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E. V. GRIGGS

SECRECY TRANSMISSION SYSTEM

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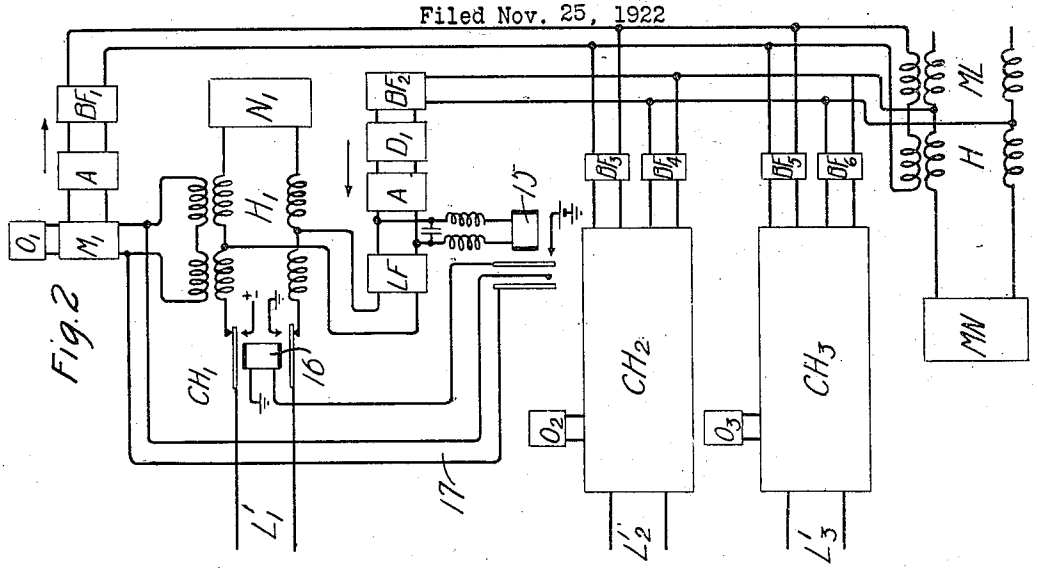


