

Feb. 23, 1926.

1,573,924

H. FLETCHER

SECRET SIGNALING

Filed July 31, 1923

3 Sheets-Sheet 1

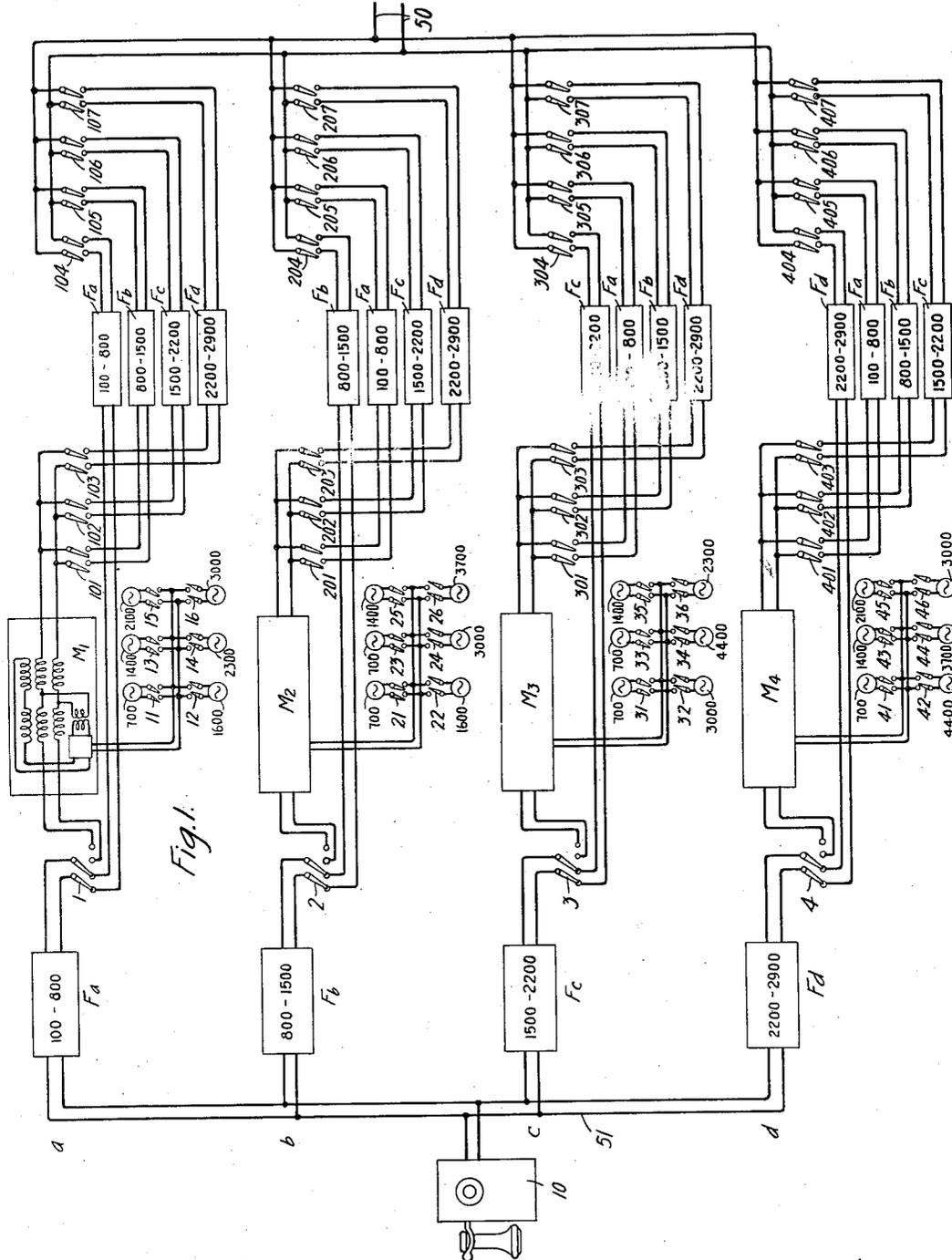


Fig. 1.

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Fig. 2.

