

Nov. 7, 1939.

C. C. TAYLOR ET AL
SECREC Y SIGNALING SYSTEM

2,179,106

Filed Aug. 11, 1937

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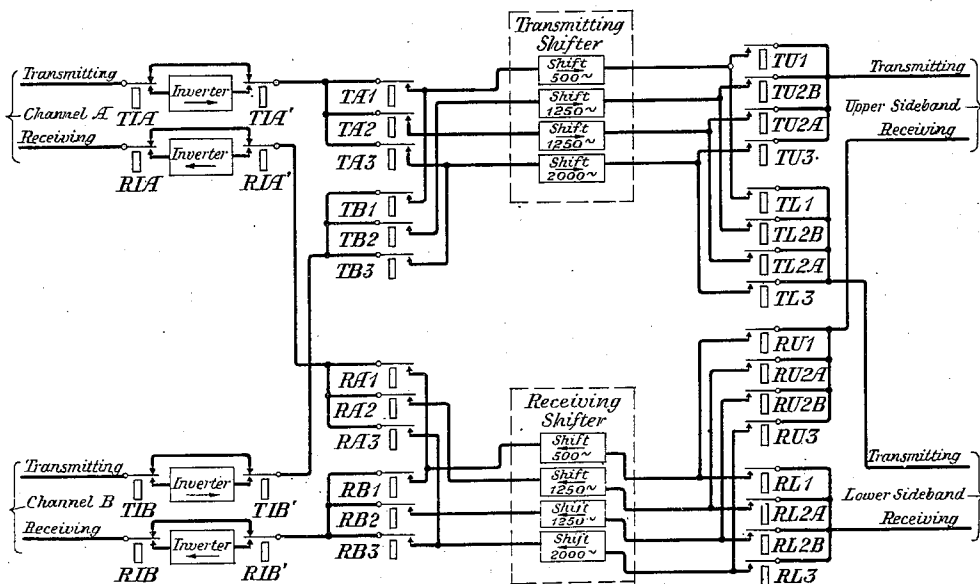
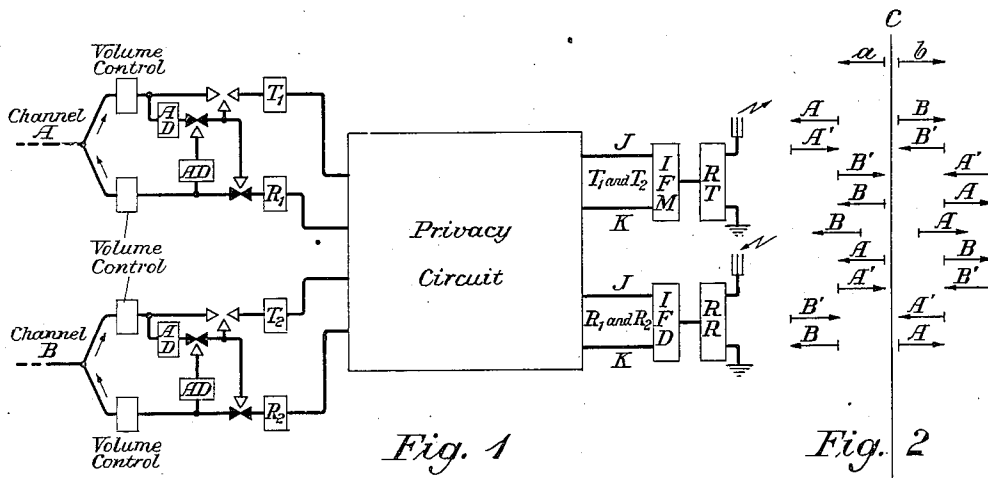