Fig. 2

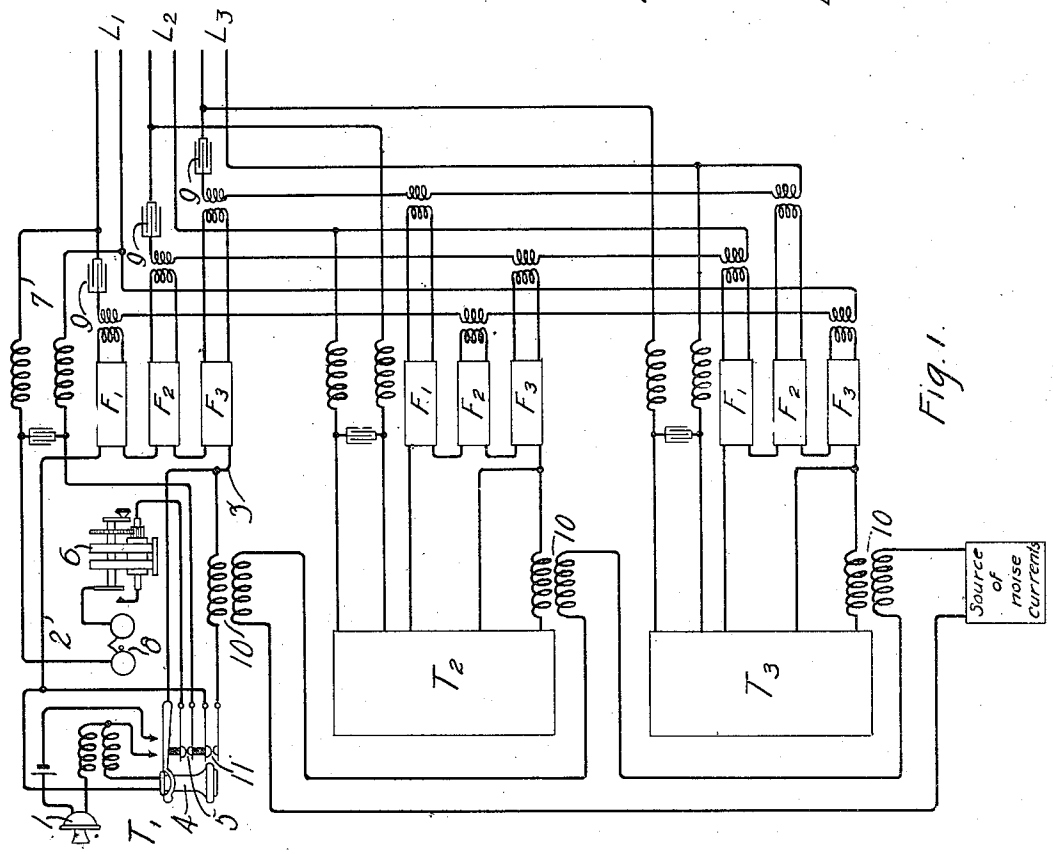


Fig. 1.

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by J. E. Roberts Atty.

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UNITED STATES PATENT OFFICE.

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SECRECY TRANSMISSION SYSTEM.

Application filed November 25, 1922. Serial No. 603,162.

To all whom it may concern:

Be it known that I, ELMER V. GRIGGS, a citizen of the United States, residing at East Orange, in the county of Essex and State of New Jersey, have invented certain new and useful Improvements in Secrecy Transmission Systems, of which the following is a full, clear, concise, and exact description.

The present invention relates to the transmission of currents or waves of different frequencies, or different ranges of frequencies for signaling or kindred purposes, and has particular reference to making such transmission secret.

It has been proposed to secure secrecy of transmission of a message wave, or similar wave, by resolving the wave into essential component frequencies and transmitting the different component frequencies over separate paths so that the components transmitted over any given path if intercepted would be insufficient to enable the message to be understood. By recombining the component frequencies transmitted over all of the paths, however, the original message wave can be built up and the message received. A system employing this principle is disclosed in U. S. Patent No. 1,395,378 to Wilson, et al., issued November 1, 1921.

In the present invention a signal or other wave is resolved into component frequencies for separate transmission as in the previously suggested systems referred to, but it is a feature of this invention that the path over which component frequencies of one message wave are transmitted serves also to transmit components of other frequencies derived from another or other message wave or waves. This not only extends the permissible range of component frequencies transmitted over any given path thereby increasing the usefulness of each path, but it also adds to the degree of secrecy of the transmission since the current components which might be intercepted on any given path comprise portions of two or more different message waves and are still more complicated and more confusing than the components in any one path that are derived from a single message. In accordance with this feature of the invention, each path transmits a total range of frequencies which may be equal to or comparable with the frequency range of any one complete message, the range so transmitted, however, being composed of component frequencies from a plurality of message waves, the other components of the respective message waves being transmitted over other respective paths.

A related feature of the invention is the distribution of the various component frequencies among the transmission paths so that in each path the frequency components from the different messages build up to form a total range of suitable extent, that is, the various component bands of frequencies are "dove-tailed" together.

A further feature of the invention is the provision of noise or confusion currents to take the place of the message components when there is a cessation in the transmission of any given message. In the case of carrier wave transmission systems these confusion currents may advantageously result from the interaction of the carrier components themselves, due to arrangements provided by the invention, as will be more fully described below.

Another feature of the invention relates to the provision for transmitting call signals through the various channels of the system.

The invention is applicable either to wire or wireless transmission. Likewise the invention may be used where the message currents are transmitted at their own frequencies, as in the case of a telephone line, or where carrier waves are transmitted each accompanied by a fringe or band of frequencies representing the message variations.

In the case of speech transmission over a line, which may be taken as typical, the frequency components representing each speech message or conversation, are divided by filters or other suitable means into relatively narrow bands of frequencies, each band being insufficient of itself to convey intelligence. For example, if essential speech frequencies are assumed to comprise the range 200 to 2000 cycles, this range may be divided for purposes of the invention into, say, three ranges of 200 to 800, 800 to 1400 and 1400 to 2000, respectively. If desired, a larger or smaller number than three bands may be used. Assuming that three such sub-ranges or bands are used, whether comprising the frequencies indicated above or

some other frequencies, let the lowermost frequency range for simplicity be indicated as A_1, the next higher range as B_1, and the next higher range as C_1. A second message so sub-divided would have sub-ranges of frequencies A_2, B_2 and C_2, and a third message would have bands A_3, B_3 and C_3. If, now, three paths are used to transmit these three messages, such as ordinary telephone lines I, II and III, the frequency components transmitted over the different lines are preferably as follows:

Lines	I	II	III
Bands	A_1 B_2 C_3	A_3 B_1 C_2	A_2 B_3 C_1

With this arrangement it is seen that each line transmits substantially the same range of frequencies as though normal speech were being transmitted over it. However, anyone obtaining access to a line would hear only sounds incapable of being understood. To receive an intelligible message it is necessary to select the proper band from each line and combine the bands so selected. The difficulty presented to an outsider of doing this is increased as the number of lines in any vicinity is increased, the task of selecting out the proper ranges and matching them together becoming very difficult where several score of circuits of identical appearance are strung together as in a cable or on a pole line. However, the method used by the system for restoring the speech is simple in form and since the speech components are in no way mutilated the restored speech is of the same degree of quality as normally transmitted speech.

In the case of a system employing carrier waves, either radiated or transmitted over wires, the application of the component bands to the various carriers may be exactly as indicated above for the lines I, II, and III, the three carrier channels taking the place of the three lines in the above table.

In the drawing, to which reference will now be made for a more detailed description of the invention, Fig. 1 is a diagrammatic representation of one terminal of a three-channel system of preferred form, employing voice frequency transmission between stations; and Fig. 2 represents a terminal of a system employing carrier waves which may be radiated or transmitted over a line.

In Fig. 1, three lines L_1, L_2 and L_3 which may be ordinary telephone lines, are used to convey three telephone messages between terminal telephone stations T_1, T_2 and T_3 and similar stations at the opposite ends of the lines, each line, however, carrying only a fragmentary part of any one telephone message as explained above. These telephone stations may be of ordinary construction except for details to be noted hereinafter in connection with ringing and noise current transmission, and are illustrated as local battery instruments although the invention is not limited to local battery circuits.

When the receiver 4 is raised, the speech waves from microphone 1 are impressed in the usual manner across conductors 2 and 3, across which are connected a group of filters F_1, F_2 and F_3 which serve to select out from the speech waves component frequencies lying within definite frequency limits. For example, the filter F_1 may select and transmit through to the line L_1 only those frequency components lying between the limits of 200 and 800 cycles. Similarly the filter F_2 may transmit to line L_2 only frequencies between 800 and 1400 cycles and filter F_3 may transmit to line L_3 only frequencies between 1400 and 2000 cycles. Any other arbitrary limits may be used for these filters and their construction and design are preferably in accordance with the principles set forth in U. S. Patent to Campbell No. 1,227,113, issued May 22, 1917. An identical group of filters F_1, F_2 and F_3 is placed between the station T_2 and the lines L_1 L_2 and L_3 but these filters are so connected to the lines that the component band of lowest frequencies, transmitted through F_1, is impressed on line L_3, the next higher component band is transmitted by F_2 to the line L_1 and the highest component band is transmitted through F_3 to the line L_1. A third group of filters, identical with the other two groups, connects the station T_3 to the lines, the filter F_1 of this station being connected to line L_2, the filter F_2 to line L_3 and the filter F_3 to line L_1. When speech is being transmitted from all three stations T_1, T_2 and T_3, each of the lines L_1, L_2 and L_3 carries a range of frequencies substantially the same as normal speech. However, if the limits of the filters F_1, F_2 and F_3 are properly chosen, the currents on any one line represent only unintelligible sounds and the speech transmission over any line is to a very high degree secret.

Receiving and restoring the speech to intelligible form takes place in exactly the reverse order of the transmission. For example, currents received over the lines L_1, L_2 and L_3 from three distant stations arranged similarly to the stations T_1, T_2 and T_3 will contain such a number and arrangement of component bands that the three component bands of one speech message, distributed over the three lines, will be selected from the respective lines by the filters associated with station T_1, the com-

ponent bands of another speech message will be selected by the filters associated with station T_2, and so on. The three component bands so received through the filters of station T_1 are impressed across the conductors 2 and 3 and currents of the total range of the three superposed component bands pass into the receiver 4 and produce intelligible speech. Similarly, speech of another conversation is heard in the receiver of station T_2, and so on.