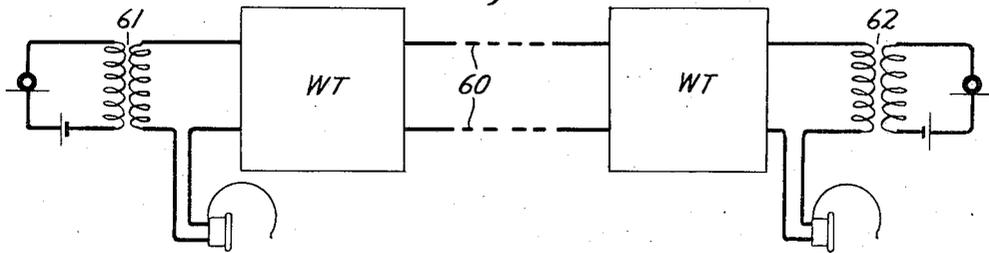


Fig. 3.

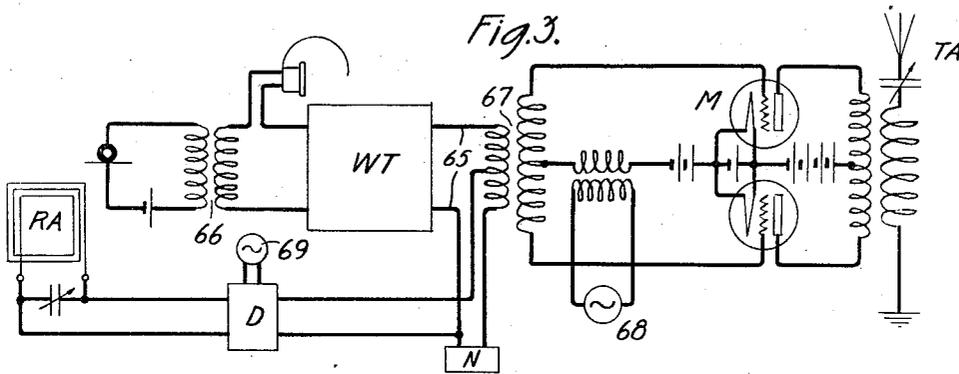
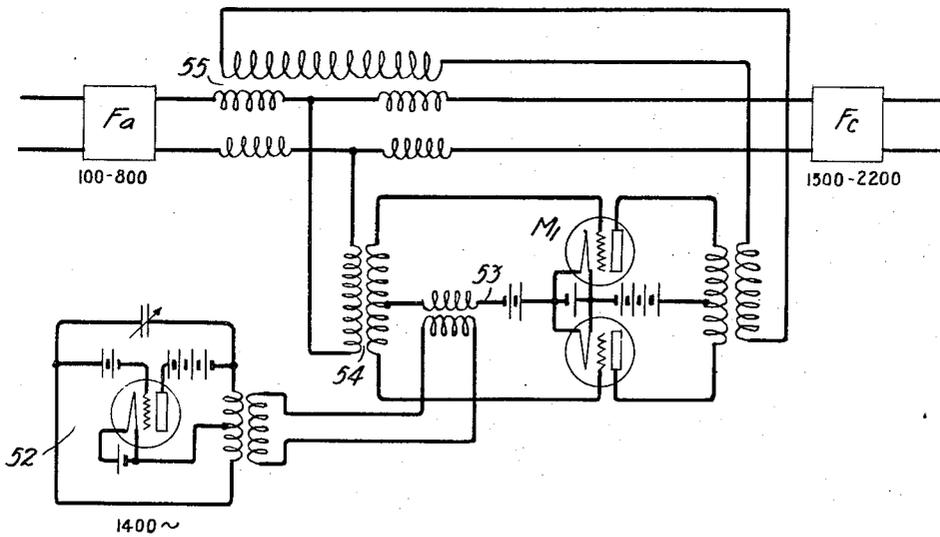


Fig. 4.



