the signaling frequency and of the normal frequency order. This has been accomplished by introducing frequency variations into the transmitting carrier wave so that the entire band of frequencies transmitted undergoes cyclic frequency variations. Detection of such a wave yields the modulation component directly, and if the cyclic frequency variations are not so rapid as to produce an audible sound upon detection, no interference in the detected signal results. The detected wave in such a system is incapable of being understood since it represents the inverted frequencies of the signal, and the system possesses a high degree of secrecy, therefore, since the operation of simple detection must be followed by a frequency inverting operation in order to reproduce the signal. As stated above, the cyclic frequency variations of the transmitted waves make it impossible for one to receive the signal by a single step of detecting and inverting by use of a local source of beating waves.

According to the invention, a higher degree of secrecy is obtained by varying the frequency of the signal component with respect to the carrier component. The carrier component may have a constant or a variable frequency, and in either case the transmitted wave components, representing the signal, commonly called the side band components, have cyclic frequency variations entirely independent of the carrier. Upon simple detection of such a wave, a band of audio frequency components is obtained, which band, as a whole, undergoes cyclic frequency variations. If the carrier wave has been modulated by speech of normal frequency order but varying in frequency as to the entire speech band, a similar speech band shifting upward and downward in the frequency spectrum is received upon simple detection, and such a wave is not only incapable of being understood as it is but is very difficult to transform into understandable speech, since in order to transform it, continuous oscillations of the proper absolute frequency and with the same frequency variations as the detected band are required. By inverting the speech at the transmitter, a still greater degree of unintelligibility is produced in the detected wave.

The signals sent according to the invention are received at an authorized station by combining with the detected audio band of varying frequency a wave of similarly varying frequency and of proper absolute frequency, and this wave is obtained at the receiver by operating upon a control wave component sent from the transmitting station and reproduced at the receiver upon simple detection. This control component, however, may be of the same amplitude as the signal components and may have a frequency lying in the normal signal frequency range, so that an outsider would not have any reason to consider the control wave component as anything but one of the signal components. Moreover, in case it should be learned that a certain component of the detected wave is a control component, this information would not enable the signal to be reproduced since the wave that is essential to the reproduction of the signal is, according to the invention, only derived by op-

erating upon the control wave component in a particular manner to derive from it the necessary wave.

Instead of using for the control wave a single component transmitted from the transmitting station, a plurality of waves may be transmitted either from one station, or, preferably, one from each of a plurality of stations, as, for example, one from each of two communicating stations, and at each station the beat between the transmitting waves may be used as the control component. If, for example, Chicago were communicating with Seattle and at each station the control wave were derived as the beat between two waves, one sent from each station, the only location at which these components would appear of equal intensity would be half way between the two stations, assuming both stations had equal power, of course. At a point between the stations but not equi-distant from them, one of the components would be stronger than the other, so that an outsider who might be looking for a control component would be led to suspect that the stronger component would be the key. Similarly, at New York for example, any person who could receive Chicago but who could not receive Seattle would be unable to hear even one side of the conversation since he could not receive the component from Seattle necessary to reproduce the control component.

The invention may be briefly and specifically characterized, therefore, as fundamentally comprising the transmission of a carrier wave with a side band of varying frequency relative to the carrier frequency. Preferably the speech to be transmitted is inverted by modulating a variable frequency wave by the speech and selecting the lower side band. The variable frequency wave used for inverting is derived from a control wave, which, together with the inverted speech, modulates a carrier wave for transmission. At the receiver, the waves are detected and the control component is used to reproduce an inverting wave identical with that used at the transmitter. This inverting wave is then employed to re-invert the detected band and reproduce it as understandable speech.

The various features and objects of the invention will be more fully set forth in the following detailed description, in connection with the accompanying drawings. In the drawings, Fig. 1 is a schematic circuit arrangement of one terminal station of a system according to the invention and Fig. 2 is a similar showing of a station adapted to cooperate with the station of Fig. 1. Figs. 3, 4 and 5 are modified circuit arrangements which may be employed in the system shown in Figs. 1 and 2. Fig. 6 shows a two-way station with a somewhat different arrange-

ment. Fig. 7 shows a two-way station employing modifications similar to those shown in Figs. 4 and 5; and Fig. 8 shows a modification of the arrangement of Fig. 7.