Fig. 3

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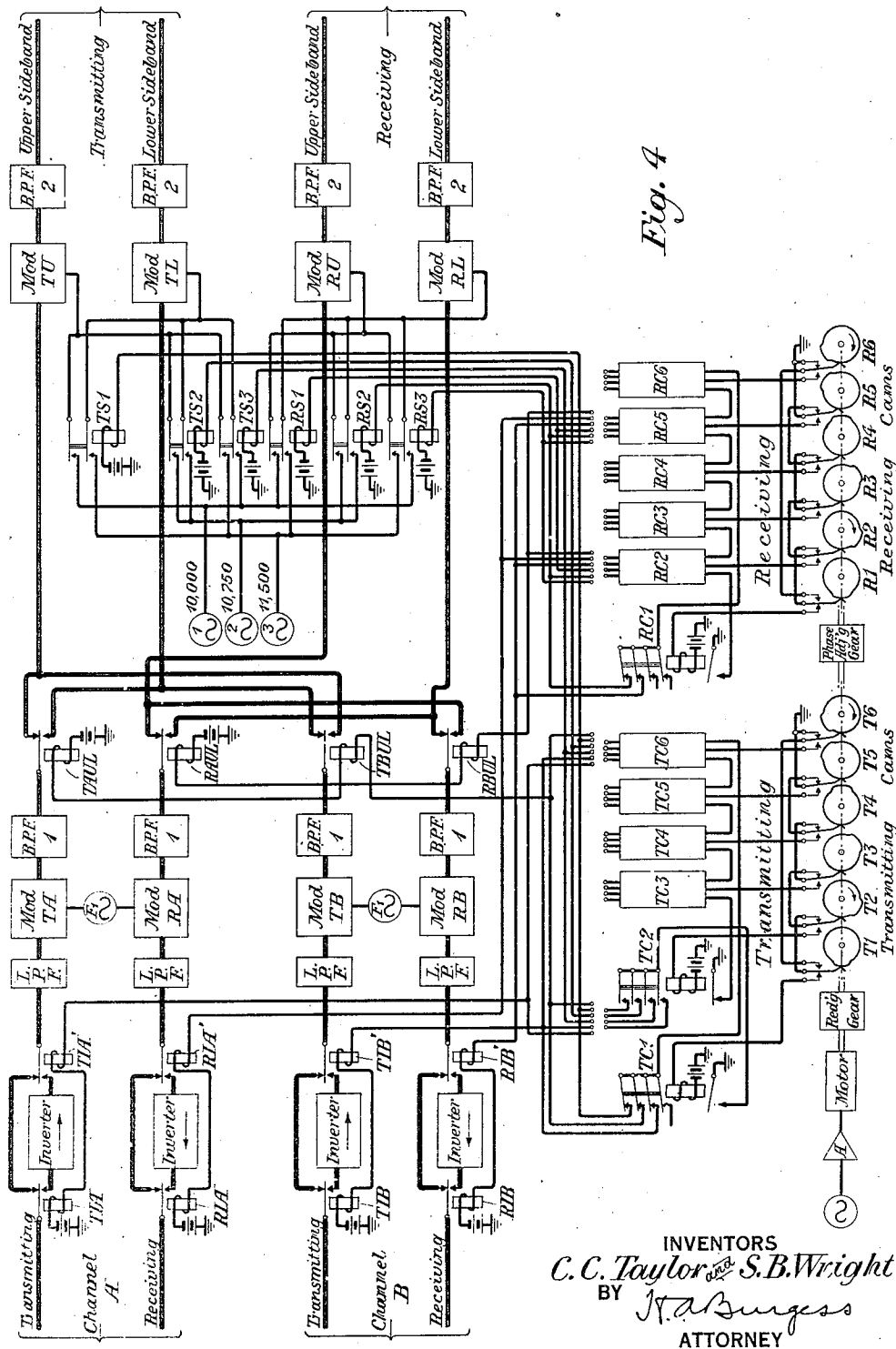
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SECURITY SIGNALING SYSTEM

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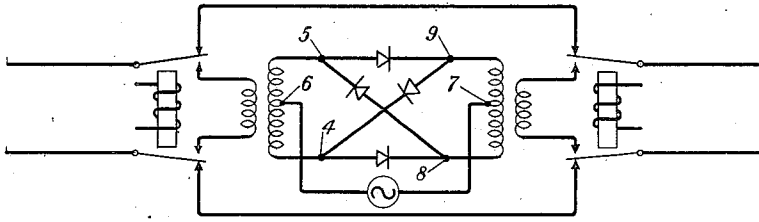