Each line may serve to transmit ringing current in addition to the currents of speech frequency. For example, when the receiver 4 is on its hook, so that the contacts 5 are closed, ringing current may be sent out from the generator 6 through the branch 7 to the line L_1, or may be received through branch 7 for actuating the ringer 8. The branch 7 preferably contains series inductance and shunt capacity as shown for preventing currents of speech frequency which may be present on line L_1 due to a conversation taking place from station T_2 or T_3, from being shunted through the ringer 8 when station T_1 is not in use and when, therefore, contacts 5 are closed. Also a condenser 9 may be employed on each line, of such capacity that the portion of the line to the left of the point in the drawing at which the ringing currents are applied to, and derived from, the line, offers high attenuation to currents of ringing frequency, but readily transmits currents of speech frequency.

With the arrangements described thus far, if any one station such as T_1, is not in use, each line carries only two of the component bands of frequencies, and if two stations are idle and the other is being used, each line carries only one of the component bands. It is conceivable that anyone exploring a group of lines could pick out the three lines that are used for one conversation, and also could identify the frequencies employed on each of the three lines for one conversation, if for any considerable length of time only one conversation, or possibly only two conversations, were being transmitted. In order to forestall such possibility, it is preferable to provide a source of noise currents of speech frequency range and to substitute these noise currents for speech when the speech currents are withdrawn. Such a source is indicated on the drawing, and it may, in practice, advantageously comprise a phonographic apparatus or the like. Currents from this source pass to the transformers 10 of the respective stations. When the receiver 4 of any station is replaced on the switchhook after completing a conversation, the contacts 11 are closed and the noise currents of speech frequency are impressed across conductors 2 and 3 and are transmitted to line to take the place of the conversation currents.

In the description thus far, it has been assumed that the lines L_1, L_2, and L_3 extend to the distant station with which communication is to be had, and that the distant station has an arrangement identical with that of the station shown in Fig. 1. If it is desired to transmit over a carrier wave system to the distant station, it is only necessary to associate the lines L_1, L_2, and L_3 of Fig. 1 with the terminals of three respective carrier wave channels such as are shown in Fig. 2, and for the purposes of understanding the application of the invention to carrier wave transmission, it will be assumed that the line L_1 of Fig. 1 is connected to the line L_1' of Fig. 2, and that the lines L_2 and L_3 of Fig 1 are similarly connected respectively to the line terminals L_2' and L_3' of Fig. 2. The carrier channels indicated at CH_1, CH_2 and CH_3 of Fig. 2 serve in the well-known manner to translate the speech frequency waves received from the station of Fig. 1 into modulations of high frequency carrier waves to be transmitted to the distant station, and likewise serve to translate received modulated carrier waves into waves of the speech range for transmission back over the lines L_1, L_2, etc. to the station of Fig. 1. The channels CH_1, etc., of Fig. 2, are specifically shown as being associated with the terminal of the multiplex carrier line ML, but this may equally well be the terminal of a radio system, in which case the carrier waves would be radiated to the distant station. At the distant station, it will be understood, carrier wave terminal apparatus will be provided for cooperating with that shown in Fig 2, and the character and arrangement of this terminal apparatus may be identical with that shown in Fig. 2. The carrier channels at the distant station will be extended by lines to telephone terminal apparatus which may be identical with that shown in Fig. 1.

The carrier channels of Fig. 2 may be identical with each other, except for the carrier frequencies which the respective channels employ. The specific arrangement of the channels is indicated in the showing of the channel CH_1. The low frequency terminal line L_1' of this channel is provided with a conjugate repeating coil, or hybrid coil H_1 and a balancing network N_1 in accordance with usual telephone repeater practice. The transmitting branch of this hybrid coil leads to the input of a modulator M_1 which is supplied by a sustained high frequency wave from generator O_1 of the carrier frequency employed by the channel CH_1 in transmitting. The output side of the modulator is shown connected thru an amplifier A to the band filter BF_1

which is designed to transmit the modulated wave to the line ML. This carrier line ML is shown provided with a balancing network MN and a hybrid coil H for enabling carrier waves to be impressed on the line ML and received from it without interference. Channel CH_1 is connected with the receiving branch of the hybrid coil H by means of the band filter BF_2, the detector D_1, the amplifier A and a low frequency filter LF. The band filter BF_1 is designed to have a transmission range for only the frequencies employed by the channel CH_1 in receiving and the filter LF is designed to transmit frequencies in the voice range. The filter LF preferably suppresses both the components of frequencies lower than the essential speech frequencies and components of frequencies higher than the essential speech frequencies, its transmission range for example, being from 200 to 2000 cycles.

