

Nov. 10, 1942.

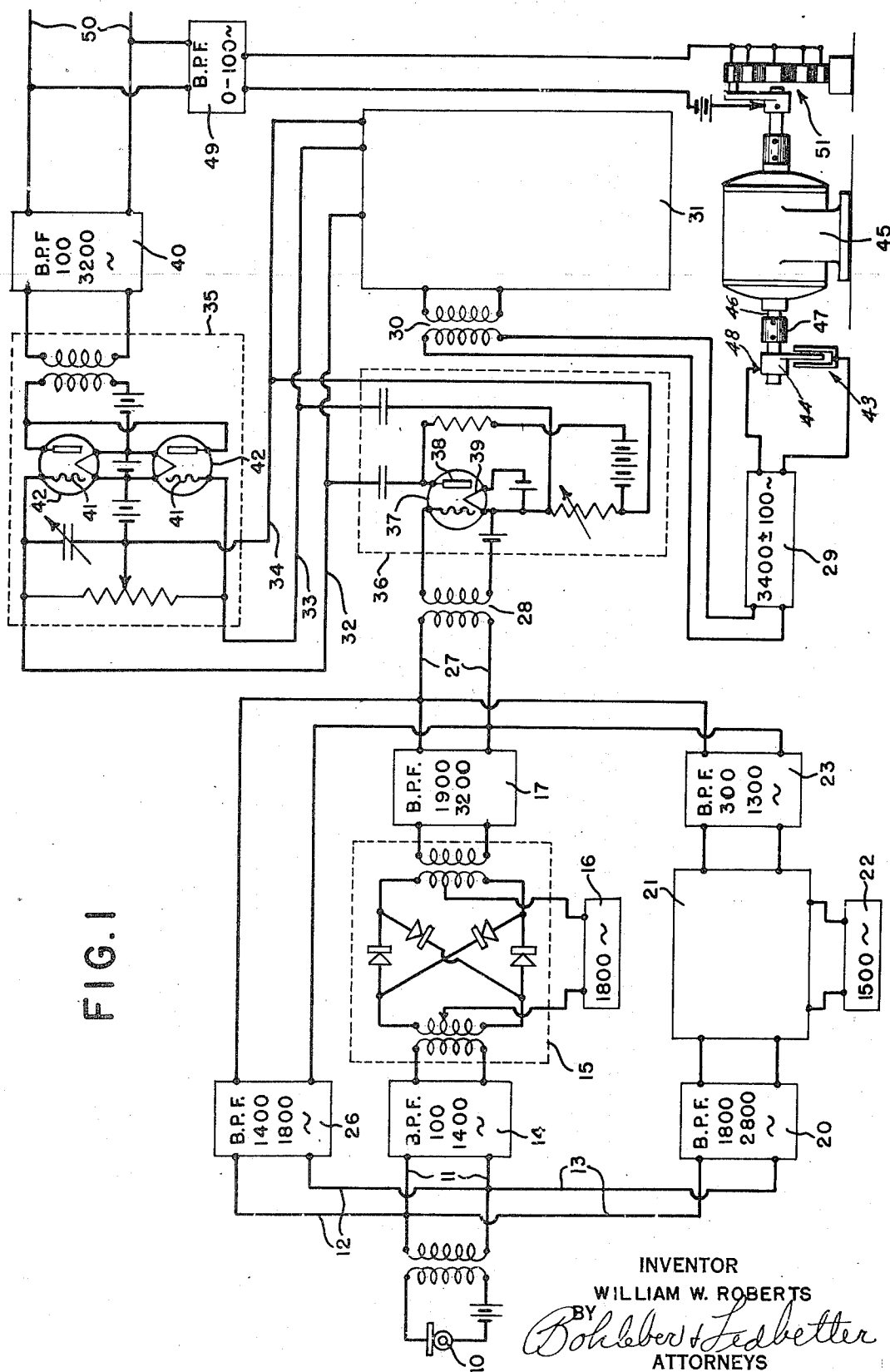
W. W. ROBERTS

2,301,455

APPARATUS AND METHOD FOR COMMUNICATION

Filed Oct. 27, 1939

2 Sheets-Sheet 1



INVENTOR

WILLIAM W. ROBERTS

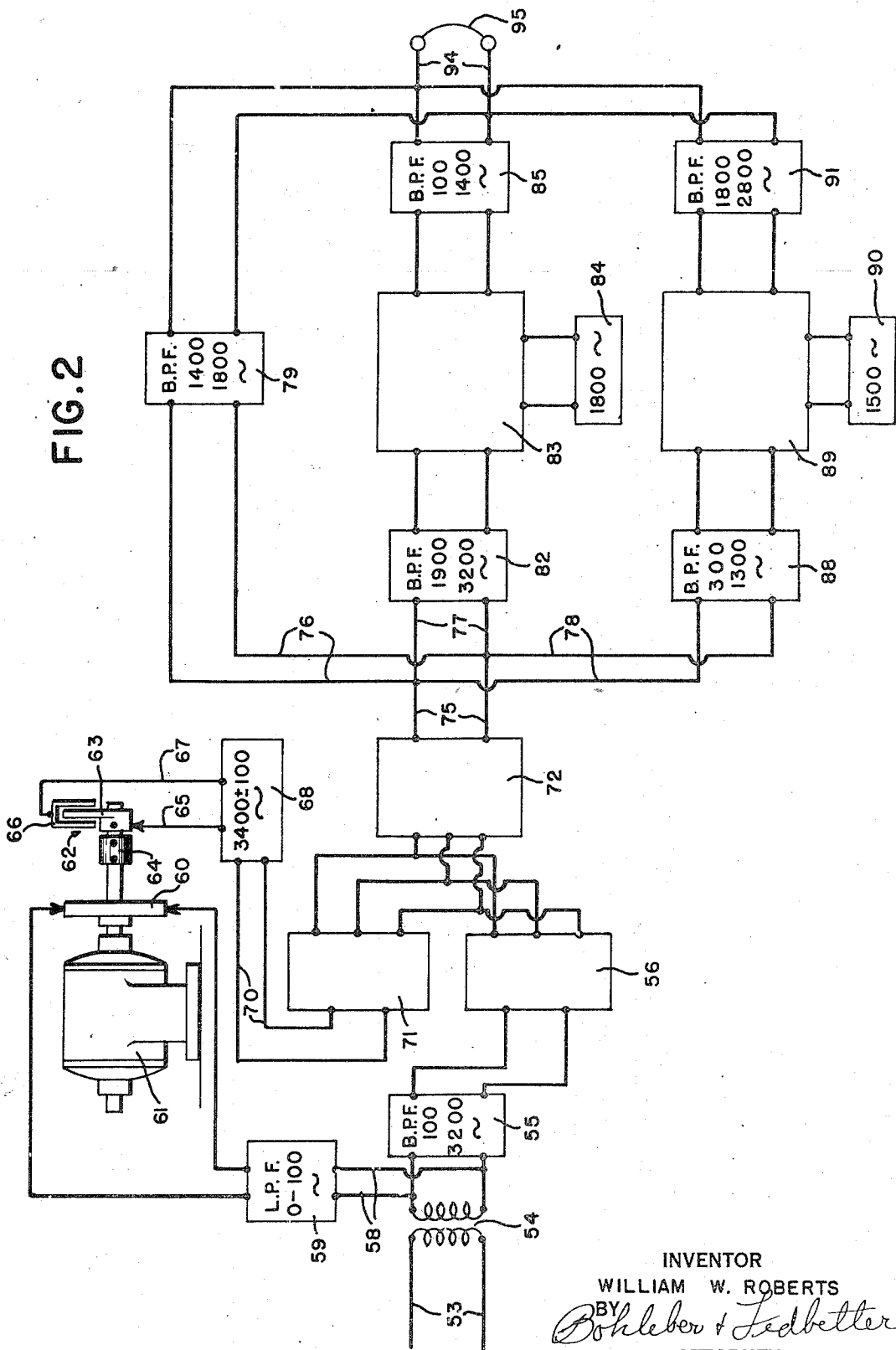
BY *Bohleber & Leabetter*
ATTORNEYS

APPARATUS AND METHOD FOR COMMUNICATION

Filed Oct. 27, 1939

2 Sheets-Sheet 2

FIG. 2



INVENTOR
WILLIAM W. ROBERTS
BY *Bohleber & Ledbetter*
ATTORNEYS

UNITED STATES PATENT OFFICE

2,301,455

APPARATUS AND METHOD FOR
COMMUNICATION

William W. Roberts, Trenton, N. J., assignor to
Wireless Research Corporation, Princeton, N. J.,
a corporation of New Jersey

Application October 27, 1939, Serial No. 301,632

51 Claims. (Cl. 179—1.5)

This invention relates to an apparatus and method for communication by which secret signalling or secret transmission of speech or other intelligence may be accomplished. The method and apparatus employed so scramble the speech or intelligence that it is believed to be impossible for any unauthorized receiver of the electrical oscillations to unscramble the message and obtain an understandable message. The invention uses what may be termed combination scrambling for transmitting spoken messages or other intelligence.

It has long been recognized as being desirable to send a telephone or radio telephone conversation in such a form as to be absolutely unintelligible when picked up by the usual telephone or radio receiver and such that an unauthorized interceptor cannot possibly decipher or unscramble the message into intelligible speech. No clues are furnished by the meaningless jargon produced by the device as to the method of scrambling and hence it is impossible for an interceptor to ascertain how the secret transmissions are being carried out and then unscramble the message. Specially designed receiving apparatus, at the point where the message is intended to be received and understood, will of course unscramble the meaningless sounds or electrical oscillations into oscillations which can be converted into intelligible speech by the usual radio or telephone receiver.