Fig. 5

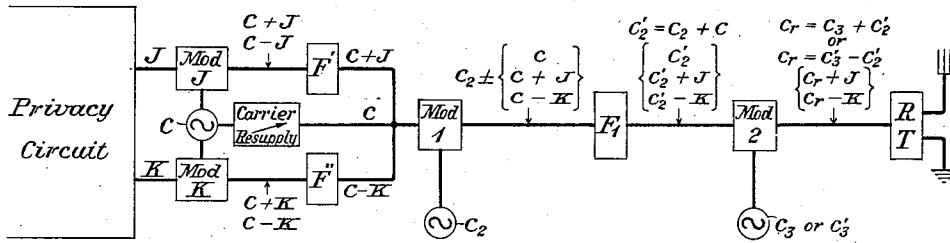


Fig. 6

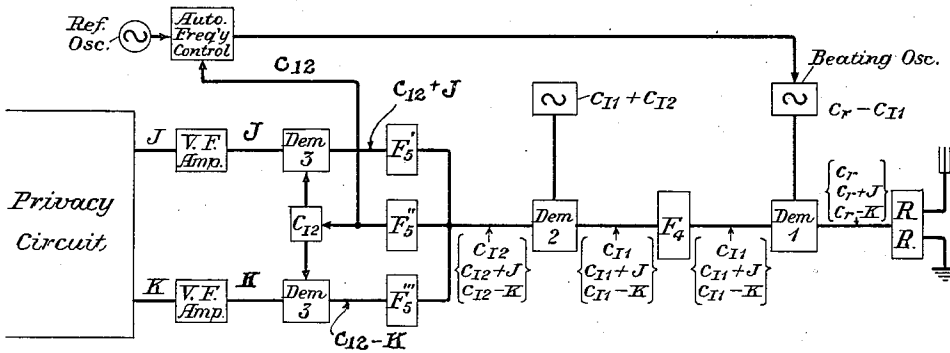


Fig. 7

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2,179,196

SECURITY SIGNALING SYSTEM

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Application August 11, 1937, Serial No. 158,464

12 Claims. (Cl. 179—15)

This invention relates to transmission systems and more particularly to the method and means for providing secrecy in the transmission of messages over such systems.

5 Various arrangements have been already proposed for such purposes as disclosed, for instance, in patent to Chesnut et al. No. 1,829,783 of November 3, 1931. In that patent the speech or signal waves are divided on a frequency basis into subbands which are transposed among themselves or which have their frequency orders inverted prior to transmission, or both. In order to receive and understand the signals thus transmitted, it is necessary at the receiving point to retranspose the subbands to their original positions. In case any of the subbands have had their frequency order inverted, it is necessary to reinvert the frequencies to their original order. While a fairly high order of privacy is obtainable by such systems, there is ordinarily some impairment of the quality of the received message resulting from the use of the band-splitting devices, particularly during unfavorable transmission conditions.

25 It has been proposed and has become the practice in certain radio transmission systems to transmit the carrier and one side-band only. In some instances the carrier itself has been largely reduced or eliminated. It has also been shown that one may transmit two independent messages on a single carrier, spoken of as "twin-channel" radio circuits. In the "twin-channel" arrangement two separate single side-band speech channels, each relating to a separate independent message, are transmitted through the same radio transmitter and radiated with a small amount of carrier. They are received by a single side-band receiver which uses the radiated carrier for synchronization and demodulation purposes. Privacy, by dividing into sub-bands, has been applied in some cases.

The present invention relates to a method and means applicable to the "twin-channel" signaling system in which privacy or secrecy is obtained by so manipulating the two side-bands as to render their intelligibility extremely difficult, if not impossible, for unauthorized reception, all in a manner which does not necessarily include band splitting. More specifically it provides means by which the bands may be interchanged so that the message which at one time constitutes the upper side-band may be transposed to the lower side-band, with a simultaneous transposition of the other message. It also provides means by which either or both of the message side-bands may be inverted, quite independently of each other. It further provides means by which the side-bands are shifted to and away from the carrier frequency.

60 In this invention we avoid certain undesired

characteristics of the subband shifting and operate on the message band as a whole, providing privacy by shifting, inverting and interchanging the channels between the side-bands on a synchronously switched basis. In the specific embodiment of the invention the shifting, the inverting and the interchanging is made under control of driving cams which are independently driven by accurately controlled driving members at the different stations. These separate driving members can be kept in proper step in any suitable manner and may be frequently checked up in order to maintain the proper quality of transmission through the system. One suitable method for the maintenance of proper synchronism between the different stations is disclosed in Chesnut et al. supra.

For two-way operation provision is made for transmitting totally different and unrelated combinations in the two opposite directions. When any combination is set up for transmitting on one of the channels from a given station, there is also set up another combination for receiving purposes. These two transmitting combinations may be unrelated to each other but each is complementary to its respective receiving combination at a distant station with which communication is being carried on. That is, the cam arrangement at the different stations is such that for transmitting from one and receiving at the other station on one channel, complementary combinations are provided; while for transmitting in the opposite direction complementary combinations are also provided but these latter are not in any wise dependent upon the former.