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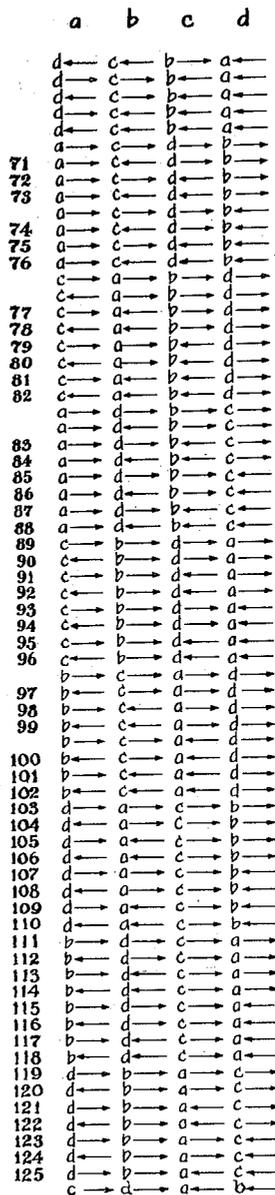
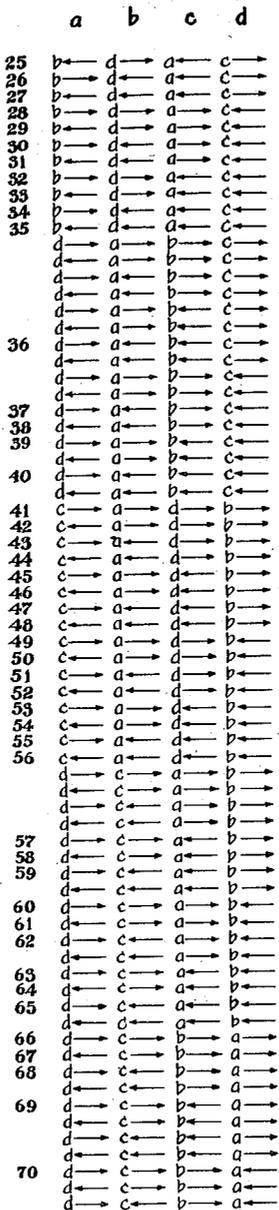
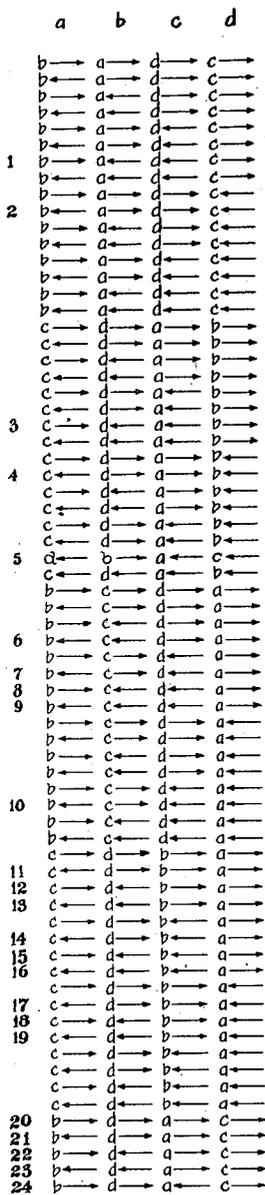
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Fig. 5.



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UNITED STATES PATENT OFFICE.

HARVEY FLETCHER, OF NEW YORK, N. Y., ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

SECRET SIGNALING.

Application filed July 31, 1923, Serial No. 654,803.

To all whom it may concern:

Be it known that I, HARVEY FLETCHER, a citizen of the United States of America, residing at New York city, in the county of New York and State of New York, have invented certain new and useful Improvements in Secret Signaling, of which the following is a full, clear, concise, and exact description.

The present invention relates to wave transmission and reception; and more particularly has to do with the securing of secrecy in the transmission of waves for any purpose such as signaling.

It has been proposed to secure secrecy of wave transmission by sub-dividing the waves, such as speech waves, for example, into sub-bands of relatively narrow frequency ranges and displacing the individual bands or inverting the frequency order within the individual sub-bands or otherwise operating on the sub-bands to render very difficult the restoration of the transmitted waves to their original form. Such systems rely for secrecy on the fact that it is impossible to restore the waves to their original form by means of the ordinary types of receivers even if the secrecy scheme be known. Special apparatus, such as wave filters, designed to have the proper frequency transmission characteristics together with wave combining circuits, are generally required. If the scheme of transforming the waves to their unrecognizable condition were known and if this same scheme were invariably used, it is conceivable that an unauthorized person of sufficient patience and resourcefulness might in time be able to construct a receiver that would produce the waves in intelligible form.

It is an object of the present invention to increase the secrecy in wave transmission of the type referred to by changing from time to time the scheme of transformation of the wave to be secretly transmitted.

It is a further object of the invention to provide a large number of highly secret schemes of transformation and to facilitate shifting from one scheme to a different scheme of transformation.

It is a further object of the invention to facilitate and simplify two-way transmission with secrecy.

The invention comprises a number of characteristic novel features which will ap-

pear hereinafter in the description and claims.