With the system of the invention, secret communication can be had between any two points either by wired transmission or by radio transmission. Secret conversations can therefore be had between ground and an aeroplane, between a ship and shore, between ships, and in fact between any two points where radio or telephonic communications are now had, when these points are equipped with the apparatus of the invention. No time is lost by the transmission of the secret messages since the scrambled component of an intelligible word is produced immediately upon speaking into the microphone or telephone transmitter of the apparatus, and the receiving apparatus immediately unscrambles the message or intelligence which has been transmitted so that the person receiving hears the spoken message.

It is an object of the invention to construct a new and novel method and apparatus for sending a secret message, or other intelligence, and for receiving the same.

Another object of the invention is to provide a method and construct apparatus to divide a range of speech frequencies desired to be trans-

mitted into a plurality of frequency bands, interchange the frequency range, or their position in the frequency spectrum, of a plurality of the frequency bands so as to change the frequency level or the spacing between sub-bands or to change both, and transmit the new interrelation of frequency bands.

Another object is to provide a method and apparatus as set forth above, and in addition to invert the frequency relation of one or more of the frequency bands before combining them and transmitting the combined frequency range in its new interrelation or condition.

A still further object is to devise a method and construct apparatus which interchanges a plurality of frequency bands as in each of the above stated objects, and in addition inverts the frequencies of the combination of frequency bands in their new interrelation.

Another object is to provide a method and apparatus which divide a range of speech or other frequencies desired to be transmitted into a plurality of frequency bands, change the frequency range of at least one divided or separated band or its position in the frequency spectrum so as to change the frequency level or the spacing between sub-bands or to change both, and continuously vary the combined frequency bands in their new interrelation for transmission.

A further object of the invention is to provide a method and apparatus for secret communication which divide a range of speech or other frequencies desired to be transmitted into a plurality of frequency bands, change the frequency range or position of at least one frequency band in the frequency spectrum and form a combined frequency range with the bands in the new interrelation, invert this new combined frequency range, and continuously vary the combined frequency bands for transmission.

A still further object is to provide a method and apparatus for each of the above stated objects which may invert the frequency relation of one or more of the plurality of divided or separated frequency bands.

Another object of the invention is to provide a method and apparatus for receiving the message or intelligence transmitted by any one of the above methods or apparatuses and retranspose or restore the same to its initial interrelation or condition, that is, to an understandable message or intelligence.

Another object is to provide a method and a combination of transmitter and receiver which scramble or garble a message, as in each of the

above stated objects, for transmission and restore the message to its initial interrelation or condition.

Other objects of the invention will be more apparent from the following description taken in connection with the accompanying drawings, illustrating a preferred embodiment of the invention, in which:

Figure 1 is a diagrammatic view showing the apparatus for scrambling or rendering unintelligible the message to be transmitted.

Figure 2 is a diagrammatic view showing the apparatus for unscrambling or rendering intelligible the message transmitted and received by the receiving apparatus.

In the transmitting apparatus illustrated in Figure 1, the intelligence to be transmitted thereby is a spoken message. A microphone or telephone transmitter 10 receives the spoken message or audible waves and transforms the same into electrical oscillations. It is not necessary to transmit the entire spoken or audible frequency range in order to understand the message at the receiving end. However, the electrical oscillations or speech frequency waves of 100 to 2800 cycles per second (C. P. S.) have been selected as being the desired frequency range to transmit. The selected or audible frequency range is divided or separated into a plurality of frequency bands by providing a circuit or branch for each frequency band, and in each circuit there is provided a band pass filter which passes a band of frequencies of the selected frequency range and suppresses all other frequencies.

In the apparatus shown in Figure 1 as an example, the audible frequency range desired to be transmitted is divided or separated into three frequency bands or sub-bands and a plurality of parallel circuits or branches 11, 12 and 13 is provided for each band. The speech frequency waves of 100 to 2800 C. P. S. are the frequency range selected for transmission in order to explain the invention. It is to be understood that the frequency range may be greater or less, as desired, but the total range cannot be narrowed to such an extent that the speech is unintelligible. The electrical oscillations are divided by the band-pass filter means 14, 20 and 25 so that each circuit carries a particular frequency band or sub-band of the total selected frequency range.

The band-pass filter means 14 has been selected to pass frequencies ranging from 100 to 1400 cycles per second, although any other range of low frequencies may be selected by suitably designing the filter means. This band of frequencies is transmitted to a modulator 15. A carrier frequency of 1800 C. P. S. is produced by an oscillator 16 and impressed upon the band of frequencies supplied to the modulator 15 where the frequency band is raised in the frequency spectrum by creation of a side band having frequencies from 1900 to 3200 C. P. S. This transfer of the frequency band to another frequency band occurs without changing the frequency order. A band-pass filter means 17, connected with the output of the modulator, passes the 1900-3200 C. P. S. side band and suppresses all other frequencies. If desired, the carrier frequency produced by oscillator 16 may have a frequency of 3300 C. P. S. in which case a side band is produced having frequencies from 1900 to 3200 C. P. S., the same frequency band as was produced with the 1800 C. P. S. carrier, but the frequencies would be in inverted relation with

respect to the order or relation of the frequencies existing in the original frequency band.

In circuit or branch 13, a filter means 20 selects or passes a band of frequencies from 1800-2800 C. P. S. The frequency range of this band will be changed because most of this band is now occupied by the transposed frequencies of circuit 11 and there can be no overlapping of the frequency ranges in the plurality of frequency bands. The output of the filter means 20 is connected with a modulator 21 which receives a carrier frequency of 1500 cycles from the oscillator 22 and transposes the frequency band fed to the input of the modulator to a lower frequency position of 300-1300 C. P. S. without alteration of the order of the frequencies. It is understood that if the oscillator 22 produces a carrier frequency of 3100 C. P. S., a resultant side band produced would be in the same frequency range of 300-1300 C. P. S., but the frequencies would now be inverted or in an inverse relation from their original relation. A band-pass filter means 23 passes the side band frequencies of 300-1300 C. P. S. and suppresses all other frequencies.

The frequency band selected by filter means 26 in the circuit 12 is not shifted in the frequency spectrum. The outputs of the filter means 17, 23 and 26 are connected together so that the three frequency bands are combined in circuit 27, including the repeating coil or transformer 28, as a single frequency band having a frequency range from 300-3200 C. P. S., but with the bands in their transposed relation or transposed position in the frequency spectrum. This combined frequency band may be transmitted to a receiving station either by wire or radio waves. However, further scrambling of the message renders the same more difficult to decipher or unscramble and hence such further scrambling will be described hereinafter.

It will now be understood that the invention so far described provides a method and apparatus for transmission of secret communications which involves dividing or separating all or a desired range of speech frequencies into a plurality of frequency bands, three being particularly illustrated and described although two or more are contemplated, and spacing each sub-band with respect to its adjacent sub-bands. The explanation of the principle or theory of the invention so far described indicates many variations which may be made in practicing the invention without deviating from the principle thereof. Several of such variations will be discussed in order to make apparent the scope of the invention. It is obvious that the greater the number of frequency bands into which the speech frequencies are divided or separated, the difficulty increases for an unauthorized receiver attempting to unscramble the message; however it is not believed possible for anyone not knowing the original scrambling to decipher the message.

A plurality of the divided or separated frequency bands are now transposed so that they occupy a different position in the frequency spectrum from that which they originally occupied. Although two such frequency bands have been transposed in the illustrated embodiment, it is understood that all three may be transposed if desired. In order to transpose three frequency bands, there would be required further apparatus because each frequency band or its separating circuit must then have its mod-

ulator, oscillator and side band filter. It should be understood too that when the original frequency range is separated into more than three frequency bands, more than one of the separated frequency bands may, if desired, remain unchanged as to its position in the frequency spectrum, although two adjacent frequency bands should not be selected as remaining unchanged. Again, one or more of the transposed frequency bands may be inverted as explained hereinbefore, although the scrambling of the message may be more effective if adjacent transposed frequency bands are not inverted and also if all transposed frequency bands are not inverted.

Each of the modulators 15 and 21 may be bilateral modulators, preferably of the double balanced copper-oxide type as illustrated. The modulators include a lattice network having a copper-oxide rectifier unit in each of the series and lattice arms with all units being poled in the same direction, and a transformer connected across the input terminals of the network and another connected across the output terminals. The oscillator for each modulator, which is the source of the carrier frequency which is modulated with the divided voice frequency band or the voice sub-band, is connected across the mid-points of the transformers as shown. Although the balanced copper-oxide type of modulator is preferred, any type of modulator may be used, another suitable kind being disclosed in the Carson Patent No. 1,343,306 dated June 15, 1920.

The band filter means used should have exceedingly sharp cut-off frequency curves and each filter means will be composed of a number of sections to give the proper attenuation of the undesired frequencies. Such filter means may be constructed from the data disclosed in the Campbell Patent 1,227,113 dated May 22, 1917.