Referring first to Fig. 1, the transmitting side will be seen to comprise a speech inverting portion comprising the microphone circuit 1, a modulator M_1 and the source 2 of inverting frequencies; and the high frequency transmitting portion comprising the transmitting modulator M_2 and the carrier wave source 3. The modulator M_1 is preferably of the balanced tube type shown, for example, in the Hartley Patent 1,419,562 June 13, 1922, and the input circuit is supplied with continuous waves from the amplifier A_1 and with speech waves from the microphone circuit 1. The source 2 is preferably a vacuum tube oscillator of the type shown in the Hartley Patent 1,356,763, October 26, 1920 and is arranged to produce a continuously varying frequency as, for example, by having the movable plate of its tuning condenser 4 continuously rotated by the motor 5. The frequency of the source 2 may conveniently vary between the limits 494 and 506 cycles per second.

The mathematical convention $\pm$ will be used throughout the specification and drawings to indicate that the mean frequency or band of frequencies written before the symbol varies between upper and lower limits differing from the mean by the amount written after the symbol.

The varying frequency wave from source 2 is impressed on the harmonic generator HG, and the sixth harmonic is selected by the filter F_1 from the harmonic generator and applied to the amplifier A_1 . The continuous wave supplied to the modulator M_1 is, therefore, a wave of varying frequency having the extreme frequencies 2964 and 3036. The harmonic generator may be of the type disclosed in Kendall Patent 1,446,752, February 27, 1923. The filter F_1 should have a uniform frequency transmission characteristic over the range of variation of the transmitted wave. This result may be accomplished by constructing the filter F_1 as a band filter in the manner described in the Campbell Patent 1,227,113, May 22, 1917. Each of the other filters shown throughout the drawing may be constructed in the manner disclosed in the Campbell patent and may be designed to have the transmission range required in any particular instance.

The filter F_2 in the speech circuit is preferably designed to transmit the essential speech frequencies, for example 200 to 2000 cycles inclusive. The output of the modulator M_1 is transmitted through the band filter F_2 and amplifier A_2 to the modulator M_2 from which the outgoing wave is supplied through the radio frequency amplifier A_3 to the antenna 6. The source of carrier waves 3 may be

of the type disclosed in Hartley's Patent 1,356,763 above referred to. This wave is modulated at M_2 both by the waves received through the filter F_2 and by a small amount of the wave from the source 2, this being applied through the transformer 7 to the input of the modulator.

In operation, the source 2 supplies waves of continuously varying frequency to the harmonic generator HG_1 , from which, as stated, the wave of 3000 ± 36 cycles is selected by the filter F_1 , amplified at A_1 and applied to the modulator M_1 . Also, the essential speech frequencies are selectively transmitted to the filter F_2 and supplied to the modulator M_1 . By the well known action of the modulator, two side bands are produced, each having a frequency width of 1,800 cycles at any instant. When the inverting frequency is 3000 cycles, one of these side bands extends from 1000 to 2800 cycles and the other extends from 3200 to 5000 cycles. The two side bands and the inverting frequency vary together upward and downward in frequency through a total variation range of 72 cycles. The filter F_3 is a band filter designed to transmit selectively only the lower side band from the modulator M_1 . By referring to the Hartley Patent 1,419,562 mentioned above, it will be seen that a property of the modulator M_1 is to suppress the unmodulated component of the applied inverting wave and also of the applied speech waves. Even though the frequency range of the filter F_3 overlaps that of the filter F_2 , none of the original speech can pass through to the carrier modulator M_2 on account of the suppressing action of the modulating circuit M_1 . The lower side band transmitted through the filter F_3 represents inverted speech, that is, the lowest speech frequency has been transformed into the highest frequency of the band and the highest speech frequency has been changed to the lowest frequency of the band. Also, the band has been shifted upward in frequency a slight amount, since, as stated above, it now extends from 1000 cycles to 2800 cycles with a cyclic shift in frequency to the values 36 cycles higher and 36 cycles lower than these limits.