The invention will be better understood by reference to the following specification and the accompanying drawings in which:

Fig. 1 is a highly simplified diagrammatic scheme of our circuit arrangement;

Fig. 2 shows a typical scheme of cyclical changes to give the desired privacy;

Fig. 3 shows the arrangement of the privacy portion of the circuit in somewhat further detail;

Fig. 4 is an extension of Fig. 3 showing still greater detail;

Fig. 5 is a circuit diagram of certain parts of the circuit arrangement; and

Figs. 6 and 7 give details of the radio transmitting and receiving terminals.

Referring more particularly to Fig. 1, there are shown two channels A and B, each channel comprising a transmitting and a receiving circuit adapted for two-way transmission. The incoming message may be on a two-wire circuit in which case it is impressed by means of the standard hybrid coil on a four-wire terminal and at this terminal there may be included various volume control devices, anti-singing devices and supplemental attachments of a kind now well

known in the art as illustrated in patent to Taylor et al. 2,072,227 of March 2, 1937. Two speech messages from the two channels are then identified as being present at T_1 and T_2 and are ultimately used at the radio station for producing in the intermediate frequency modulator IFM the two side-bands of a radio signal which is transmitted from a radio transmitter RT. The speech messages received at R_1 and R_2 are the ultimate products of the modulated wave received at the radio receiver RR. In the path of these messages, however, there is introduced a privacy circuit, the function of which is to condition the messages from T_1 and T_2 so that they may be used for modulating a carrier wave but so that they embody such shifting, inverting and interchanging as is desired. This privacy circuit also has the function of receiving from the station RR the side-bands which have been shifted or inverted or interchanged and so operates on them or reconditions them that they proceed to their respective points R_1 and R_2 in the normal message form.

The specific arrangement at the four-wire circuits shown on the left hand of Fig. 1 and the radio equipment shown on the right hand do not constitute a part of our invention, but the novelty resides in the privacy circuit, as set forth hereinafter. Nevertheless the manner in which IFM may operate at the transmission output of the privacy circuit is described in further detail in connection with Fig. 6 and the manner in which the radio message received at RR may be operated upon before reaching the privacy circuit is described in connection with Fig. 7.

The invention will be better understood by reference to Fig. 2 in which one typical order of introducing changes for the purpose of privacy is represented. In that figure the carrier frequency is represented by the vertical line C. The two sidebands representing the separate messages modulated to this carrier C would normally occupy frequency regions represented by *a* and *b*. It is our purpose to change this arrangement in a manner which will bring about the desired privacy. For normal modulation the side-band above the frequency C consists of frequencies running in the same order as in the original message but in the lower side-band the frequencies are in the reverse order of that in the original message. This is indicated by the position of the arrow heads in the bands *a* and *b*. In case one of these bands is inverted, this will be indicated by priming the representatives of the channel, which channels will be represented A and B.

In Fig. 2 channel A is shown in the position it occupies from moment to moment, from top to bottom, (1) shifted 3,000 cycles in the lower side-band, (2) shifted 3,000 cycles in the lower side-band and inverted, (3) shifted 3,000 cycles in the upper side-band and inverted, (4) shifted 3,000 cycles in the upper side-band, (5) shifted 1,500 cycles in the upper side-band (6) normal in the lower side-band, (7) inverted in the lower side-band, (8) inverted in the upper side-band, and, (9) normal in the upper side-band. Similarly channel B is shown in synchronous positions, (1) normal in the upper side-band, (2) inverted in the upper side-band, (3) inverted in the lower side-band, (4) normal in the lower side-band, (5) shifted 1,500 cycles in the lower side-band, (6) shifted 3,000 cycles in the upper side-band, (7) shifted 3,000 cycles in the upper side-band and inverted, (8) shifted 3,000 cycles in the lower side-band and inverted, (9) shifted 3,000 cycles

in the lower side-band. This sequence is shown merely for example and is not intended to indicate the sole or even the best cyclical order for privacy. The length of time that the bands occupy a given position or arrangement is subject to wide latitude but might well be of the order of twenty seconds.

In order to give a better understanding of the manner in which such cyclical changes are carried on, reference may be had to Fig. 3. This figure is confined to the portion of Fig. 1 which is identified as the privacy circuit. Numerous relays are shown but the manner of connection and operation of these will not be discussed at the moment. Here, for the purpose of an illustration which differs from the one given above, the voice band in each channel is shifted one of three amounts from the normal; either (1) 500 cycles, (2) 1,250 cycles or (3) 2,000 cycles. This circuit will also be explained on the basis that when the voice in one band is shifted 500 cycles, that in the other is shifted 2,000 cycles; when the voice in one side-band is shifted 1,250 cycles, that in the other is shifted in a like amount. Inversion may be applied when desired and the channels A and B may be interchanged between the side-bands.