In order to further scramble the message so that it becomes even more difficult for an unauthorized person to fathom the scrambling which has been done, the combined transposed frequency bands or the combined frequency-oscillations from the side band filter means 17 and 23 and the band filter means 26 may be inverted. This is accomplished by supplying a carrier frequency from an oscillator 29, which carrier frequency is applied to the combined frequency oscillations and then passed through a modulator 35, of any suitable kind, for inversion, as will be described. The modulator is preferably of the balanced tube type shown, for example, in the Hartley Patent 1,419,562 dated June 13, 1922.

Before the frequencies from transformer 28 can be applied to modulator 35, they must have their phase inverted. It is necessary in this type of modulator to furnish the grid 41 of each of the tubes 42 with signal voltages that are equal in magnitude and 180 degrees out of phase. The Hartley type of modulator suppresses in the output circuit the unmodulated component of the applied inverting or carrier wave and also the applied speech waves or the combined speech frequencies. To do this and prevent them from appearing in the output, it is necessary that each grid receive the signal voltages 180 degrees out of phase and of equal amplitude. The Hartley patent shows the use of an input transformer with a center tapped secondary winding to produce secondary voltages equal in magnitude and 180 degrees out of phase and then provides means to compensate for inequalities of the two

secondary windings and the unequal distributed capacity.

Instead of using the Hartley type of modulator circuit as disclosed in the patent, it is preferred to modify it somewhat in order to assure that the voltage oscillations appearing at the grid 41 of each tube 42 of the modulator 35 will be equal in magnitude and 180 degrees out of phase. Therefore a phase inverter circuit 36 is connected with the secondary of the transformer 28, and the modulator 35 is connected with modulator 36 as will be described in more detail hereinafter. The phase inverter takes advantage of the equal and out of phase signal voltages that are developed in the plate and cathode circuits of a thermionic tube or triode 37. Thus when the plate 38 of the tube swings positive, the cathode 39 swings negative, and vice versa, and the voltage variations are always exactly 180 degrees out of phase. Also in this phase inverter 36, the plate current is at every instant equal to the cathode current. Thus the unmodulated frequencies from transformer 28 go through the process of phase inversion and enter modulator 35 for modulation. Since the phase inverter is in effect a substitute for the input transformer of the Hartley modulator circuit having a center tapped secondary and compensating means, it may be regarded as a part of the modulator 35 if desired.

The carrier frequency supplied by the oscillator 29 passes to a transformer 30 which feeds into a phase inverter 31 which is identical with the phase inverter 36 heretofore described. The three output wires 32, 33 and 34 of the phase inverter 31 from plate, cathode and neutral point of the tube circuit, respectively, are connected with corresponding parts of the tube circuit of the phase inverter 36 so that the carrier frequency and the combined frequency oscillations pass together to the modulator 35.

The combined frequency oscillations, carried by the transformer 28, and the carrier frequency oscillations from the oscillator 29 preferably have their phase inverted separately by a phase inverter 36 and 31 for each kind or class of oscillations. The carrier frequency may be connected with the transformer 28 for the input of phase inverter 36 if desired, although the provision of separate phase inverters assures that intermodulation will not take place between these frequencies.

The transposed speech frequencies extending from 300 to 3200 C. P. S. and the inverting carrier frequency of 3400 C. P. S. from the oscillator 29 and phase inverter 31 enter the modulator 35 in which two side bands are produced, namely an upper and a lower or difference side band, and a filter means 40 passes the lower or inverted side band frequencies and suppresses other frequencies. The inverted and combined transposed speech frequencies may be transmitted by wire or radio in a known manner, or may be used to form a sound track upon a record of which there are many forms, or may be transmitted in any other suitable manner.

A modulator of the Hartley type is used for the modulator 35 because here the carrier frequency and the speech frequency are balanced out in the output of the modulator. The filter means 40 also prevents the carrier frequency from the oscillator 29 from being transmitted so that there is in effect a double elimination of this frequency which assures, as a precaution, that this frequency shall not be transmitted.

Further scrambling of, or the inclusion of additional variation in, the transmitted speech which naturally further increases the difficulty of unscrambling or making understandable the transmitted message may be accomplished by constantly varying the inverting carrier frequency, produced by the oscillator 28, upwardly and downwardly a predetermined number of cycles per second and at a predetermined speed. The illustrated embodiment shows the inverting carrier frequency varied by 100 C. P. S. upwardly and downwardly, or a total of 200 C. P. S., that is from 3300 to 3500 C. P. S. This wide variation is rendered possible by the raising of the frequency level of the communication. The side band frequency is therefore constantly varying although it has a frequency width of 2900 cycles at any instant. Now when the inverting carrier frequency is at its lower frequency limit of 3300 cycles, the lower inverted side band extends from 100 to 3000 cycles, and the upper side band from 3600 to 6500 cycles. When the inverting carrier frequency reaches its upper limit of 3500 cycles, the lower inverted side band will occupy a range from 300 to 3200 cycles per second. The filter means 40 has been selected or designed to transmit or pass to the output line only the lower inverted side band over its varying frequency range while extinguishing the frequencies of the varying upper side band. Since the inverting carrier frequency is constantly varying, the filter means 40 must necessarily pass a slightly greater frequency band, namely 100-3200 C. P. S., than if the inverting carrier frequency were constant at 3400 cycles, in which case the filter means would be constructed to pass a slightly narrower range, namely from 200-3100 C. P. S.

The oscillators 16, 22 and 29 may be of any suitable kind, although the vacuum tube type is preferred, one such oscillator being shown in the Hartley Patent 1,356,763 dated October 26, 1920.

As is seen, the inverting carrier frequency from oscillator 29 varies between 3300 and 3500 C. P. S. These frequency variations are obtained by constantly varying the frequency determining tuned circuit of the oscillator 29 such as by connecting this circuit with a cyclically varying capacity means 43. By constructing the condenser plates in a desired shape, the frequency of the oscillator can be made to vary cyclically in any desired manner between 3300 and 3500 cycles per second. The cyclically varying capacity means may include a plate or plate means 44 which is driven rotatively by a motor 45. The plate means is illustrated as mounted upon the motor shaft 46 from which it is insulated in any suitable fashion such as by the insulation 47. A brush connection 48 may establish electrical connection between the rotatable plate means 44 and the oscillator 29.

In the present system it is necessary, in order to receive the scrambled speech, to have at the receiving station a variable inverting carrier frequency that must vary continuously and in the same manner as the inverting frequency at the transmitting station. A motor similar to the motor 45 is therefore provided at the distant or receiving station for producing the varying frequency of the wave generated at that station, and the synchronizing mechanism at the receiving station has suitable control mechanism to maintain two such independently driven variable capacity means in step with each other. A correcting or synchronizing means 51 is preferably employed for this purpose. The correcting or

synchronizing means per se forms no part of the present invention and any suitable synchronizing means may be used with the present invention. However, the synchronizing system, used at both the transmitting station and the receiving station and indicated diagrammatically in the drawings, may be such as that disclosed in the patent to Heising 1,501,711 dated July 15, 1924. The synchronizing impulses are shown as being in the range of 0 to 100 C. P. S., that is, outside of the range of the transmitted speech or intelligence frequencies of 100 to 3200 C. P. S. passed by the band pass filter means 40.

The synchronizing means described in the Heising patent sends out synchronizing impulses which are sent with the scrambled oscillations or message and these impulses control or synchronize the speed of the varying capacity means of the receiving station so that it rotates in step with the received impulses. If the two driven capacitive devices are in step, the synchronizing impulses produce no result, but if the distant or driven capacitive device at the receiving station is either lagging or leading with respect to the transmitting controlling device, the correction or synchronizing impulses cause a shift in the varying capacity means with respect to its driving motor so as to restore the same to in-phase position with respect to the synchronizing impulses. The impulses are merely phase-correcting impulses and have no significance whatever as to the signals or message oscillations being transmitted. Since the number of synchronizing impulses transmitted per revolution of the condenser plate may be varied at will, as may also the shape of the condenser plates, the gear ratio, etc., these synchronizing impulses give no clue as to the manner of variation of the inverting carrier frequency. A low pass filter means 49 permits the transmission of the synchronizing impulses, but keeps the circuit through the synchronizing mechanism free of or blocks out the high frequencies used in transmitting the message.

It will now be noted that the original audio frequency range of 100 to 2800 C. P. S. not only has been divided into a plurality of sub-bands which have been shifted or transposed to another band in the spectrum and one or more of which may be inverted, but has also had its combined frequency range in circuit 27 raised to a higher level. In other words, the lower frequency is now 300 C. P. S., as compared to the lower frequency in the input of 100 C. P. S. By so raising the frequency level of the original range of frequency, the carrier frequency produced by the oscillator 29 may vary through a considerable range. With the plus and minus 100 C. P. S. variation particularly illustrated, a variation of 200 C. P. S. can be used and still keep the varying frequencies well above zero C. P. S., or, as shown, above the 100 C. P. S. range. The raised or higher level of frequency range of the transposed bands also enables a wide separation to be obtained between the high frequencies of the low or difference side band and the low frequencies of the high side band. Such wide separation permits the use of a band pass filter of fixed value which does not require sharp frequency characteristics or limits.

The transposed message may be transmitted by radio or wire in a known manner, or may be recorded and the record transmitted to the receiving station.