The inverted frequencies modulate the radio waves from the source 3 in the modulator M_2 and the resulting modulated wave is transmitted from the antenna 6. It is not necessary that both side bands of the radio frequency wave be transmitted but it is sufficient if only a single side band of the inverted speech and control wave is transmitted. Accordingly, if desired, the modulator M_2 may be of the same type as modulator M_1 or, of the type shown in the Carson Patent 1,243,306 June 15, 1920, so as to prevent transmission of the unmodulated radio frequency wave, and the antenna 6

may be tuned to select one of the two side bands for transmission.

If the wave so transmitted is intercepted on a simple detecting receiver whether one or both side bands are transmitted and whether or not the carrier is suppressed, only waves incapable of being understood will be received. For the most that can be obtained from a single stage of detection will be a band of waves of speech frequency width continuously varying in frequency and shifted from the normal speech frequency wave. If this band occupied the normal speech range it would be unintelligible on account of this cyclic variation. To render the wave intelligible, therefore, the frequency variations must be neutralized and this is practically impossible without a knowledge of the manner and frequency of the variation.

The waves so transmitted may be received and reproduced as understandable speech by a station of the type shown in Fig. 2. The waves intercepted on the antenna 8 are detected at D_1 and the resulting low frequency components comprising in part the control wave of 500 ± 6 cycles and the inverted speech waves are separated by the respective filters F_4 and F_5 . The control waves are applied to the harmonic generator HG_2 , which may be identical with HG_1 , and the filter F_6 selectively transmits the sixth harmonic or 3000 ± 36 cycles to the amplifier A_4 and filter F_7 connected to the demodulator DM_1 . The inverted speech waves are selectively transmitted through the filter F_5 , amplifier A_5 and preferably through a second filter F_8 and amplifier A_6 to the demodulator, DM_1 .

The construction and mode of operation of the demodulator DM_1 may be identical with that described of the modulator M_1 , its purpose being to re-invert the received inverted speech waves by combining them with the same harmonic of the control wave as was used in the transmitter. The lower side band produced in the demodulator DM_1 will extend from 200 to 2000 cycles and will have the same order of frequencies as the waves in the output of the filter F_3 at the transmitting station. This lower side band is selected by the filter F_9 , which may be identical with the filter F_3 , and is applied to the receivers 10 where it is heard as understandable speech.

In a two-way system there will be at one terminal, a transmitting station of the type shown in Fig. 1, and at the other station a receiving circuit of the type shown in Fig. 2.

It is not necessary, however, to duplicate these circuits, in order to provide a transmitter and a receiver at each station. For example, in Fig. 2 the inverting wave from the output of filter F_7 may be applied to the inverting modulator M'_1 , of the transmitter

of that terminal, thus avoiding duplication of the harmonic generator circuits. Similarly in Fig. 1, the inverting demodulator DM_1 , may be supplied with an inverting wave from the output of filter F_1 . The remaining elements of the respective transmitter and receiver may be identified from the reference characters, which are the same as are employed in the other respective figure with a prime (') mark added.

Instead of controlling the inverting waves at the transmitting and receiving stations by transmitting a single control wave as was done in the system of Fig. 1, this control wave may be derived at both the transmitter and receiver as a beat frequency wave between two separately generated and transmitted waves. An arrangement for doing this is shown in Fig. 3. The oscillator 19 may supply waves of a frequency of 200 cycles and the oscillator 20 may produce waves of 700 cycles and either or both of these frequencies may be varied by connecting the appropriate tuning condenser 21 or 22 or both of them to the motor 23. The beat frequency wave between the two waves thus produced will have a frequency of the order of 500 cycles. This beat frequency may be derived at the transmitter by applying the waves to the detector D_2 so that a variable wave of the order of 500 cycles is produced in its output circuit. Both of the waves from the sources 19 and 20 may be applied to the outgoing modulator so that they are sent to the distant station. The circuit arrangement of Fig. 3 may be substituted for that portion of Fig. 1 shown to the left and above the dotted line A—A. At the receiving station the products of detection of the transmitted wave will include the beat wave between the 200 and 700 cycle modulation components at the transmitting station.