To permit the desired operations inverters are provided in each transmitting and receiving path and arranged to be cut in and out individually by relays. A transmitting shifter and a receiving shifter common to the two side-bands or channels shift the bands as required. Relays under control of a synchronized switching circuit to be described hereinafter operate to give the desired combination of degree of shift, normal or inverted, and interchange between side-bands. The shifting is independent in the two directions permitting different shifts transmitting and receiving if desired. Likewise, the inverter apparatus is four wire so that in the two directions and on the two channels the use of inversion may be selected for each path without regard to the others if additional privacy is thus secured. Also transmitting and receiving paths on the channels may be on different side-bands if desired.

The operation may be explained by examples. Any combination desired may be traced through the relays if the following designation code is kept in mind:

T—Transmitting R—Receiving
A & B—Channels
U & L—Upper and lower side-bands
1, 2, 3—Degree of shift 500, 1,250 and 2,000 cycles respectively
I—Inverter

As a first example consider that channel A, transmitting and receiving, is inverted, shifted 500 cycles and transmitted on the upper side-band. At the same time channel B, transmitting and receiving, is normal, shifted 2,000 cycles and transmitted on the lower side-band. The cams and combination relays in the synchronized switching circuit will then cause the following relays to be operated: Transmitting channel A—TIA, TIA', TA1 and TU1; receiving channel A—RU1, RA1, RIA' and RIA. Transmitting channel B—TB3 and TL3; receiving channel B—RL3 and RB3.

The second example shows the 1,250 cycle shift. Channels A and B are both transmitted, inverted and shifted 1,250 cycles, channel A on the lower side-band and channel B on the upper. The operated relays are then: Transmitting channel A—TIA, TIA', TA2 and TL2A; receiv-

ing channel A—RL2A, RA2, RIA' and RIA. Transmitting channel B—TIB, TIB', TB2 and TU2B; receiving channel B—RU2B, RB2, RIB' and RIB.

While these two combinations have been described, it is to be understood that the various set-ups may follow each other in any desired order, thus giving rise to a large number of combinations in each direction. Furthermore, it will be seen that the same combination need not be used in the two directions at the same time.

In Fig. 3 the inverters and the shifting devices have been shown in schematic form only. Actually the equipment required for one of these changes or shifts may become fairly extensive. As an indication, however, of the form which circuits for this purpose may take, reference may be made to Fig. 5. Here a balanced modulating and demodulating device is shown. This may comprise four rectifiers, such as copper-oxide rectifiers. Message frequency is supplied to two terminals 4 and 5 and carrier frequency to two other terminals 6 and 7. As a result there will appear at the terminals 8 and 9 the various modulation products consisting primarily of the principal two side-bands. If the speech message transmitted covers a band from 250 cycles to, say, 3,000 cycles, and if the carrier frequency supplied is 3,250, then the lower side-band will consist of a band extending from 3,000 to 250 and comprises an inversion of the original message. By suitable filters the upper side-band may be eliminated. Such a circuit arrangement would constitute the essential elements of an inverter. If the carrier frequency supplied has a higher value, then the side-bands will move up in the frequency spectrum with the carrier. Again by suitable filters one of the side-bands may be suppressed, thus permitting one of the side-bands to pass either in normal frequency order or inverted and shifted by a desired amount.

A still more detailed understanding of the invention will be obtained by reference to Fig. 4, which again is limited to the privacy circuit. One follows the transmitting channel A from left to right and notes that the voice waves go through or around the inverter, depending upon the operation or non-operation of relays TIA and TIA', to a low pass filter (0-3,000 cycles). The output of this filter enters a modulator supplied with a carrier which we will assume is 9,500 cycles. The lower side-band of the 250-3,000 cycle voice waves, namely, 9,250-6,500 cycles, is passed by band-pass filter 1. These waves then go to the transmitting upper or lower side-band circuit depending upon the non-operation or operation of relay TAUL. In either case they go through a modulator supplied with one of three carrier frequencies to band-pass filter 2 and to the ratio transmitter. The three carriers shown are 10,000, 10,750 and 11,500. The 10,000 cycle carrier shifts the 9,250-6,500 cycle voice band to 750-3,500 cycles; the 10,750 cycle carrier shifts it to 1,500-4,250 cycles; and the 11,500 cycle carrier shifts it to 2,250-5,000 cycles. Band-pass filter 2, therefore, should pass 750 to 5,000 cycles.