The receiving station or apparatus uses sub-

stantially the identical means used with the transmitting apparatus and nearly in the reverse relation as will appear hereinafter. The scrambled signal is received in the input circuit 53 which is connected with a transformer 54. It is to be understood that the circuit 53 may be connected with a wire for wired transmission from the transmitter, or may be connected with suitable radio receiving equipment which receives the radio transmission and suitably detects the radio waves so that the scrambled message is restored to the same combined frequency range as it was sent from the output circuit 50 of the transmitter of Figure 1. The electrical waves or oscillations may be suitably amplified before applied to the receiving apparatus for unscrambling the message. The secondary of the transformer is connected with a by-pass filter means 55 which passes the oscillations having frequencies from 100-3200 C. P. S. The by-pass filter means is connected with a phase inverter 56.

The secondary of the transformer 54 is also connected with a branch circuit 58 having a low pass filter means 59 for passing the synchronizing impulses in the 0-100 C. P. S. frequency range. The branch circuit 58 connects with the receiving means of the synchronizing mechanism 60, described and illustrated in the Heising Patent 1,501,711 previously referred to, and which is illustrated diagrammatically in Figure 2. The synchronizing mechanism is driven by a motor means 61 which also drives a variable capacity means 62, such as the rotatable condenser plate 63. The rotation of this condenser plate is controlled by the synchronizing mechanism 60 so that the rotatable plate 63 rotates in step with the received message, that is, with the received synchronizing impulses. The rotatable plate of course is insulated from the motor in any suitable fashion such as by insulating means 64. A brush or contact 65 maintains electrical contact with the rotatable plate 63 and is connected with an oscillator 68.

The fixed condenser plates 66 are connected by a wire 67 with an oscillator 68. It is to be understood that the means for varying the oscillations produced by the oscillator 68, that is, the characteristics or shapes of the condenser plates 63 and 66, must be identical with the characteristics of the variable capacity means 43. It is also to be understood that whatever means is utilized to continuously vary the frequency produced by the oscillator 68 in the transmitter should be duplicated in the receiver, in order that the variation in carrier frequency produced by the oscillator 68 of the receiver shall be the same as the variations in carrier frequency produced by oscillator 29 of the transmitter. The oscillator 68 produces a carrier frequency which is the same as that produced by the oscillator 29 in the transmitter, namely 3400 C. P. S., which varies, plus and minus, to a maximum of 100 C. P. S. under the influence of the variable capacity means 62.

The oscillator 68 is connected by the wires 70 to a phase inverter 71. Corresponding parts of each phase inverter 56 and 71 are connected together and to a balanced modulator 72. The phase inverters 56 and 71 correspond with the phase inverter 36 in the transmitter, and the balanced modulator 72 may correspond with the balanced modulator 35 in the transmitter. These devices, therefore, need no detailed description here. As in the transmitter, the transposed frequency bands and the local carrier may

use or feed into a single phase inverter, however the circuit illustrated is preferred to avoid any possibility of intermodulation. The carrier frequency of 3400 C. P. S. plus and minus 100 C. P. S. produces a high and low side band and the low side band is the transmitted frequency band in inverted relation and without variation, thereby restoring the speech frequencies as they were in circuit 27 of the transmitting circuit.

The output connection or wires 75 from the balanced modulator 72 divides into three separating or dividing circuits 76, 77 and 78, which circuits or branches correspond in number with the number of the frequency bands into which the original message was divided or separated. The circuit 76 includes a band pass filter means 78 which passes frequencies from 1400-1800 which are the frequencies which were unchanged in the original transmission of the message. In other words, the circuit 76 corresponds with the circuit 12 of the transmitter.

The circuit 77 leads to a band pass filter means 82 which passes frequencies from 1900-3200 C. P. S. and suppresses all other frequencies. In other words, the circuit 77 corresponds with the circuit 11 of the transmitter. The band pass filter means is connected with a balanced modulator or demodulator 83, which corresponds with the balanced modulator 15 of the transmitter, into which modulator an oscillator 84 feeds a carrier frequency corresponding to the carrier frequency produced by the oscillator 16. This oscillator will therefore develop a frequency of 1800 cycles per second. The output of the modulator 83 carries two side bands so that the modulator is therefore connected with a band pass filter means 82 which passes the low frequency side band of 100-1400 C. P. S. and suppresses all other frequencies. It will be observed, therefore, that the band of frequencies fed into the circuit 11 has been restored to its original frequency band, that is, its original position in the frequency spectrum.

The circuit 78 includes a band pass filter means 88 which passes frequencies of 300-1300 C. P. S. and suppresses all other frequencies. The band pass filter means is connected with a balanced modulator or demodulator 89 which receives a carrier frequency of 1500 C. P. S. from the oscillator 90. It will be understood that the oscillator 90 produces the same carrier frequency produced by the oscillator 22 in the transmitter. The output of the modulator 89 carries two side bands so that it is connected with a band pass filter means 91 which passes frequencies from 1800-2800 C. P. S. and suppresses all other frequencies. It will be noted, therefore, that the output of the circuit 78 restores the original frequencies carried by the circuit 13.

The output of each of the band pass filter means 79, 85 and 91 is connected together in the wires or circuit 94 and restores the transmitted frequency range of 100-2800 cycles per second. The wires 94 are connected to any suitable translating device or means 95, such as a loud speaker or telephone receiver, for translating the electrical oscillations into an audible message. It will be noted that the receiving mechanism has unscrambled the message or transposed the separated frequency bands or sub-bands originally received so that the message may be heard in the sound receiver 95 just as it was transmitted.

The method and apparatus described also has another distinct advantage in addition to those discussed hereinbefore, in that one of the com-

bination components is constantly changing, even while conversations are being carried on over the system or apparatus. To further complicate things, the manner or scheme in which this combination component is varied can be changed from time to time. This is accomplished by changing the shape or geometric design of the rotatable capacitive means or condenser plate or plates, such as by removing the connected capacitive means and substituting therefor another of a different size or shape. It is to be understood that the same shape of capacitive plate or plates must be used in both the transmitter and the receiver.

The possibility of understanding any of the message contained in any one of the transposed and separated frequency bands or sub-bands is not possible. In other words, the frequency bands are chosen narrow enough so that there is no understandable speech in any band. In one such divided frequency band it may be possible to understand one word now and then, but the words in between are unintelligible and hence no understandable message has been intercepted. In this connection, it has been found that the separated frequency bands or sub-bands in the center of the speech frequency range should be narrow in frequency range, about 400 C. P. S. or less, in order not to carry any understandable speech. The upper and lower separated bands may be greater in frequency range so long as each band by itself does not carry an understandable message. Obviously, any inverted separated frequency band or sub-band is entirely unintelligible. In other words, any one of the sub-bands within itself would be incapable of being understood. This is assuming that an interceptor had somehow managed to separate one of the sub-bands from the rest. Such unauthorized separation is of course not possible because in the fully scrambled message utilizing a constantly varying inverting carrier frequency from oscillator 29, not one of the sub-bands occupy the same place in the spectrum for more than an instant. The manner in which they shift in the spectrum and the speed of the shifting would never be ascertained by an unauthorized interceptor because no clues are transmitted as to the manner of the variation.

An interceptor attempting to heterodyne any of the sub-bands would succeed only in producing the utmost confusion. Heterodyning of any of the sub-bands would automatically superimpose one sub-band on another in the same frequency range, and since the heterodyne frequency could not be varied in the correct manner, further garbling would result.

The method and apparatus of the invention has been described and illustrated in the voice frequency range, and it is to be understood that the principles thereof are applicable as well to other types of signalling systems employing higher frequencies.

This invention is presented to fill a need for improvements in an apparatus and method for communication. It is understood that various modifications in structure, as well as changes in mode of operation, assembly, and manner of use, may and often do occur to those skilled in the art, especially after benefiting from the teachings of an invention. Hence, it will be understood that this disclosure is illustrative of preferred means of embodying the invention in useful form by explaining the construction, operation and advantages thereof.

What is claimed is:

1. An apparatus for receiving a communication comprising a circuit carrying a communication in the form of electrical oscillations of transposed frequency bands, means connected with the aforesaid circuit to produce a carrier frequency which produces side bands with the received communication, means to continuously vary the carrier frequency at the same speed and the same frequency range as the transmitted communication was varied, means to select one side band, a plurality of circuits branching from the next aforesaid means including means in each circuit to separate the electrical oscillations into a plurality of frequency bands corresponding in number and frequency range with the original separation of the frequency range transmitted, means in each branch circuit carrying a transposed frequency band to restore the same to its original frequency range, means connecting together the outputs of each of the next aforesaid means and any branch circuit carrying untransposed frequency bands to form a combined frequency band, and means to convert the restored frequency bands to audible speech.

2. An apparatus for communication comprising means to convert an audible communication into electrical oscillations, a plurality of circuits including means in each circuit to separate the electrical oscillations of the audio frequency range desired to be transmitted into a plurality of frequency bands, means in a plurality of circuits to transpose a plurality of the frequency bands to another frequency band and each band having a frequency range different from that carried by any other circuit, means connecting together the outputs of each of the next aforesaid means and any circuit carrying untransposed frequency bands to form a combined frequency band, means connected with the next aforesaid means to invert the combined frequency band, and means to continuously vary the combined frequency band for transmission.

3. An apparatus for communication comprising means to convert a communication into electrical oscillations, a plurality of circuits including means in each circuit to separate the electrical oscillations of the frequency range desired to be transmitted into a plurality of frequency bands, means in a plurality of circuits to transpose a plurality of the frequency bands to another frequency band and each band having a frequency range different from that carried in the output of any other circuit, means connecting together the outputs of each of the next aforesaid means and any circuit carrying untransposed frequency bands to form a combined frequency band, means connected with the next aforesaid means to produce a carrier frequency which produces side bands with the combined frequency band, means to continuously vary the carrier frequency over a predetermined frequency range, and means to select one side band for transmission.