A modified system for producing the inverted speech frequency waves is indicated in Fig. 4, which arrangement may be substituted for that portion of the system of Fig. 1 shown to the left of the dotted line B—B. In the modified arrangement, the speech waves from the filter F_2 modulate at M_3 , a varying frequency wave of the order of 7500 cycles, supplied through the filter F_{10} from the harmonic generator HG_1 associated with the source 2. The 7500 cycle wave is obtained as the 15th harmonic and the frequency of this wave will lie at any instant between the limits of 7590 and 7410 cycles. The upper side band comprising frequencies from 7700 to 9500 cycles with variation of 90 cycles upward and downward from these values, is selected by the filter F_{11} and applied to the modulator M_5 . The filter F_{12} selects the 21st harmonic from the harmonic generator HG_1 . This harmonic having a frequency of $10,500 \pm 126$ cycles is applied to the modulator M_5 . The filter F_{13} selects the

lower side band of the modulated wave from modulator M_5 . This side band extends from 1000 to 2800 cycles, the limits of which vary cyclically through 36 cycles upward and downward from these values. The advantage of this type of inverting arrangement is that the inverted wave does not depend upon any balanced circuit arrangement to prevent the occurrence in the output circuit of the modulating system of speech frequency components having the normal speech frequency order. The modulators M_4 and M_5 may be single tube modulators, since there is no possibility for speech to pass directly from the filter F_2 through the filter F_{13} .

Whether or not the modification shown in Fig. 4 is used at the transmitting station, it may be desirable, at times, to use at the receiving station the type of inverting system shown in Fig. 5, this system being substituted for that portion of the circuit in Fig. 2 to the right of the dotted line C—C. The operation of the circuit of Fig. 5 will be clear from the description already given of Fig. 4. The received and detected control wave of 500 ± 6 cycles is applied to the harmonic generator HG_2 from which the filters F_{14} and F_{15} derive, respectively, the frequencies $10,500 \pm 126$ and 7500 ± 90 . These frequencies are supplied through the respective amplifiers to the respective modulators M_7 and M_6 . The detected inverted speech waves from the filter F_2 are applied to the modulator M_6 and the upper side band of frequencies from 850 to 10,300 with their cyclic variation of 126 cycles is selected by the filter F_{16} and applied to the modulator M_7 . The filter F_{17} selects the lower side band from the modulator M_7 , this side band representing normal speech between the frequencies 200 and 2000 cycles. As in the case of Fig. 4, the circuit of Fig. 5 removes the possibility of the received speech being confused or distorted due to the direct transmission to the receivers 10 of components from the detector in case of an unbalance in the suppressing circuit DM_1 when such a circuit is used.

In the system shown in Fig. 6, the control of the inverting frequencies at the transmitting and receiving stations is effected by using two waves and deriving their beat wave at both stations. The system of this figure, however, differs from that of Fig. 3 in that one of the two components is transmitted from one of the two communicating stations, and the other component is transmitted from the other station. In this figure, it will be assumed that a variable frequency of the order of 700 cycles is continuously transmitted from the antenna 25 as a modulation of the carrier wave from source 26 in the modulator M_4 by the variable frequency source 27. As in the case of Fig. 1, the carrier wave is also modulated at M_5 by in

verted speech waves resulting from modulation of a variable frequency inverting wave of 3000 ± 36 cycles in the modulator M_6 , by speech.

5 At the distant cooperating station, a source similar to 27 is assumed to be present, this source emitting a wave of 200 cycles which modulates the carrier wave at that station for transmission
10 to the station in Fig. 6. This 200 cycle wave may have either a varying or a constant frequency, but for simplicity, in the present case it will be assumed to have a constant frequency, if its frequency, were cyclically varied, the total range of variation
15 of the signal as finally transmitted could be increased. The wave so transmitted is received on the antenna 28 and detected at D_4 to yield as one of the components a 200 cycle wave which is selected by the filter F_{18} .
20 This 200 cycle wave is supplied to the detector D_1 together with a wave from the source 27 and the beat note of 500 cycles ± 6 is selected by filter F_{19} and applied to the harmonic generator HG_4 . The filter F_{20}
25 selects the sixth harmonic or 3000 ± 36 and this is used as the inverting frequency for the modulator M_5 and the demodulator DM_1 .