Briefly and specifically described, the invention may take the form of a wire or wireless transmission system in which the waves to be transmitted are first sub-divided by filters into sub-bands of frequency components, after which the sub-bands may be variously treated preparatory to transmission. For example, in a system in which the waves are divided into four sub-bands, four modulating or wave-combining circuits are provided together with appropriate wave sources and filters for obtaining any desired one of a large number of waves possessing a high degree of secrecy, 125 such highly secret combinations being provided by the invention. By simply throwing certain switches, a change may readily be made from one secrecy combination to another. This arrangement makes it practically an impossible task for an unauthorized person to decipher the message being sent, since the order of variation from one secrecy combination to another may be varied to almost an infinite degree.

A more detailed description of the invention will now be given in connection with the accompanying drawings, in which Fig. 1 is a schematic showing of the arrangement of the various elements of a wave transforming system capable of use both in transmitting and in receiving with secrecy; Fig. 2 shows a two-way two-station system employing the arrangement of Fig. 1; Fig. 3 shows a two-way radio terminal employing the wave transforming arrangement of Fig. 1; Fig. 4 shows details of the modulating or wave combining circuit, and Fig. 5 is a table showing in symbolic form the secrecy combinations according to the invention.

In Fig. 1 there is shown a wave transforming circuit leading on the left to the telephone instrument 10 and terminating on the right in the leads 50, which may be connected to any desired type of transmission system as will be explained hereinafter. This wave transforming circuit may serve both for detecting waves originating in the telephone 10 and for incoming waves to be received at 10, on the assumption that the leads 50 are connected to a two-way system.

The speech currents originating in the telephone 10 pass into the leads 51 to which are connected the sub-dividing or analyzing

filters F_a , F_b , F_c and F_d which are designed to transmit the respective frequency ranges 100 to 800, 800 to 1500, 1500 to 2200 and 2200 to 2900 cycles, respectively, on the assumption that the total range of 100 to 2900 cycles is to be transmitted. Any other desired range of frequency components may be transmitted and received and any desired number of sub-dividing filters may be used. It will be obvious to proportion the transmission ranges of the respective filters in accordance with the number of filters and the total frequency range covered.

Four wave combining or modulating circuits designated M_1 , M_2 , M_3 and M_4 are associated with the respective analyzing filters. These wave combining or modulating circuits are for the purpose of shifting the sub-bands transmitted through the respective analyzing filters so that they will occupy a different range in the outgoing wave. This will be described more fully hereinafter.

Associated with each of the modulating circuits M_1 to M_4 is a group of filters F_a , F_b , F_c and F_d adapted to be connected by the switches shown between the respective modulator and the outgoing or two-way circuit 50.

Associated with each modulating circuit are a number of wave sources for supplying to the modulating circuits the waves of the proper frequencies for introducing the required frequency shift in the sub-bands.

Each of the filters above referred to, as well as those shown throughout the system, may be constructed in accordance with the disclosure in the patent to Campbell, No. 1,227,113, May 22, 1917. The wave sources associated with the modulating circuits may be oscillation generators of the type shown in the patent to Hartley, No. 1,356,763, October 26, 1920. The modulating circuits may all be constructed alike and are preferably of the type shown more in detail in Fig. 4.

Referring, for a moment, to Fig. 4, the modulating circuit M_1 is shown as of the balanced tube type disclosed, for example, in the patent to Carson, No. 1,343,306, June 15, 1920. The oscillator 52 is connected to the common branch 53 of the input circuit of the modulator and the individual circuits are connected by means of the transformer 54 to the midpoint of the hybrid coil 55. The output side of the modulator is connected to the series winding of the coil 55.

Assuming the frequency of oscillator 52 to be 1400 cycles, a wave transmitted through the filter F_a is applied to the input circuit of the modulator M_1 along with the 1400 cycle wave and the modulator acts in the well known manner to produce an upper side band of 1500 to 2200 cycles and a lower side band of 600 to 1300 cycles. These side bands are applied from the output of the modulator to the series winding of the repeating

coil 55. It will be seen that the upper side band only comprising frequencies of 1500 to 2200 cycles will be transmitted from the filter F_c to the outgoing circuit. It is a well known property of the balanced tube modulator that it balances out and suppresses the unmodulated carrier component so that none of the 1400 cycle wave from the oscillator 52 is impressed on the transmission circuit. However, in case some of the unmodulated carrier component is present in the output due to slight unbalance, it is suppressed by the filter F_c . Waves received through the filter F_c and having frequencies of 1500 to 2200 cycles are impressed on the input circuit of the modulator M_1 where they combine with the 1400 cycle wave to give an upper side band having frequencies extending from 2900 to 3600 cycles and a lower side band having frequencies extending from 100 to 800 cycles. These side bands are transmitted through the repeating coil 55 and only the lower side band is transmitted through the filter F_a to the circuit lying to the left in the figure. The modulating circuit serves, therefore, for transmission in both directions.