4. An apparatus for communication comprising means to convert an audible communication into electrical oscillations, a plurality of circuits including filter means in each circuit to separate the electrical oscillations of the audio frequency range desired to be transmitted into a plurality of frequency bands, a balanced modulator in each of a plurality of the circuits, means to produce a carrier frequency for each modulator to transpose the frequency band carried thereby and form a side band having a desired frequency range, filter means connected to the output of each modulator

to pass only the desired frequency side band for that circuit so that the output of each circuit has a frequency range different from the frequency range in any other circuit, means connecting together the outputs of each of the next aforesaid filter means and the outputs of any circuits carrying untransposed frequency bands thereby combining the frequency bands, a balanced modulator connected with the connecting means, an oscillator connected with the next aforesaid balanced modulator and producing a carrier frequency above the maximum frequency in the combined frequency band, means to continuously vary the frequency produced by the next aforesaid oscillator, and filter means connected with the output of the last mentioned balanced modulator to pass a side band to be transmitted and suppressing other frequencies.

5. An apparatus for receiving a communication comprising a circuit carrying a communication in the form of electrical oscillations of transposed frequency bands, means connected with the aforesaid circuit to invert the combined transposed frequency bands and continuously vary the combined frequency band at the same speed and over the same frequency range as the transmitted communication was varied, a plurality of branch circuits including means in each circuit to separate the electrical oscillations into a plurality of frequency bands corresponding in number and frequency range with the original separation, means in each circuit carrying a transposed frequency band to restore the same to its original frequency range, means connecting together the outputs of each of the next aforesaid means and any branch circuit carrying untransposed frequency bands to form a combined frequency band, and means to convert the electrical oscillations to audible speech.

6. An apparatus for receiving a communication comprising a circuit carrying a communication in the form of electrical oscillations of transposed frequency bands, means connected with the aforesaid circuit to produce a carrier frequency which produces side bands with the transmitted electrical oscillations, means to continuously vary the carrier frequency at the same speed and over the same frequency range as the transmitted electrical oscillations, means to select the difference side band for transmission whereby the electrical oscillations are inverted, a plurality of circuits branching from the next aforesaid means including means in each branch circuit to separate the electrical oscillations into a plurality of frequency bands corresponding in number and frequency range with the separation of the communication transmitted, means in each branch circuit carrying a transposed frequency band to restore the same to its original frequency range, means connecting together the outputs of each of the next aforesaid means and any branch circuit carrying untransposed frequency bands to form a combined frequency band, and means to convert the electrical oscillations into audible speech.

7. An apparatus for receiving a communication comprising a circuit carrying a communication in the form of electrical oscillations of transposed frequency bands, a balanced modulator connected with the circuit, an oscillator connected with the balanced modulator and producing a carrier frequency to restore the original frequency range of the transposed and combined frequency band transmitted, means to continuously vary the frequency produced by the oscil-

lator at the same speed and extent as the variation of the transmitted communication, filter means connected with the output of the balanced modulator to pass a side band restoring the original combined frequency bands and suppressing other frequencies, a plurality of circuits branching from the filter means including filter means in each branch circuit to separate the electrical oscillations into a plurality of frequency bands corresponding in number and frequency range with the original separation of the frequency range transmitted, a balanced modulator in each of the circuits carrying a transposed frequency band, means to produce a carrier frequency for each modulator in a branch circuit to transpose the frequency band carried thereby and form a side band which restores the frequency band to that of the original frequency band, filter means connected to the output of each modulator in a branch circuit to pass only the restored frequency side band for that circuit, means connecting together the outputs of each of the next aforesaid filter means and the outputs of any circuits carrying untransposed frequency bands thereby combining the restored frequency bands, and means connected to the next aforesaid means to convert the oscillations of the combined frequency bands into audible speech.

8. An apparatus for communication comprising means to convert an audible communication into electrical oscillations, a plurality of circuits leading therefrom including means in each circuit to separate the electrical oscillations of the audio frequency range desired to be transmitted into a plurality of frequency bands, means in a plurality of the separating circuits to transpose a plurality of the frequency bands to another frequency band and each band having a frequency range different from that in the output of any other circuit, means connecting together the outputs of each of the next aforesaid means and any circuit carrying untransposed frequency bands to form a combined frequency band, means connected with the next aforesaid means to invert the combined frequency band, means to continuously vary the inverted combined frequency band for transmission, a receiving circuit carrying the transmitted communication in the form of electrical oscillations of transposed frequency bands, means connected with the receiving circuit to invert the combined transposed frequency bands and continuously vary the combined frequency band at the same speed and over the same extent that the transmitted communication was varied, a plurality of circuits branching from the next aforesaid means including means in each circuit to separate the electrical oscillations into a plurality of frequency bands corresponding in number and frequency range with the original separation, means in each circuit carrying a transposed frequency band to restore the same to its original frequency range, means connecting together the outputs of each of the next aforesaid means and any branch circuit carrying untransposed frequency bands to form a restored combined frequency band, and means to convert the restored combined frequency band to audible speech.

9. An apparatus for communication comprising means to convert a communication into electrical oscillations, a plurality of circuits leading therefrom including means in each circuit to separate the electrical oscillations of the frequency range desired to be transmitted into a

plurality of frequency bands, means in a plurality of circuits to transpose a plurality of the frequency bands to another frequency band and each band having a frequency range different from that in the output of any other circuit, means connecting together the outputs of each of the next aforesaid means and any circuit carrying untransposed frequency bands to form a combined frequency band, means connected with the next aforesaid means to produce a carrier frequency which produces side bands with the combined frequency band, means to continuously vary the carrier frequency over a predetermined frequency range and at a predetermined speed, means to select one side band for transmission, a receiving circuit carrying the communication in the form of electrical oscillations of transposed frequency bands, means connected with the receiving circuit to produce a carrier frequency which produces side bands with the received communication, means to continuously vary the carrier frequency at the same speed and over the same frequency range as the transmitted communication was varied, means to select one side band, a plurality of circuits branching from the next aforesaid means including means in each circuit to separate the electrical oscillations into a plurality of frequency bands corresponding in number and frequency range with the original separation of the frequency range transmitted, means in each branch circuit carrying a transposed frequency band to restore the same to its original frequency range, means connecting together the outputs of each of the next aforesaid means and any branch circuit carrying untransposed frequency bands to form a restored combined frequency band, and means to convert the restored combined frequency band to audible speech.

10. An apparatus for communication comprising means to convert a communication into electrical oscillations, a plurality of circuits leading therefrom including means in each circuit to separate the electrical oscillations of the frequency range desired to be transmitted into a plurality of frequency bands, means in a plurality of circuits to transpose a plurality of the frequency bands to another frequency band and each band having a frequency range different from that in the output of any other circuit, means connecting together the outputs of each of the next aforesaid means and any circuit carrying untransposed frequency bands to form a combined frequency band, means connected with the next aforesaid means to produce a carrier frequency which produces side bands with the combined frequency band, means to continuously vary the carrier frequency over a predetermined frequency range and at a predetermined speed, means to select the difference side band for transmission whereby the combined frequency band is inverted, a receiving circuit carrying a communication in the form of electrical oscillations of transposed frequency bands, means connected with the receiving circuit to produce a carrier frequency which produces a difference side band with the transmitted electrical oscillations which corresponds with the combined frequency band, means to continuously vary the carrier frequency at the same speed and over the same frequency range as the transmitted electrical oscillations, means to select the difference side band for transmission whereby the electrical oscillations are inverted, a plurality of circuits branching from the next aforesaid means including means in

each branch circuit to separate the electrical oscillations into a plurality of frequency bands corresponding in number and frequency range with the separation of the communication transmitted, means in each branch circuit carrying a transposed frequency band to restore the same to its original frequency band, means connecting together the outputs of each of the next aforesaid means and any branch circuit carrying untransposed frequency bands to form a restored combined frequency band, and means to convert the electrical oscillations into audible speech.

11. An apparatus for communication comprising a circuit carrying a communication in the form of electrical oscillations, a plurality of parallel circuits including means in each circuit to separate the electrical oscillations into a plurality of frequency bands including a low band and at least one higher band, means in at least one of the parallel circuits to transpose one of the frequency bands to another frequency band and so that the frequency level of the combined frequency range in the output of the parallel circuits is changed, each band having a frequency range different from that carried in the output of any other parallel circuit, and means connecting together the outputs of each of the parallel circuits.

12. An apparatus for communication comprising a circuit carrying a communication in the form of electrical oscillations, a plurality of parallel circuits branching therefrom to separate the electrical oscillations into a plurality of frequency bands including a low band and at least one higher band, the low band having a frequency range different from that of the higher band to be transposed to the low band position, means in a plurality of the parallel circuits to transpose the low frequency band to another frequency band and a higher band to the low band position whereby the overall frequency level is changed, each band having a frequency range different from that carried in the output of any other parallel circuit, and means connecting together the outputs of each of the parallel circuits.

13. An apparatus for communication comprising a circuit carrying a communication in the form of electrical oscillations, a plurality of parallel circuits branching therefrom to separate the electrical oscillations into a plurality of frequency bands including a low band and at least one higher band, each parallel circuit including means to select a different frequency band, means in at least the parallel circuit carrying the low frequency band to transpose the same to another frequency band and so that the frequency level of the combined frequencies is raised, the output of each parallel circuit having a band with a frequency range different from that carried in the output of any other parallel circuit, and means connecting together the outputs of each of the parallel circuits.