The distant terminal station may be a
30 duplicate of that of Fig. 6 except that as stated, the source 27 of that station has a frequency of 200, and the filter F_{18} of that station is selective of 700 ± 6 cycles. The inverted speech frequencies occupying the
35 range 1000 to 2500 cycles with a plus and minus 36 cycle variation received from the distant station on the antenna 28 and detected at D_4 , are selectively transmitted through the filter F_{21} to the demodulating circuit DM_2
40 where they combine with the inverting wave from the filter F_{20} to yield understandable speech, for application to the receivers 30.

The system described in Fig. 6 possesses a greater degree of secrecy than that described in the previous figures for the reason
45 that is necessary to receive the control component from each of the two intercommunicating stations in order to receive even one side of the conversation. Thus, if an outsider should have a directional receiver and
50 should arrange it to receive from only one of the two stations he would not obtain sufficient wave components to enable him to reproduce understandable speech. Furthermore,
55 at any point except midway between the two stations, on the assumption that they transmit equal power, the two control components would not appear to be equal and an experimenter would be unlikely to assume that
60 the two components of unequal magnitude and of different frequency were an essential part of the secrecy scheme. A station so situated as to be able to receive only one of the two intercommunicating stations as for
65 example, a receiver at New York which could

receive Chicago but not Seattle, would not be able to pick up even one side of a conversation between Chicago and Seattle since it would be unable to receive the control component sent out from Seattle, which is essential to the reception of any of the message waves.

Fig. 7 illustrates a system similar to that shown in Fig. 6 but provided with the double modulation inverting arrangements of the
75 type described in connection with Figs. 4 and 5. In Fig. 7, the speech from the microphone circuit 1 modulates at M_{10} a frequency of 7500 ± 90 derived through the filter F_{22} from the harmonic generator HG_4 . The filter
80 F_{23} transmits the upper side band or 7700 to 9500 with a plus and minus 90 cycle variation in the side band frequencies, and this band is applied to the modulator M_{11} . The modulator M_{11} is supplied with a wave of 10,500
85 ± 126 derived through the filter F_{24} from the harmonic generator HG_4 and the resulting lower side band from the modulator M_{11} is selectively transmitted by the filter F_{25} to the transmitting modulator M_8 , the frequency
90 of this side band being 1000 to 2800 with a band variation of plus and minus 36 cycles. This side band represents inverted speech of varying frequency. A wave from the source
95 27 to 700 cycles ± 6 also modulates the outgoing carrier.

The received waves incident on the receiving antenna 28 contain a 200-cycle control component produced at the distant station as explained in connection with Fig. 6,
100 and this component resulting from detection of the received waves at D_2 is transmitted through the filter F_{18} to the detector D_4 where it is combined with some of the
105 700 ± 6 cycle wave from the source 27. The beat wave of 500 ± 6 cycles is selected by the filter F_{19} and is applied to the harmonic generator HG_4 . The inverted speech components of the received wave are selected
110 by the filter F_{21} and applied to the modulator M_{12} where they modulate the 10,500 ± 126 cycle wave. The filter F_{27} selects the lower side band and applies it to the modulator M_{13} where it modulates with some of
115 the 7500 ± 90 cycle wave. The filter F_{28} selects the lower side band or normal speech and applies it to the receivers 30.

The invention lends itself readily to various schemes of frequency transformations and it is to be understood that the numerical
120 values thus far given are to be taken merely as examples and not as in any wise limiting the frequencies that may actually be used. A further scheme employing somewhat different frequencies from those above given, is
125 shown in Fig. 8. The general arrangement of Fig. 8 is identical with that shown in Fig. 7 except for the portion of the circuit included in the dotted line enclosure of the two
130 figures. The filters of Fig. 8, however, have

different frequency ranges as indicated on the drawing. The elements in Fig. 8, similar to those in Fig. 7 except for the frequency ranges, bear the same reference characters with a prime (') added.

The result of making the substitution of the circuit of Fig. 8 for the circuit of Fig. 7 is that the control wave component generated by the variable source 27', corresponding to the source 27 in the previous figure, at this station is now 2500 ± 9 cycles and that separate harmonic generators HG_5 and HG_6 are employed for independently transforming the locally produced control component and the control component received from the distant station. It will be assumed that a similar change is made at the distant station except that the control component generated at that station is now 3100 cycles, this 3100 cycles component may be varied in frequency or not, but it will be assumed, in the present instance, that it has a constant frequency.