Returning now to Fig. 1, it will be seen that if switch 1 is thrown to the right, switch 13 closed, and switches 102 and 106 are closed, a circuit condition exists between the uppermost filters F_a and F_c similar to that just described in connection with Fig. 4. If switch 1 is left thrown to the right and other of the switches 101 to 107 are closed in pairs in an appropriate manner and also if the appropriate switches 11 to 16 are closed, the sub-band transmitted through the filter F_a may be shifted in frequency so as to be sent out through any one of the filters F_b , F_c and F_d connected to the modulator M_1 . The frequency order of the sub-band may also be either normal or inverted. That is, the 100 to 800 cycle sub-band may be stepped up as a whole in the frequency range in such a manner that a constant frequency is added to each of the frequency components, or, if desired, the 100 cycle component may be shifted so as to occupy the highest frequency position of the resultant sub-band and the 800 cycle component, the lowest frequency position. If the band transmitted through the filter F_a is, for example, to be inverted and stepped up in frequency so as to pass through the outgoing filter F_c , the 800 cycle component of the incoming sub-band will be shifted upward in frequency 700 cycles and the incoming 100 cycle component will be shifted upward in frequency 2100 cycles. This is accomplished by modulating a 2300 cycle wave by the incoming sub-band and selecting the lower side band of the resultant modulated wave. Similar frequency transformation may be made in each of the other

sub-bands by means of the modulators M_2 , M_3 and M_4 and the associated wave sources and filters.

Referring now to Fig. 5, the four sub-bands derived by the respective filters F_a to F_d of Fig. 1, are designated, for convenience, by the letters, a , b , c and d respectively. The heavy letters at the top of the column indicate the normal frequency position of the sub-bands in the wave that is to be analyzed. The letters with the accompanying arrow indicate in each horizontal row of the column a different combination which is obtainable by merely shifting the switches that are shown in Fig. 1. An arrow following a letter and pointing to the right indicates that the particular sub-band has a normal frequency order and a letter followed by an arrow pointing to the left means that the corresponding sub-band has an inverted frequency order. For example in the uppermost row of the left-hand column of Fig. 5, the "b" sub-band is stepped down in frequency so that it occupies the normal "a" sub-band position and the "a" sub-band is stepped upward in frequency so that it occupies the normal "b" sub-band position. Also, the "c" and "d" sub-bands are interchanged in position, all of the frequency orders being left normal in each of the sub-bands. In the second horizontal row of the left-hand column, the same frequency shifts are made as in the case of the first row but in addition the "b" sub-band is inverted in frequency.

To obtain an output wave having the combination indicated in the first horizontal row of Fig. 5, the switches 1, 2, 3 and 4 of Fig. 1 will all be thrown to the right. Since the "a" band is to be stepped up 700 cycles in frequency, switches 11, 101 and 105 will be closed. Since the "b" band is to be stepped down in frequency one position, switches 21, 201 and 205 are closed. Similarly, since the "c" band is stepped upward one band-width, switches 31, 303 and 307 are closed, and in order to step the "d" band downward, switches 41, 403 and 407 are closed.

To obtain an output wave having the combination represented in the second row of Fig. 5, the only change that is necessary from the set-up described for the first combination is that switch 22 instead of switch 21 is closed. The effect of this is to modulate 1600 cycles by the "b" band producing a lower side band extending from 100 to 800 cycles, the 800 cycle component being produced by subtracting the highest component, that is, 1500 cycles of the "b" band from the modulating frequency so that the frequency order of the resultant sub-band is inverted.

It is to be noted that if the sub-band F_a

is to be stepped upward in frequency to occupy the next higher range with a normal frequency order, switch 11 is closed. If it is to be stepped up to the second higher sub-band, switch 13 is closed, and, if it is to be stepped up to the third higher sub-band position, switch 15 is closed. If the "a" band is to be stepped up to the next higher sub-band and inverted the switch 12 is closed. Similarly, if it is to be stepped up two positions and inverted, switch 14 is closed, and if it is to be stepped three steps and inverted, switch 16 is closed.