14. An apparatus for communication comprising a circuit carrying a communication in the form of electrical oscillations, a plurality of parallel circuits branching therefrom to separate the electrical oscillations into a plurality of frequency bands including a low band and at least one higher band, each parallel circuit including means to select a different frequency band and the circuit carrying the low band having a frequency range greater than the higher band to be transposed to the low band position, means in the parallel circuit carrying the low frequency band to transpose the same to another frequency

band, means in the parallel circuit carrying a higher band of low frequency range than the low frequency band to transpose the same to the low band position whereby the frequency level of the combined frequencies is raised, each parallel circuit carrying a band having a frequency range different from that carried in the output of any other parallel circuit, and means connecting together the outputs of each of the parallel circuits.

15. An apparatus for receiving a communication comprising a circuit carrying a communication in the form of electrical oscillations of transposed frequency bands and of a raised frequency level, a plurality of parallel circuits branching from the aforesaid circuit including means in each circuit to select one of a plurality of frequency bands corresponding in number and frequency range with one of the transposed frequency bands transmitted, means in each parallel circuit carrying a transposed frequency band to transpose and restore the frequency band carried by each circuit to its original frequency band and to lower the frequency level of the combined frequency bands, and means connecting together the outputs of each of the parallel circuits to form a combined frequency band.

16. An apparatus for receiving a communication comprising a circuit carrying a communication in the form of electrical oscillations of transposed frequency bands including a low band and at least one higher band having a greater frequency range than that of the low band, a plurality of parallel circuits branching therefrom to separate the electrical oscillations into a plurality of frequency bands, each parallel circuit including means to select a different frequency band corresponding in frequency range with one of the transposed frequency bands transmitted, means in each parallel circuit carrying a transposed frequency band to transpose and restore the frequency band carried by that circuit to its original frequency band whereby the higher band having a greater frequency range is transposed to the lower band position and thereby lowering the frequency level of the combined frequency bands, and means connecting together the outputs of each of the parallel circuits to form a combined frequency band.

17. An apparatus for communication comprising a circuit carrying a communication in the form of electrical oscillations, a plurality of parallel circuits branching therefrom including means in each circuit to separate the electrical oscillations of the frequency range desired to be transmitted into a plurality of frequency bands including a low frequency band and at least one higher frequency band, means in the parallel circuit carrying the low frequency band to transpose the same to a higher frequency band and to a frequency range different from that in the output of any other parallel circuit and to transpose the same so as to raise the frequency level of the combined oscillations, means connecting together the outputs of each of the parallel circuits to form a combined frequency band and to transmit the same, a receiving circuit carrying the transmitted communication in the form of electrical oscillations of transposed frequency bands, a plurality of parallel receiving circuits branching from the receiving circuit including means in each circuit to separate the electrical oscillations into a plurality of frequency bands corresponding in number and frequency range with the original transposed frequency bands, means in each parallel

circuit carrying a transposed frequency band to transpose and restore the same to its original transposed frequency range thereby restoring the original frequency level, and means connecting together the outputs of each of the parallel receiving circuits to form a restored combined frequency band.

18. An apparatus for communication comprising a circuit carrying a communication in the form of electrical oscillations, a plurality of parallel circuits branching therefrom including means in each circuit to separate the electrical oscillations of the frequency range desired to be transmitted into a plurality of frequency bands including a low frequency band and a higher frequency band having a lower frequency range, means in the parallel circuit carrying the low frequency band to transpose the same to another frequency band, means in the parallel circuit carrying the aforesaid higher frequency band to transpose the same to the position occupied by the low frequency band and so as to raise the frequency level of the combined oscillations, each band having a frequency range different from that in the output of any other parallel circuit, means connecting together the outputs of each of the parallel circuits to form a combined frequency band and to transmit the same, a receiving circuit carrying the transmitted communication in the form of electrical oscillations of transposed frequency bands, a plurality of parallel receiving circuits branching from the receiving circuit including means in each circuit to separate the electrical oscillations into a plurality of frequency bands corresponding in number and frequency range with the original transposed frequency bands, means in each circuit carrying a transposed frequency band to restore the same to its original frequency range thereby restoring the original frequency level, and means connecting together the outputs of each of the parallel receiving circuits to form a restored combined frequency band.

19. An apparatus for communication comprising a circuit carrying a communication in the form of electrical oscillations, a plurality of parallel circuits branching therefrom including means in each circuit to separate the electrical oscillations of the frequency range desired to be transmitted into a plurality of frequency bands including a low frequency band and at least one higher frequency band, means in the parallel circuit carrying the low frequency band to transpose the same to a higher frequency band and to a frequency range different from that carried in the output of any other parallel circuit and to transpose the same so as to raise the frequency level of the combined oscillations, means connecting together the outputs of each of the parallel circuits to form a combined frequency band, modulating means connected with the connecting means and producing a carrier frequency, and means to vary the carrier frequency over a predetermined frequency range.

20. An apparatus for communication comprising a circuit carrying a desired range of electrical oscillations, a plurality of parallel branches connected with the input circuit including means in each parallel branch to separate the electrical oscillations into a plurality of frequency bands, means in at least one of the parallel branches to transpose its frequency band to another frequency band and each parallel branch having in its output a band having a frequency range different from that carried in the output of any

other parallel branch, the outputs of each of the next aforesaid means and of any parallel branch carrying an untransposed frequency band being connected to form an output circuit carrying a combined frequency band, said transposing means also changing the frequency level of the combined frequency band, modulating means connected with one of the aforesaid circuits, an oscillator connected with the modulating means to produce a carrier frequency, and means to vary the carrier frequency over a predetermined frequency range.

21. An apparatus for communication comprising a circuit carrying a desired frequency range of electrical oscillations, a plurality of parallel circuits branching therefrom including means in each parallel circuit to separate the electrical oscillations of the frequency range desired to be transmitted into a plurality of frequency bands, means in at least one of the parallel circuits to transpose its frequency band to another frequency band and each band having a frequency range different from that carried in the output of any other parallel circuit, said transposing means also raising the frequency level of the combined frequency bands, means connecting together the outputs of each of the next aforesaid means and any circuit carrying an untransposed frequency band to form a combined frequency band, means connected with the next aforesaid means to produce a carrier frequency which produces side bands with the combined frequency band, means to vary the carrier frequency over a predetermined frequency range, and means to select one side band for transmission.

22. An apparatus for communication comprising a circuit carrying a desired range of electrical oscillations, a plurality of parallel circuits branching therefrom including means in each parallel circuit to separate the electrical oscillations of the frequency range desired to be transmitted into a plurality of frequency bands, means in at least one of the parallel circuits to transpose its frequency band to another frequency band and each band having a frequency range different from that carried in the output of any other parallel circuit, the outputs of each of the next aforesaid means and of any parallel circuit carrying untransposed frequency bands being connected to form a combined frequency band, said transposing means also raising the frequency level of the combined frequency band, means connected with the output of the parallel circuits to produce a carrier frequency which produces side bands with the combined frequency band, means to vary the carrier frequency over a predetermined frequency range, and means generating a synchronizing impulse in timed relation with the next aforesaid means.

23. An apparatus for communication comprising a circuit carrying a communication in the form of electrical oscillations, a plurality of parallel circuits branching therefrom including means in each circuit to separate the electrical oscillations of the frequency range desired to be transmitted into a plurality of frequency bands including a low band and at least one higher band, the low band having a frequency range greater than the higher band to be transposed to the low band position, means in a plurality of circuits to transpose the low frequency band to another frequency band and a higher band of lower frequency range than the low frequency band to the low band position whereby the fre-

quency level is raised, each band having a frequency range different from that carried in the output of any other parallel circuit, means connecting together the outputs of each of the parallel circuits to form a combined frequency band, means connected with the next aforesaid means to produce a carrier frequency which produces side bands with the combined frequency band, and means to vary the carrier frequency over a predetermined frequency range.

24. An apparatus for receiving a communication comprising a circuit carrying a communication in the form of varying electrical oscillations of transposed frequency bands and having a raised frequency level including a demodulator means, means connected with the demodulator means to produce a carrier frequency to demodulate the received oscillations, means to vary the carrier frequency at the same speed and the same frequency range as the transmitted communication was varied, a plurality of circuits branching from the demodulator means including means in each circuit to separate the electrical oscillations into a plurality of frequency bands corresponding in number and frequency range with the frequency bands after transposition in the transmitter, means in each branch circuit carrying a transposed frequency band to restore the same to its original band thereby restoring the original lower frequency level, and means connecting together the outputs of each of the parallel circuits to form a combined frequency band.

25. An apparatus for receiving a communication comprising a circuit carrying a communication in the form of varying electrical oscillations of transposed frequency bands and having a raised frequency level including a demodulating means, means connected with the demodulating means to produce a carrier frequency to demodulate the received oscillations, means to vary the carrier frequency at the same speed and the same frequency range as the transmitted communication was varied, a plurality of parallel circuits branching from the demodulating means including means in each circuit to separate the electrical oscillations into a plurality of frequency bands corresponding in number and frequency range with the frequency bands after transportation in the transmitter, and means in each parallel circuit carrying a transposed frequency band to restore the same to its original band thereby restoring the original lower frequency level, the outputs of each parallel circuit being connected together to form a restored combined frequency band.