The general arrangement of the channel CH_1 and the operation of the carrier apparatus is substantially the same as that described in the paper entitled "Carrier Current Telephony and Telegraphy" by E. H. Colpitts and O. B. Blackwell, published in the Journal of the American Institute of Electrical Engineers, beginning April, 1921. The specific construction and arrangement of the individual parts of the channel CH_1 may be understood from this publication. For further reference, the oscillator O_1 may be of the type shown in the U. S. patent to Hartley 1,356,763, October 26, 1920. The filters may each be constructed in accordance with the principles disclosed in U. S. patent to Campbell, 1,227,113, above referred to, and the amplifier, modulator and detector may be of the well-known vacuum tube type such as are shown in the Colpitts and Blackwell publication.

The channel CH_2 may have an arrangement precisely similar to the channel CH_1, except that the oscillator O_2 of this channel generates a carrier wave of a frequency different from that supplied by the oscillator O_1 and the band filters BF_3 and BF_4 are designed to transmit selectively and exclusively the modulated waves employed by this channel for sending and receiving. Similarly the oscillator O_3 and the band filters BF_5 and BF_6 are designed for the frequencies employed exclusively by the channel CH_3, the arrangement of the channel being otherwise the same as described in the case of channel CH_1.

The waves of the speech range representing components derived from different conversations and transmitted over the line L_1 from the station of Fig. 1, traverse the line L_1' and pass into the input circuit of the modulator M_1 where they serve to modulate the carrier wave supplied from the generator O_1 and the resulting modulated wave is selectively transmitted to the line ML. In similar manner waves received over the lines L_2 and L_3 modulate the respective carrier waves supplied from the generators O_2 and O_3 and the resulting modulated waves are transmitted to the line ML. The manner in which these modulated waves are received and retranslated at the distant station will be clear from considering the reception and translation of waves received over the line ML at the station shown in Fig. 2. The receiving filters BF_2, BF_4 and BF_6 serve to separate the incoming transmissions to their respective channels CH_1, CH_2 and CH_3. The wave received by the channel CH_1 is detected at D_1 and after amplification, is selectively passed through the voice filter LF to the line L_1' and thence over the line L_1 to the station of Fig. 1. The waves received by the other channels are similarly translated and the speech components are transmitted over the lines L_2 and L_3 to the station of Fig. 1.

Ringing current transmitted over the line L_1 passes into the circuit of the modulator M_1 and there modulates the carrier wave in the same manner as described in the case of speech waves. These ringing currents are assumed to have a frequency below the speech range and may, for example, be of the order of 100 cycles, or lower, if desired. Accordingly these ringing currents received over the line L_1' are suppressed in the filter LF and are prevented from producing disturbances in the receiving side of channel CH_1. A wave received over the line ML by the channel CH_1 and modulated by ringing currents is detected at D_1 and after amplification at A, causes the energization of relay 15. The ringing currents so received are prevented from passing to the hybrid coil H_1 by the filter LF, this filter, as described, being designed to suppress currents of the frequency employed for ringing. Relay 15 in pulling up its armatures in response to the receipt of the detected ringing current closes a circuit for the ringing relay 16 and also closes a circuit 17 in shunt of the input circuit of the modulator M_1. Ringing relay 16 in pulling up its armatures applies ringing current from the source indicated to the line L_1', from which it passes over the line L_1 and to the apparatus shown in Fig. 1. Closure of the circuit 17 as described short-circuits any disturbing currents arising from the ringing operation and prevents their being impressed on the modulator M_1.

In a similar manner ringing currents from the lines L_2 and L_3 are transmitted over the carrier channels CH_2 and CH_3 and vice versa.

Where carrier wave transmission is em-

ployed, and especially in the case of radio signaling, the carrier waves themselves afford a convenient method of producing noise or interference currents, whether speech is being transmitted on all three channels or not. The filters in the various receiving and transmitting sides of the channels are preferably designed to transmit the carrier frequency and one side band of the respective modulated wave, but to suppress the transmission of the other side band.