In the operation of the modified circuit of Fig. 8 the control wave component from the source 27', is supplied to the harmonic generator HG_5 and the 4th harmonic, that is, $10,000 \pm 36$ cycles is now selected by the filter F'_{24} , this filter being designed in the modified arrangement to select these frequencies. The modulators M'_{11} and M'_{12} are, therefore, both supplied with the $10,000 \pm 36$ cycle frequency. At the distant station the control component is, as stated, 3100 cycles constant frequency and this modulates the outgoing carrier in the same way as described in connection with the previous figures. The wave received at the station in Fig. 8 upon detection yields a constant frequency component of 3100 cycles which, it will be assumed, is selectively transmitted by the filter F'_{18} and applied to the harmonic generator HG_6 . The 4th harmonic or 12,400 cycles is selectively transmitted by the filter F'_{22} and is supplied to the two modulators M'_{10} and M'_{13} . Speech currents from the microphone filter are impressed on the modulator M'_{10} where they modulate the 12,400 cycle frequency and the filter F'_{23} is so proportioned as to transmit the lower side band or the band of frequencies 10,400 to 12,200 cycles. This band is supplied to the modulator M'_{11} where it modulates the varying frequency of $10,000 \pm 36$ cycles and the filter F'_{25} selects the lower side band which it will be seen comprises frequencies from 400 to 2200 cycles having a frequency variation of plus and minus 36 cycles. As stated, the 2500 ± 9 control component together with the inverted variable frequency speech waves are applied to the transmitting modulator M'_8 . In this modification, therefore, the inverted voice frequency waves are shifted only a very small amount from their normal frequency range and the control component has a fre-

quency higher than any of the signaling components.

The received inverted speech frequency components from the distant station comprising the band 400 to 2200 cycles with a frequency variation of plus and minus 36 cycles is selectively passed through the filter F'_{21} and applied to the modulator M'_{12} , where it is combined with the $10,000 \pm 36$ cycle wave. The filter F'_{27} selects the upper side band between the fixed limits of 10,400 and 12,200 cycles and applies this band to the modulator M'_{13} where it is combined with the 12,400 cycle wave. The filter F'_{28} selects the lower side band which will be seen to comprise the frequencies 200 to 2000.

From the examples which have been given it will be clear that a great variety of frequency values may be employed in carrying out the principles of the invention.

Except in Figs. 1 to 5 no amplifiers have been indicated but, it will be obvious to provide amplification at any desired points in the system.

In some instances, it has been assumed that a harmonic generator has supplied a harmonic frequency of a high order such as the 15th, 21st, etc. In practice, it may be found desirable to employ a number of harmonic generators in tandem when harmonics of this order are to be developed. For example, a harmonic producer capable of efficiently producing harmonics up to the 5th may supply these harmonics to a second harmonic generator capable of producing harmonics up to say the 4th or 5th and this process may be continued as may be desired. Wherever a single harmonic generator is shown, therefore, it is to be assumed that it may be replaced by any required number of harmonic generators.

For convenience in illustration it has been assumed that the carrier transmission was in the form of a radiated wave and also that the speech transmitter and receiver were directly associated with the radio transmitter and radio receiver, respectively. It is to be understood, however, that the invention is applicable to wire transmission and that a two-way telephone line may be arranged in any known manner for two-way repeating into the carrier system.

What is claimed is:

1. The method of secret signaling comprising modulating a carrier wave by the signal to be transmitted to produce side bands of signaling-frequency width, and causing the side band frequencies to vary cyclically in frequency with respect to the carrier frequency.

2. The method of secret telephony comprising transforming a speech wave into a wave of cyclically varying frequency, and modulating a carrier wave thereby.

3. The method of secret telephony com-

prising inverting the frequency order of speech waves, cyclically varying the frequency of the inverted waves, and modulating a carrier wave by the inverted varying frequency waves.

4. The method of secret telephony comprising modulating a carrier wave by speech waves and causing the side-band frequencies of the resulting modulated wave to vary cyclically relative to the carrier frequency.

5. The method of secret telephony comprising inverting the frequency order of speech waves, modulating a carrier wave by the inverted waves, and causing the frequency of the side-band components of the resulting modulated wave to vary cyclically with respect to the carrier frequency.