If the "b" band is to be stepped downward one position, switch 21 is closed. If it is to be stepped upward one position, switch 23 is closed and if it is to be stepped upward two positions, switch 25 is closed. If it is to be similarly shifted and also inverted, the corresponding switch 22, 24 or 26 is closed. If this arrangement is observed throughout the connections it is seen to be a very simple matter to change from one combination to any other desired combination.

It will be noted also, that the switches for connecting the filters between the modulators and the leads 50 are placed in horizontal and vertical rows, with four switches on each side of the filters. It will be convenient in practice to arrange these switches in some suitably manner so that, for example, by referring to a table such as that shown in Fig. 5, a corresponding switch closure will appear from the labelling. After switch 103 is closed, it will be necessary to throw switch 4 to the right. It will also be obvious that only a single pair of switches in any horizontal level are to be closed and furthermore, that at least one pair of switches in each vertical level must be closed. This inter-relation between the various switches may readily be taken advantage of in a practical system to facilitate the setting up of a combination which will produce an outgoing wave in the leads 50 having the total frequency range of 100 to 2900 cycles and having an arrangement indicated by one of the horizontal rows of Fig. 5.

As stated above, the wave transforming circuit serves both for transmitting and receiving. For example, waves incoming on the line 50 will be divided into their respective sub-bands by the filters that are connected in circuit at the time between the leads 50 and the modulators M_1 to M_4 . These sub-bands will be impressed on the respective modulators in the manner described in connection with Fig. 4 and will be combined with the appropriate waves from the sources 11 to 16, and 21 to 26, etc., so as to produce and transmit through the filters F_a to F_d to the telephone 10, a wave representing intelligible speech. The cir-

cuit 50, therefore, carries only waves which occupy the speech range but which do not represent normal speech.

If an unauthorized person attempts to intercept the message being transmitted over the leads 50 to any point in the system, he will find any one of the combination represented in Fig. 5 unintelligible. However, by using a heterodyne method of reception and filtering arrangements to suppress portions of the wave, he would, with some difficulty, be able to receive at least portions of the message in the case of some of the combinations indicated in Fig. 5. For example, in the case of the first combination indicated in this figure, if the observer should set a heterodyne oscillator frequency so as to receive the "a" sub-band correctly, he would also receive the "c" sub-band correctly. Of course, the "c" sub-band would have superposed on it the "b" sub-band which would be inverted, and there would be included between the normally received "a" and "c" sub-bands the "d" sub-band as noise. Since it is conceivable that the reception of the two sub-bands "a" and "c" in their normal position might possibly permit the chance understanding of some slight portions of the message being transmitted, this combination is not counted as one of the most highly secret combinations. In a similar manner, in the case of the second combination indicated in this figure, the "a" and "c" sub-bands could be received normal by the heterodyne method, and in the third combination, the "b" and "d" sub-bands could be similarly received. It will be seen by inspection that each of the combinations numbered 1 to 125, however, is incapable of yielding more than a single one of the sub-bands in its normal form for any one heterodyning frequency and these combinations are, therefore, highly secret. As pointed out above, even in the case of those combinations which yield two sub-bands normally, the presence of the other sub-bands as noise will greatly reduce the chances of understanding the message, so that all of the combinations are secret to a very considerable degree.

Figs. 2 and 3 show applications of the invention to an ordinary telephone line and to a radio system respectively. The rectangles WT indicate that the wave transforming system of Fig. 1 connected between the leads 50 and the telephone 10 is to be inserted at this point of the circuit. The telephone line 60 terminates at each of the two stations shown, in a wave transforming circuit and in the subscribers' sets 61 and 62, respectively. Conversations in both directions may be carried on between these subscribers' stations with secrecy since any one listening on the line 60 will receive only unintelligible waves.

In Fig. 3, a transmitting antenna TA and a receiving antenna RA are connected through radio transmitting and receiving apparatus to the telephone line 65 which has included between it and the subscriber's set 66; a wave transforming circuit WT. The usual two-way connection including a balancing network N for the telephone line and the conjugate transformer 67 is employed. The waves originating in the subscriber's set 66 and transformed into a secrecy combination, are transmitted through the repeating coil 67 to the input of the modulator M which is supplied also by radio frequency waves from the source 68. Due to the balanced type modulator, the unmodulated carrier component is suppressed and only the two side bands of the unmodulated wave are impressed by the antenna TA. This antenna is preferably tuned to transmit only one side band of the modulated wave in order to economize in the transmitted energy. The receiving antenna RA is connected to a detector D of any suitable type supplied by a wave of the carrier frequency from the source 69 and the detected waves are applied from the detector to the bridged circuit of the conjugate repeating coil. These waves pass over the line 65 through the wave transforming device where they are rendered intelligible and are impressed on the subscriber's set 66.