The three carriers are under the control of relays TS1, TS2 and TS3. When TS1 operates, 10,000 cycle carrier is supplied to Mod. T. U. and 11,500 to Mod. T. L. TS3 reverses this condition when it is operated instead of TS1. TS2 puts 10,750 cycles on both Mod. T. U. and Mod. T. L. Therefore when TS1 is operated the voice on the upper side-band is shifted 500 cycles to 750-3,500 cycles while that on the lower is shifted

2,000 cycles to 2,500 to 5,000 cycles. When TS3 is operated the shift is 2,000 cycles on the upper side-band and 500 cycles on the lower. When TS2 is operated the shift is 1,250 cycles on the upper and likewise on the lower side-band.

Transmitting channel B likewise goes through inverter and modulator equipment to relay TBUL which operates in series with TAUL and places channel B always on the side-band not occupied by channel A. As explained above channel B is shifted in synchronism with channel A and the amount of shift depends upon which of the shift relays TS1, TS2 or TS3 is operated.

The operation of the receiving branches is similar except that it is reversed. Received shifted speech enters from the right through B. P. F. 2 and modulators RU or RL. Here a carrier is supplied which is synchronized with the amount of shift which has been introduced at the transmitting end. If the shift is 500 cycles to 750-3,500 cycles the 10,000 cycle carrier is supplied and the output is 9,250-6,500 cycles. This goes through side-band switching relays RAUL or RBUL and B. P. F. 1 to Mod. RA or RB where the 9,500 cycle carrier shifts it to 250-3,000 cycles. Similarly 10,750 cycle carrier or 11,500 cycle carrier is supplied for shifts at the transmitting end of 1,250 cycles and 2,000 cycles, respectively. These carriers are controlled by relays RS1, RS2 and RS3, which are identical in function with TS1, TS2 and TS3, described above.

It is obvious that the transmitting branches and likewise the receiving branches have six switching relays or groups of relays any four of which may be used at once. The inverter relays on channels A and B may be operated or released, the side-band interchange relays may be operated or released and one of the three shifting relays must be operated. To permit selecting desired combinations of these conditions, transmitting and receiving combination relays are used. These are in turn operated by cams which are run at a constant speed by a motor controlled by a stable source of frequency. The transmitting cams are shown driven by the motor through a reduction gear and it will be assumed that the cam makes a complete rotation in two minutes so that each of the six cams will operate its contact for twenty seconds. The receiving cams run at the same speed but are connected through a phase adjusting gear. This not only permits adjustment to care for transmission time over the circuit but may be used to stagger the time of switching in the two directions.

The operation of the combination relays may best be understood by following through relays TC1 and RC1. These are both shown operated by their respective cams T1 and R1. TC1 when operated causes, with its combination contacts, the operation of relays TS1, TBUL and TAUL and TIB and TIB'. It also, with its lower contact, removes ground from the combination contacts of relay TC2 so that TC2 may not cause operation of switching relays until TC1 releases. When the cams have rotated sufficiently T1 will open its contact and T2 close its. T2 in operating removes the ground from the contact on T1 and thereby determines the release of TC1. TC2 is operated when T2 closes contact and the switching occurs when TC1 releases. Similar action occurs as each subsequent cam operates. The same arrangement is used for the receiving cams and combination relays.

It is to be noted that the ground and battery

connections are not shown for those relays indicated in block form, namely, TC3, TC4, TC5, TC6 and likewise RC2, RC3, RC4, RC5, RC6, but only for TC1, TC2, RC1. The circuits of all these relays are the same and the inclusion of all these identical details would unnecessarily complicate the drawing. It is apparent that when relay TC2 is operated its combination contact is connected to ground through cross connection to the lower contact of relay TC1 when relay TC1 has released. Similarly, the combination contacts of relays TC3, TC4, TC5, TC6, TC1 as these relays are operated in turn will get ground connections respectively through cross-connections to the lower contacts of the next preceding relays, namely, TC2, TC3, TC4, TC5, TC6. The cross-connections are indicated in the drawings. Thus in the shown condition the operating circuits of relays TBUL, TAUL, TS1, TIB' and TIB are completed to ground through the lower contact of relay TC6.

The grouping of switching relays desired for each combination may be secured by connecting any four or less of the six switching relays to the combination contacts on the particular combination relay. For example, as stated above, TC1 is connected to relays TS1, TBUL and TAUL and TIB and TIB'. This means that the upper side-band is spread 500 cycles, the lower is spread 2,000 cycles, the channel A is connected to the lower side-band, channel B to the upper; and channel B is inverted. That is the combination for the transmitting channels. At the same time the combination for the receiving channels as determined by relay RC1 is as follows: Relays RIB and RIB' and RS2 are operated. This means that both side-bands are received spread 1,250 cycles; that the upper side-band is channel A and the lower is channel B; and that channel B is inverted. The connections to the other six combination relays will be such that those conditions will be set up which are found to be best for reasons of privacy or transmission.