According to this invention the filters will be so designed that the upper side band and the carrier will be transmtted in the case of one channel, and in the case of the channel employing the next lower carrier frequency the carrier and lower side band will be transmitted. This scheme may be repeated for each pair of carrier waves. By so relating the frequencies of the neighboring channels, it is possible to set the frequencies of two carriers so close to each other that their separation is of the order of the extreme limits of a speech side band or less. For example, a carrier wave of 8000 cycles may be transmitted with its upper side band, representing a total range of 8000 to 10,000 cycles or thereabout. The next lower carrier frequency may be 7000 and its lower side band would extend downward to, say, 5000 cycles. These two ranges can easily be separated from each other by suitable filters. However, if an outsider should attempt to receive the secret message by impressing all of the received frequencies on a detecting circuit, on the theory that it might be possible to detect portions of a conversation that happen to continue during a pause in each of the other conversations, he would be defeated in this since the two carriers would interact to give a detected note of an audible frequency, 1000 cycles in the example given, which would be superposed on the signal. The carrier components are preferably made of large amplitude compared with the side bands, and as a result the detected beat between two carriers will be louder than any signal component, and may easily be made so much louder as to overwhelm the signal. This large amplitude of the carrier offers no disadvantage to the secret reception of the messages since the carriers are separately detected. It is rather an advantage since, other things being equal, the clearness of the detected speech is greater, the greater the amplitude of the carrier component.

What is claimed is:

1. In a signaling system, a plurality of sources of signaling waves representing different messages to be transmitted, a plurality of transmission paths for effecting the simultaneous transmission of said messages, and means to transmit a correspondingly different portion of each message wave simultaneously over each of said paths.

2. In a signaling system, a plurality of sources of signaling waves representing different messages to be transmitted, a plurality of transmission paths for effecting the simultaneous transmission of said messages, means to distinguish a corresponding plurality of characteristically different portions of each message wave, and means to transmit simultaneously over each of said paths a characteristically different portion of each of said message waves.

3. In a signaling system, a plurality of sources of message waves, a plurality of transmission paths for enabling the simultaneous transmission of all of said messages, means to resolve each message wave into components differing from one another respectively in frequency, and means to transmit over each of said paths simultaneously a portion of each of said message waves, each portion transmitted over a given path having a different frequency.

4. In a telephone system, sources of waves representing different telephone messages, a plurality of paths for enabling the simultaneous transmission of said messages, means to resolve each message into a plurality of component frequency bands, and means to transmit over each of said paths a plurality of said bands derived from a plurality of different messages.

5. In a telephone system, sources of waves representing different telephone messages, a plurality of paths over which said messages are to be transmitted, means to resolve each message into a plurality of component frequency bands, the frequencies composing each band being insufficient to reproduce intelligible speech, and means to transmit over each of said paths a plurality of said bands derived each from a different message.

6. In a telephone system, a plurality of transmission paths, means to transmit waves of a range of frequencies over each path, the waves transmitted over each path being incapable of reproducing understandable speech, means to resolve the waves transmitted over each path into a plurality of component frequency bands, and means to combine each band derived from the wave transmitted over a transmission path with a band derived from the wave transmitted over another of said paths to produce understandable speech.

7. In a telephone system, a plurality of telephone stations, a corresponding plurality of transmission circuits connected to said stations, wave filters interposed between each station and each of the several circuits, the filters connected to each station being proportioned to transmit a different frequency from said station and each of the different circuits.

8. In a telephone system having a plurality of telephone stations, a corresponding plurality of transmission circuits associated with said stations, means to transmit over a said transmission circuit currents of frequencies of the range of essential speech frequencies, and means to derive certain of the frequencies composing the transmitted range from one of said stations and certain other of the transmitted frequencies from another of said stations.

9. A telephone system having a plurality of telephone stations, a plurality of transmission circuits associated with said stations, and means to transmit over each one of said lines simultaneously currents derived from each of said stations, the currents on each line derived from the respective stations being of respectively different frequency.

10. In a telephone system, a plurality of telephone stations each for translating sound waves into current variations, a plurality of wave filters associated with each station for selecting from the current variations components of different ranges of frequency, a plurality of transmission circuits associated with said stations, each circuit being connected to one of said stations through one of said filters, and to another station through a filter having a different transmission frequency range.