What is claimed is:

1. In a secret signaling system, a circuit carrying signal waves, a plurality of filters connected to said circuit for selectively transmitting respectively different frequency components of the signal, wave combining circuits associated with said filters, a transmission circuit, and a plurality of groups of filters between said wave combining circuits and said transmission circuit, the filters of each group being respectively similar to the filters connected to the circuit carrying the signal waves, and means for variably connecting the individual filters of said groups between the respective wave combining circuits and the transmission circuit.

2. In a secret signaling system, an incoming circuit, an outgoing circuit, filters connected to said incoming circuit for selectively transmitting different bands of frequency components from the incoming wave, a plurality of sources of waves of different frequencies, wave combining circuits adapted to be associated with said filters and with said sources for combining said waves and said bands, other filters between said wave combining circuits and said outgoing circuit for separating the combined waves into bands of frequency components, and switching means for selecting and associating with said outgoing circuit various combinations of the first mentioned filters, said wave

combining circuits and said other filters, to produce different desired combinations of frequency bands to make up the waves transmitted into the outgoing circuit.

3. In a secret signaling system, an incoming circuit, an outgoing circuit, filters for selecting bands of frequency components from waves in the incoming circuit, means to shift the frequencies of the bands to cause each shifted band to occupy the frequency range occupied by a different band of components of the incoming wave, switching means for changing the scheme of shifting of the several bands, and means to impress the shifted bands on the outgoing circuit.

4. In a secret signaling system, an incoming circuit, an outgoing circuit, filters for selecting bands of frequency components from waves in the incoming circuit, means to shift the frequencies of the bands to cause each shifted band to occupy the frequency range occupied by a different band of components of the incoming wave and to invert the frequency order of the components within certain of the shifted bands, switching means for changing the scheme of shifting and inverting of the several bands, and means to impress the shifted bands on the outgoing circuit.

5. In a signaling system, a two-way transmission circuit, means to impress waves having a band of frequency components upon said circuit, means interposed in said circuit for sub-dividing the waves being transmitted in either direction over said circuit into a plurality of sub-bands of frequency components, means for interchanging the positions of the sub-bands in respect to the frequency ranges which they occupy, and means to impress the shifted sub-bands on said circuit.

6. In a signaling system, a circuit for carrying signaling waves having a band of frequencies, four filters in said circuit for analyzing the waves into four different sub-bands of frequency components, a plurality of sources of waves of different frequencies, wave combining circuits, and means comprising a plurality of switches for selecting and associating said filters, said sources and said wave combining circuits in various

combinations so as to interchange the frequency position of said sub-bands and to invert the frequency order of the components within the individual sub-bands in the combined waves, thereby producing any desired one of two hundred and eight compositions in the resultant waves.

7. In combination, a modulator, means to impress a band of frequency components upon said modulator, a band filter connected to the output side of said modulator, a pair of wave sources of respectively different frequency associated with said modulator, and means to connect either wave source to said modulator at will, the frequency of one wave source being such that the upper side band of the modulated wave resulting from modulating the wave by said band of components passes through said filter to the exclusion of the lower side band, and the frequency of the other wave source being such that the lower side band resulting from modulating the wave by said band of components passes through the filter to the exclusion of the upper side band, the first mentioned upper side band and the last mentioned lower side band having the same frequency range, said frequency range being the transmission range of said filter.

8. The method of secretly transmitting waves having a band of frequency components normally occurring in a characteristic order, comprising shifting from time to time the components in said band to a different abnormal frequency order and transmitting the waves of shifted frequency orders.

9. In a secret telephone system, a circuit carrying speech waves having a band of frequencies, means to alter the frequency order of the various frequency components within the limits of the speech band in accordance with any one of a plurality of schemes to produce in each case a resultant unintelligible wave occupying substantially the normal speech frequency range, and switching means to shift from one scheme of alteration to another at will.

In witness whereof, I hereunto subscribe my name this 11 day of July A. D., 1923.

HARVEY FLETCHER.