6. The method of secret signaling comprising inverting the frequency-order of the message or other wave to be transmitted, by modulating a wave of varying frequency thereby and selecting the lower side-band of the modulated wave to the exclusion of the other components, and modulating a carrier wave by the selected side-band components.

7. The method of secret signaling comprising inverting the frequency order of the message or other wave to be transmitted, producing cyclic frequency variations in the inverted-frequency wave, modulating a carrier wave by the varying-frequency wave and by a control wave, transmitting the wave so modulated to a receiving point, and there utilizing the control wave component to reproduce the signal wave.

8. The method of secret signaling comprising inverting the frequency order of the message or other wave to be transmitted, by modulating a varying-frequency wave by the message wave, modulating a carrier wave by the lower side band of the message-modulated varying-frequency wave and by a control wave, transmitting the modulated carrier wave and utilizing at a receiving point the control wave component to reproduce a varying-frequency wave for demodulating the inverted wave to restore the message wave.

9. The method of secret signaling between two separated stations comprising transmitting from each station a carrier wave modulated by a different frequency control wave, utilizing both control-wave components at each station to obtain a wave having a frequency-order the inverse of that if the signals to be transmitted, and modulating the carrier wave sent from the respective station in accordance with the inverted wave produced at that station.

10. The method of secret telephony between two separated stations comprising transmitting from each station a carrier wave modulated by a different frequency control wave, utilizing both control-wave

components at each station to obtain a wave having a frequency-order the inverse of that of the speech signals to be transmitted, modulating the carrier wave sent from the respective station in accordance with the inverted wave produced at that station, and utilizing both control-wave components at each station to re-invert the received inverted-frequency wave to produce a wave of speech frequencies.

11. In a secret signaling system, means to produce a signaling wave having a cyclically varying frequency, means to modulate a carrier wave by the signaling wave of varying frequency, means at a receiver to detect the modulated carrier wave to yield a varying-frequency signaling wave, means to produce another varying frequency wave, means to modulate said other varying frequency wave by the detected varying-frequency signaling wave to yield the normal signal wave, and means for synchronizing the frequency variation in the signaling wave with those of the wave that is modulated at the receiver.

12. In a secret signaling system, two separated stations, means to provide at each station a wave of varying frequency, means to modulate the wave of varying frequency at one station in accordance with signaling waves to be transmitted, means to modulate a carrier wave in accordance with the modulated wave of varying frequency, means at the other station to detect the modulated carrier wave to yield the modulated varying-frequency wave, means to combine the detected wave with the varying frequency wave at said other station to yield the normal signal, and means to synchronize the waves provided at the two stations and the frequency variations in said waves.

13. In a secret telephone system, means to produce a wave of speech frequencies, means to produce therefrom a wave of cyclically-varying frequency having a frequency-order the inverse of said wave of speech frequencies, means to produce a carrier wave, means to modulate said carrier wave by said cyclically-varying frequency wave, means to receive and detect the modulated carrier wave, a source of waves of varying frequency, means to combine the detected wave with the waves of varying frequency to reproduce the speech, and means to control the frequency and the frequency variations of said source of waves to make the reproduced speech continuously intelligible.

14. In a signaling system, two stations, local sources of waves at each station, the waves produced from a local source at one station being of different characteristic from those of the other station, and means at each station controlled by the local waves produced at the other station for transmitting a signal to the other station.

15. In a telephone system, two stations,

local sources of waves of respectively different characteristics at each of the respective stations for controlling the transmission of speech waves to the other station, at least
5 one of said sources producing waves of periodically varying frequency, the wave produced by one of the local sources at one station differing in characteristic from the waves produced by the local sources at the
10 other station, and means at each station controlled by the wave produced at the other station differing in characteristic from the waves produced at the first station for receiving speech.

16. In a signaling system, two stations, local sources of waves of respectively different frequency at the respective stations, at least one of said sources producing waves of periodically varying frequency, means for utilizing said local sources to produce side band waves of periodically varying frequency representing signals, and means comprising a source of carrier waves of constant frequency for transmitting said side band waves between said stations.

In witness whereof, I hereunto subscribe my name this 28th day of June A. D., 1923.
JOHN F. FARRINGTON.