26. An apparatus for receiving a communication comprising a circuit carrying a communication in the form of synchronizing impulses and varying electrical oscillations of transposed frequency bands and having a raised frequency level including a demodulating means, means connected with the demodulating means to produce a carrier frequency to demodulate the received oscillations, means to vary the carrier frequency at the same speed and the same frequency range as the transmitted communication was varied, means responsive to the synchronizing impulses to synchronize the next aforesaid means, a plurality of circuits branching from the demodulating means including means in each circuit to separate the electrical oscillations into a plurality of frequency bands corresponding in number and frequency range with the frequency bands after transposition in the transmitter, and means in

each branch circuit carrying a transposed frequency band to restore the same to its original frequency band thereby restoring the lower frequency level, the outputs of each branch circuit being connected together to form a combined frequency band.

27. An apparatus for receiving a communication comprising a circuit carrying a communication in the form of varying electrical oscillations of transposed frequency bands and having the low frequency band of the transmitted communication of a lower frequency range than the band to be retransposed to the low band position including a demodulating means, means connected with the demodulating means to produce a carrier frequency to demodulate the received oscillations, means to vary the carrier frequency at the same speed and the same frequency range as the transmitted communication was varied whereby the varying frequency range becomes unvarying, a plurality of circuits branching from the demodulator means including means in each circuit to separate the electrical oscillations into a plurality of frequency bands corresponding in number and frequency range with the frequency bands after transposition in the transmitter, and means in each branch circuit carrying a transposed frequency band to restore the same to its original frequency range whereby the frequency level is lowered, the outputs of each of the parallel circuits being connected together to form the combined frequency band of the transmitted communication.

28. An apparatus for communication comprising a circuit carrying a communication in the form of electrical oscillations, a plurality of parallel circuits leading therefrom including means in each circuit to separate the electrical oscillations of the frequency range desired to be transmitted into a plurality of frequency bands including a low frequency band and at least one higher frequency band, means in the parallel circuit carrying the low frequency band to transpose the same to a higher frequency band and to a frequency range different from that in the output of any other parallel circuit and to transpose the same so as to raise the frequency level of the combined oscillations, means connecting together the outputs of each of the parallel circuits to form a combined frequency band, modulating means connected with the next aforesaid means including an oscillator to produce a modulating frequency, means connected to the oscillator to vary the modulating frequency and hence the combined frequency band for transmission, a receiving circuit carrying the transmitted communication in the form of electrical oscillations of transposed frequency bands, demodulating means connected with the receiving circuit including an oscillator to produce a demodulating frequency, means to vary the aforesaid demodulating frequency at the same speed and over the same frequency range that the modulating frequency was varied, a plurality of parallel circuits branching from the demodulating means including means in each circuit to separate the electrical oscillations into a plurality of frequency bands corresponding in number and frequency range with the original transposed frequency bands, means in each receiving parallel circuit carrying a transposed frequency band to transpose and restore the same to its original frequency range thereby restoring the original frequency level, and means connecting together the outputs

of each of the receiving parallel circuits to form a restored combined frequency band.

29. An apparatus for communication comprising a circuit carrying an audible communication in the form of electrical oscillations, a plurality of parallel circuits leading therefrom including means in each circuit to separate the electrical oscillations of the frequency range desired to be transmitted into a plurality of frequency bands including a low frequency band and a higher frequency band having a lower frequency range than the low band, means in the parallel circuit carrying the low frequency band to transpose the same to another frequency band, means in the parallel circuit carrying the aforesaid higher frequency band to transpose the same to the position occupied by the low frequency band and so as to raise the frequency level of the combined oscillations, each band having a frequency range different from that in the output of any other parallel circuit, means connecting together the outputs of the parallel circuits to form a combined frequency band, modulating means connected with the next aforesaid means including an oscillator to produce a modulating frequency, means to continuously vary the modulating frequency and hence the combined frequency band for transmission, a receiving circuit carrying the transmitted communication in the form of electrical oscillations of transposed frequency bands, demodulating means connected with the receiving circuit including an oscillator to produce a demodulating frequency, means to vary the demodulating frequency at the same speed and over the same frequency range that the modulating frequency was varied, a plurality of parallel circuits branching from the demodulating means including means in each circuit to separate the electrical oscillations into a plurality of frequency bands corresponding in number and frequency range with the transposed frequency bands in the transmitter, means in each parallel circuit carrying a transposed frequency band to transpose and restore the same to its original frequency range thereby restoring the original frequency level, and means connecting together the outputs of each of the receiving parallel circuits to form a restored combined frequency band.

30. An apparatus for communication comprising a circuit carrying a communication in the form of electrical oscillations, a plurality of parallel circuits including means in each circuit to separate the electrical oscillations into a plurality of frequency bands including a low band and at least one higher band, means in at least one of the parallel circuits to transpose one of the frequency bands to another frequency band so that the spacing between adjacent bands is changed, each band having a frequency range different from that carried in the output of any other parallel circuit, and means connecting together the outputs of each of the parallel circuits.

31. An apparatus for communication comprising a circuit carrying a communication in the form of electrical oscillations, a plurality of parallel circuits including means in each circuit to separate the electrical oscillations into a plurality of frequency bands including a low band and at least one higher band, means in at least one of the parallel circuits to transpose the frequency band carried thereby to another frequency band and so that each frequency band is spaced from its adjacent bands, each band having a frequency range

different from that carried in the output of any other parallel circuit, and means connecting together the outputs of each of the parallel circuits.

32. An apparatus for communication comprising a circuit carrying a communication in the form of electrical oscillations, a plurality of parallel circuits including means in each circuit to separate the electrical oscillations into a plurality of frequency bands including a low band and at least one higher band, means in at least one of the parallel circuits to transpose one of the frequency bands to another frequency band so that the frequency level of the combined frequency range in the output of the parallel circuits is changed and so that the spacing between each frequency band and its adjacent bands is changed, each band having a frequency range different from that carried in the output of any other parallel circuit, and means connecting together the outputs of each of the parallel circuits.

33. An apparatus for communication comprising a circuit carrying a communication in the form of electrical oscillations, a plurality of parallel circuits branching therefrom to separate the electrical oscillations into a plurality of frequency bands including a low band and at least one higher band, the low band having a frequency range different from that of the higher band to be transposed to the low band position, means in a plurality of the parallel circuits to transpose the low frequency band to another frequency band and a higher band to the low band position whereby the overall frequency level is changed and each band is spaced from its adjacent bands, each band having a frequency range different from that carried in the output of any other parallel circuit, and means connecting together the outputs of each of the parallel circuits.

34. An apparatus for communication comprising a circuit carrying a communication in the form of electrical oscillations, a plurality of parallel circuits connected therewith including means in each circuit to separate the electrical oscillations into a plurality of frequency bands including a low band and at least one higher band, each parallel circuit including means to select a different frequency band, means in at least the parallel circuit carrying the low frequency band to transpose the same to another frequency band so that the frequency level of the combined frequency range in the output of the parallel circuits is raised and so that each frequency band is spaced from its adjacent frequency bands, the output of each parallel circuit having a band with a frequency range different from that carried in the output of any other parallel circuit, and means connecting together the outputs of each of the parallel circuits.

35. An apparatus for communication comprising a circuit carrying a communication in the form of electrical oscillations, a plurality of parallel circuits branching therefrom to separate the electrical oscillations into a plurality of frequency bands including a low band and at least one higher band, each parallel circuit including means to select a different frequency band and the circuit carrying the low band having a frequency range greater than the higher band to be transposed to the low band position, means in the parallel circuit carrying the low frequency band to transpose the same to another frequency band and spaced from its adjacent band, means in the parallel circuit carrying a higher band of

lower frequency range than the low frequency band to transpose the same to the low band position and spaced from its adjacent band, whereby the frequency level of the combined frequencies is raised and each band is spaced from adjacent bands, each parallel circuit carrying a band having a frequency range different from that carried in the output of any other parallel circuit, and means connecting together the outputs of each of the parallel circuits.

36. An apparatus for receiving a communication comprising a circuit carrying a communication in the form of electrical oscillations of transposed frequency bands having a raised frequency level and spacing between each band, a plurality of parallel circuits branching from the aforesaid circuit including means in each circuit to select one of a plurality of frequency bands corresponding in number and frequency range with one of the transposed frequency bands transmitted, means in each parallel circuit carrying a transposed frequency band to transpose and restore the frequency band carried by each circuit to its original frequency band so that the frequency level of the combined frequency bands is lowered and the bands are positioned adjacent each other, and means connecting together the outputs of each of the parallel circuits to form a combined frequency band.

37. An apparatus for receiving a communication comprising a circuit carrying a communication in the form of electrical oscillations of transposed frequency bands which are in spaced relation including a low band and at least one higher band having a greater frequency range than that of the low band, a plurality of parallel circuits branching therefrom to separate the electrical oscillations into a plurality of frequency bands, each parallel circuit including means to select a different frequency band corresponding in frequency range with one of the transposed frequency bands transmitted, means in each parallel circuit carrying a transposed frequency band to transpose and restore the frequency band carried by that circuit to its original frequency band so that the higher band having a greater frequency range is transposed to the lower band position thereby lowering the frequency level of the combined frequency bands and bringing the bands into adjacent position, and means connecting together the outputs of each of the parallel circuits to form a combined frequency band.