11. In a secret telephone system, a plurality of telephone stations, wave filters associated with each station for deriving from the speech waves produced in the respective station a plurality of different bands of component frequencies, a plurality of transmission lines, means to connect one of said stations with the first of said lines through a filter transmitting only the lowermost band of component speech frequencies from that station, and with the second of said lines through a filter transmitting only the next higher of the bands of component frequencies from that station, and so on, and means to connect another of said stations with the second of said lines through a filter transmitting only the lowermost band of component frequencies and with the first of said lines through a filter transmitting only the next higher of said bands of component frequencies, and so on.

12. In a secret telephone system, a plurality of telephone stations each having means to produce speech currents and to separate the currents into components lying in definite frequency bands, a plurality of transmission lines for transmitting the currents from said stations, and connections for distributing the bands of components from each station to a plurality of said lines.

13. In a secret telephone system, a plurality of telephone stations, means to produce separate speech waves in each station, transmission circuits associated with said stations, and means to effect secret transmission of said speech waves over said lines comprising means to transmit different portions of the speech waves from each station over the several lines.

14. In a secret telephone system, a plurality of telephone stations, means to produce separate speech waves in each station, lines associated with said stations, means to transmit over each line a portion of the speech waves from one of said stations, and means to render unrecognizable the particular portion of the waves on any line derived from any station comprising means to superpose thereon a portion of the waves from another of said stations.

15. In a secret telephone system, a plurality of telephone stations, a plurality of transmission lines, means to produce speech waves in each of said stations, means to mingle the waves from all of said stations in each of said lines to render the individual speech waves unrecognizable, and means to derive a plurality of speech messages from the mingled waves on said lines.

16. In a secret telephone system, a plurality of telephone stations, a plurality of transmission lines associated therewith, means to transmit telephone currents from each station over a respective line, means to utilize on each line speech currents from a respectively different telephone station to mask the wave transmitted from the aforementioned station associated with the respective line, a source of noise currents, and means operative upon the establishment of the non-talking condition in a station for transmitting noise currents from said station for masking speech currents from other stations.

17. In a telephone system, telephone stations including sources of speech waves, sources of noise waves associated therewith, a plurality of paths for enabling the simultaneous transmission of waves from said stations, means to resolve the waves from each station into a plurality of component frequency bands, means to transmit over each of said paths a plurality of said bands derived from a plurality of said stations, and means controlled in each station to transmit from said station speech waves and noise waves alternately.

18. In a secret telephone system, a telephone station, a line for transmitting speech currents from said station, means to confuse the speech currents so transmitted comprising a second station and means to superpose speech currents from said second station upon the currents transmitted on said line, a source of noise currents of essential speech frequencies associated with said second sta-

tion and means to substitute said noise currents for the speech currents from said second station.

19. In a secret telephone system, a plurality of carrier wave transmission channels, separate sources of speech waves, and means for simultaneously transmitting through each of said channels a correspondingly different portion of the waves from each of said sources.

20. In a secret telephone system, a plurality of two-way carrier transmission channels, voice frequency terminals for said channels, said terminals of the respective channels being associated with the respective transmission lines of the system defined in claim 9.

21. In a secret telephone system, a plurality of two-way carrier transmission channels, voice frequency terminals for said channels, said terminals of the respective channels being associated with the respective transmission lines of the system defined in claim 11.

22. In a secret telephone system, a plurality of two-way carrier transmission channels, voice frequency terminals for said channels, said terminals of the respective channels being associated with the respective transmission lines of the system defined in claim 15.

23. In a carrier signaling system for transmitting a signal comprised of a range of frequencies, means for transmitting a pair of carrier waves differing in frequency sufficiently to enable their separation by wave filters, the frequency difference between said carriers being less than the extreme range of frequencies comprised by said signal, means to modulate each of said carrier waves by a different portion of the frequency range of said signal to be transmitted, and means to confine the modulation components in the transmitted waves to the upper side band of the wave of the higher frequency and to the lower side band of the wave of the lower frequency.

24. In a carrier signaling system, sources of signaling waves to be transmitted, means to produce two modulated carrier waves of different frequency, each modulated by one of said signaling waves, said modulated waves having non-overlapping frequency ranges, the frequency difference between the unmodulated carrier wave components of said modulated waves being less than the extreme frequency range of one of said signaling waves, and means to transmit said modulated carrier waves over the same medium.

In witness whereof, I hereunto subscribe my name this 23rd day of November, A. D., 1922.

ELMER V. GRIGGS.