While in all of the figures the voice path has been shown as a single line, it is to be understood that these are all two-wire circuits. All the relays, then, such as TIA, TAUL, etc., which operate on the voice path, may be relays with two sets of contacts to operate on both wires of the voice paths. This, for instance, is illustrated in Fig. 5 which as already described, shows one form which the circuit for the inverters may take.

While in connection with Fig. 1 reference has already been made to the use of the output of the privacy circuit to modulate a radio frequency, this was done in very brief terms only and it is important to know precisely how the messages are to be prepared for radiation and how they are to be treated upon reception. One detailed circuit for this is shown in Figs. 6 and 7, Fig. 6 showing the transmitting terminal and Fig. 7 showing the receiving terminal.

Referring more particularly to Fig. 6, the two outputs of the privacy circuit for transmission are identified by J and K. It will be recognized from what has been said heretofore that the signal over the channel J for a portion of the time carries the message from channel A and at other times carries the message from channel B, the disposition of the time of the one channel or the other being determined by the switching mechanism as it operates within the privacy circuit. Similarly channel K for a portion of the time is carrying the message from channel A and for a portion of the time, the message from

channel B. From now on it will not be necessary to identify the channels A and B but rather to refer to the mixed signals as channels J and K, these reference letters at the same time indicating the band of frequencies delivered by the privacy circuit, as heretofore described. In the specification and in the claims it is to be understood that the term "message" may refer to a normal voice frequency signal, such as at A and B, or to an abnormal or mixed voice frequency signal as at J and at K.

Connected to the output of the privacy circuit in parallel are two modulators, Mod. J and Mod. K, each supplied with a carrier C. These modulators are of the balanced type so that on the output of Mod. J there appears a band of frequencies $C+J$, and a band $C-J$. Similarly the output of Mod. K consists of the two side-bands $C+K$ and $C-K$. Filters F' and F'' are so designed that the one permits the passage of the band $C+J$ and the other the band $C-K$. These two side-bands plus a controllable and generally reduced amount of carrier C are then impressed upon modulator 1, which has supplied to it also an intermediate frequency C_1 . This modulator is also of the balanced type so that in the output there are present two side-bands, the frequencies of which are as indicated in the diagram. By means of the filter F_1 one of these side-bands, here shown as the lower side-band, is eliminated and the output of F_1 is equivalent to a carrier C_2' with an upper side-band $C_2'+J$ and a lower side-band $C_2'-K$ where $C_2'=C_1+C$. This product is now supplied to a modulator 2 which also has supplied to it a suitable carrier frequency, here identified as C_3 or C_3' , and there appears in the output thereof a side-band containing C_r , C_r+J and C_r-K where $C_r=C_3+C_2'$ or $C_r=C_3'-C_2'$, depending upon the carrier which it is desired to associate with the radiated message. This output may now be amplified for radiation by transmitter amplifier RT. It will be apparent that the carrier C_3 or C_3' must be so selected that the input carrier of RT falls at the assigned radiated frequency, the speech bands J and K being respectively above and below this frequency.

Referring to Fig. 7 there is shown the radio receiving amplifying unit RR. Suitably amplified received signal therefrom is impressed upon demodulator Dem. 1, which has supplied to it also a carrier frequency C_r-C_{11} , where C_{11} is the value of an intermediate frequency to be used as will presently be described. The output of this demodulator will include among other things a carrier frequency C_{11} and the two side-bands $C_{11}+J$ and $C_{11}-K$. A filter F_4 serves to suppress all frequencies outside the desired group. The output of the filter F_4 is impressed on a demodulator Dem. 2 which is also supplied with a carrier frequency represented by $C_{11}+C_{12}$, chosen for such value that the lower side-band of this demodulator will consist of the carrier C_{12} , $C_{12}+J$, and $C_{12}-K$. This output is then impressed upon three filters F_5' , F_5'' and F_5''' in parallel with each other. These are so designed that F_5' passes only the side-band $C_{12}+J$ and F_5''' passes only the band $C_{12}-K$, whereas F_5'' , which is a very narrow pass-band filter, passes only the carrier C_{12} . The output of F_5'' is now reconditioned to supply carrier C_{12} to the demodulator Dem. 3 one in the path of each of the side-bands and the outputs of these demodulators then yield respectively the voice frequency band J and K. These are now supplied to the

privacy circuit and by means of the switching equipment in that circuit, which is controlled by the receiving cams, the portions of J and K which relate to channel A are brought together in the proper order and the portions relating to channel B are brought together in the proper order, the message of each channel then being transmitted out to its terminal.

In order to maintain a proper frequency stability, there is provided a reference oscillator. This in turn, operating through an automatic frequency control, determines the value of the oscillations C_1 — C_{11} , maintaining this automatically at its correct value. The automatic frequency control device is rendered effective by having supplied to it from the output of F^{11} a small amount of the intermediate frequency C_{12} . One method of frequency control of this sort is disclosed in Morrison Patent 1,931,873, October 24, 1933.

While Figs. 6 and 7 have been described in some detail to indicate one type of transmitting and receiving circuit which assures stability of action, it should be understood that this is one type of circuit only and that similar results can be accomplished in other ways. It is not necessary for the exercise of our invention that this particular form of intermediate modulation and demodulation should be followed. It is to be understood also that in addition to the portions of the circuit described in connection with Fig. 7 that additional features may be added, such as suitable automatic volume control devices operating at one point or another of the circuit.

In case one channel only, such as channel A, is being used it is evident that the degree of confusion or privacy is somewhat diminished. In this event it may be desirable to introduce some "babble" on the otherwise unoccupied channel B.

What is claimed is:

1. In a signaling system in which the transmitted wave comprises a carrier and two side-bands the respective side-bands of which represent separate messages, the method comprising periodically and synchronously altering the frequency relations of the components of both side-bands with respect to the carrier frequency and shifting one or both side-bands with respect to the carrier while maintaining substantially constant frequency separation between said side-bands to render the transmitted wave difficult to interpret.

2. In signaling employing a carrier wave modulated by one message to produce an upper side-band and modulated by a separate message to produce a lower side-band, the method comprising shifting from time to time the relative frequency relations of carrier and side-band components so that at times during transmission the side-bands are symmetrically related in frequency to the carrier and at times unsymmetrically related in frequency to the carrier to render the waves difficult to interpret.

3. In twin single side-band transmission in which the two side-bands of the same carrier represent respectively different messages, the method of attaining secrecy of transmission comprising periodically and simultaneously switching each of the messages respectively from one side-band to the other during transmission.

4. In a signaling system, a pair of message wave input circuits, means to modulate a carrier wave to produce an upper side-band in accord-

ance with one of the message waves and a lower side-band in accordance with the other message wave, and means for periodically shifting the frequency relations of both of said side-bands with respect to the carrier frequency to render intelligible reception of the messages difficult.

5. In a signaling system, a pair of message input circuits, means for building up a composite wave for transmission comprising a carrier frequency and two side-bands, said building-up means including means to produce one of said side-bands from one of the message waves and the other side-band from the other message wave, and a privacy apparatus for alternating during transmission the relation between the respective message waves and the respective side-bands.

6. In a signaling system, a pair of message input circuits, means for building up a composite wave for transmission comprising a carrier frequency and two side-bands, said building-up means including means to produce one of said side-bands from one of the message waves and the other side-band from the other message wave, and a privacy apparatus for producing synchronous shifts in the frequency positions of said side-bands with respect to the carrier.

7. In a signaling system, a pair of message input circuits, means for building up a composite wave for transmission comprising a carrier frequency and two side-bands, said building-up means including means to produce one of said side-bands from one of the message waves and the other side-band from the other message wave, and a privacy apparatus including means to intermittently shift the frequency of one of the two side-bands closer to the carrier frequency and simultaneously shift the frequency of the opposite side-band away from the carrier frequency by an equal amount.

8. The method of claim 3 combined with the further step of intermittently and simultaneously shifting the side-bands with respect to the carrier.

9. The method of claim 3 combined with the step of intermittently and simultaneously shifting the two side-bands with respect to the carrier and the further step of inverting the said side-bands from time to time independently of each other.

10. In a twin-channel radio system in which there are radiated an upper and a lower side-band of relatively large width, a source of two separate messages, and means for alternately modulating one of said messages so that it appears first in one side-band region and then in the other, means for modulating the other message so that it appears in that side-band which is vacant, further means for shifting the side-bands to and away from the carrier in accordance with a prearranged time schedule.

11. The combination of claim 10 in which the means for shifting the side-band maintains a constant frequency spacing between the two side-bands.

12. The combination of claim 10 in which the means for shifting the side-band maintains a constant frequency spacing between the two side-bands and there is included means for inverting, when desired, either or both side-bands independently of each other.

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