38. An apparatus for communication comprising a circuit carrying a communication in the form of electrical oscillations, a plurality of parallel circuits branching therefrom including means in each circuit to separate the electrical oscillations of the frequency range desired to be transmitted into a plurality of frequency bands including a low frequency band and at least one higher frequency band, means in the parallel circuit carrying the low frequency band to transpose the same to a higher frequency band and to a frequency band different from that in the output of any other parallel circuit and to transpose the same so as to raise the frequency level of the combined oscillations, the aforesaid means in the transposing of a band spacing the same from its adjacent band, means connecting together the outputs of each of the parallel circuits to form a combined frequency band and to transmit the same, a receiving circuit carrying the transmitted communication in the form of electrical oscillations of transposed frequency bands, a plurality of parallel receiving circuits

branching from the receiving circuit including means in each circuit to separate the electrical oscillations into a plurality of frequency bands corresponding in number and frequency range with the original transposed frequency bands, means in each parallel circuit carrying a transposed frequency band to transpose and restore the same to its original transposed frequency range thereby restoring the original frequency level and bringing the bands into adjacent relation, and means connecting together the outputs of each of the parallel receiving circuits to form a restored combined frequency band.

39. An apparatus for communication comprising a circuit carrying a communication in the form of electrical oscillations, a plurality of parallel circuits branching therefrom including means in each circuit to separate the electrical oscillations of the frequency range desired to be transmitted into a plurality of frequency bands including a low frequency band and a higher frequency band having a lower frequency range, means in the parallel circuit carrying the low frequency band to transpose the same to another frequency band, means in the parallel circuit carrying the aforesaid higher frequency band to transpose the same to the position occupied by the low frequency band so as to raise the frequency level of the combined oscillations and to space each band from its adjacent bands, each band having a frequency range different from that in the output of any other parallel circuit, means connecting together the outputs of each of the parallel circuits to form a combined frequency band and to transmit the same, a receiving circuit carrying the transmitted communication in the form of electrical oscillations of transposed frequency bands, a plurality of parallel receiving circuits branching from the receiving circuit including means in each circuit to separate the electrical oscillations into a plurality of frequency bands corresponding in number and frequency range with the original transposed frequency bands, means in each circuit carrying a transposed frequency band to restore the same to its original frequency range thereby restoring the original frequency level and bringing the bands into adjacent relation, and means connecting together the outputs of each of the parallel receiving circuits to form a restored combined frequency band.

40. An apparatus for communication comprising an input circuit carrying a communication in the form of electrical oscillations, a plurality of parallel branches connected with the input circuit including means in each branch to separate the electrical oscillations into a plurality of frequency bands including a low frequency band and at least one higher frequency band, means in at least one of the parallel branches to transpose the frequency band carried thereby to another frequency band and to a frequency range different from that carried in the output of any other parallel branch, the transposing means changing the frequency range of the combined oscillations and spacing each band from its adjacent bands, an output circuit connecting together the outputs of each of the parallel branches to form a combined frequency band, modulating means connected with one of the aforesaid circuits and producing a carrier frequency, and means to vary the carrier frequency over a predetermined frequency range.

41. An apparatus for communication comprising a circuit carrying a communication in the

form of electrical oscillations, a plurality of parallel circuits branching therefrom including means in each circuit to separate the electrical oscillations of the frequency range desired to be transmitted into a plurality of frequency bands including a low frequency band and at least one higher frequency band, means in the parallel circuit carrying the low frequency band to transpose the same to a higher frequency band and to a frequency range different from that carried in the output of any other parallel circuit and to transpose the same so as to raise the frequency level of the combined oscillations and to space the same from its adjacent bands, means connecting together the outputs of each of the parallel circuits to form a combined frequency band, modulating means connected with the connecting means and producing a carrier frequency, and means to vary the carrier frequency over a predetermined frequency range.

42. An apparatus for communication comprising a circuit carrying a desired range of electrical oscillations, a plurality of parallel circuits branching therefrom including means in each parallel circuit to separate the electrical oscillations of the frequency range desired to be transmitted into a plurality of frequency bands, means in at least one of the parallel circuits to transpose its frequency band to another frequency band and each band having a frequency range different from that carried in the output of any other parallel circuit, the outputs of each of the next aforesaid means and of any parallel circuit carrying an untransposed frequency band being connected to form a combined frequency band, said transposing means also raising the frequency level of the combined frequency band and spacing each band from its adjacent bands, means connected with the output side of the parallel circuits to produce a carrier frequency which produces side bands with the combined frequency band, and means to vary the carrier frequency over a predetermined frequency range.

43. An apparatus for communication comprising a circuit carrying a desired frequency range of electrical oscillations, a plurality of parallel circuits branching therefrom including means in each parallel circuit to separate the electrical oscillations of the frequency range desired to be transmitted into a plurality of frequency bands, means in at least one of the parallel circuits to transpose its frequency band to another frequency band and each band having a frequency range different from that carried in the output of any other parallel circuit, said transposing means also raising the frequency level of the combined frequency band and spacing each band from its adjacent bands, means connecting together the outputs of each of the next aforesaid means and any circuit carrying an untransposed frequency band to form a combined frequency band, means connected with the next aforesaid means to produce a carrier frequency which produces side bands with the combined frequency band, means to vary the carrier frequency over a predetermined frequency range, and means to select one side band for transmission.

44. An apparatus for communication comprising a circuit carrying a desired range of electrical oscillations, a plurality of parallel circuits branching therefrom including means in each parallel circuit to separate the electrical oscillations of the frequency range desired to be transmitted into a plurality of frequency bands, means in at least one of the parallel circuits to transpose

its frequency band to another frequency band and each band having a frequency range different from that carried in the output of any other parallel circuit, the outputs of each of the next aforesaid means and of any parallel circuit carrying untransposed frequency bands being connected to form a combined frequency band, said transposing means also raising the frequency level of the combined frequency band and spacing each frequency band from its adjacent bands, means connected with the output of the parallel circuits to produce a carrier frequency which produces side bands with the combined frequency band, means to vary the carrier frequency over a predetermined frequency range, and means generating a synchronizing impulse in timed relation with the next aforesaid means.

45. An apparatus for communication comprising a circuit carrying a communication in the form of electrical oscillations, a plurality of parallel circuits branching therefrom including means in each circuit to separate the electrical oscillations of the frequency range desired to be transmitted into a plurality of frequency bands including a low band and at least one higher band; the low band having a frequency range greater than the higher band to be transposed to the low band position, means in a plurality of circuits to transpose the low frequency band to another frequency band and a higher band of lower frequency range than the low frequency band to the low band position whereby the frequency level is raised, each band having a frequency range different from that carried in the output of any other parallel circuit, the transposing means also spacing each band from its adjacent bands, means connecting together the outputs of each of the parallel circuits to form a combined frequency band, means connected with the next aforesaid means to produce a carrier frequency which produces side bands with the combined frequency band, and means to vary the carrier frequency over a predetermined frequency range.

46. An apparatus for receiving a communication comprising a circuit carrying a communication in the form of varying electrical oscillations of transposed frequency bands having a raised frequency level and each band being spaced from its adjacent bands including a demodulator means, means connected with the demodulator means to produce a carrier frequency to demodulate the received oscillations, means to vary the carrier frequency at the same speed and the same frequency range as the transmitted communication was varied a plurality of circuits branching from the demodulator means including means in each circuit to separate the electrical oscillations into a plurality of frequency bands corresponding in number and frequency range with the frequency bands after transposition in the transmitter, means in each branch circuit carrying a transposed frequency band to restore the same to its original band thereby restoring the original lower frequency level and bringing the bands into adjacent positions, and means connecting together the outputs of each of the parallel circuits to form a combined frequency band.

47. An apparatus for receiving a communication comprising a circuit carrying a communication in the form of varying electrical oscillations of transposed frequency bands having a raised frequency level and each band being spaced from its adjacent bands including a demodulating means, means connected with the demodulating

means to produce a carrier frequency to demodulate the received oscillations, means to vary the carrier frequency at the same speed and the same frequency range as the transmitted communication was varied, a plurality of parallel circuits branching from the demodulating means including means in each circuit to separate the electrical oscillations into a plurality of frequency bands corresponding in number and frequency range with the frequency bands after transposition in the transmitter, and means in each parallel circuit carrying a transposed frequency band to restore the same to its original band thereby restoring the original lower frequency level and bringing the frequency bands into adjacent position, the outputs of each parallel circuit being connected together to form a restored combined frequency band.

48. An apparatus for receiving a communication comprising a circuit carrying a communication in the form of synchronizing impulses and varying electrical oscillations of transposed frequency bands having a raised frequency level and each band being spaced from its adjacent bands including a demodulating means, means connected with the demodulating means to produce a carrier frequency to demodulate the received oscillations, means to vary the carrier frequency at the same speed and the same frequency range as the transmitted communication was varied, means responsive to the synchronizing impulses to synchronize the next aforesaid means, a plurality of circuits branching from the demodulating means including means in each circuit to separate the electrical oscillations into a plurality of frequency bands corresponding in number and frequency range with the frequency bands after transposition in the transmitter, and means in each branch circuit carrying a transposed frequency band to restore the same to its original frequency band thereby restoring the lower frequency level and bringing the frequency bands into adjacent position, the outputs of each branch circuit being connected together to form a combined frequency band.

49. An apparatus for receiving a communication comprising a circuit carrying a communication in the form of varying electrical oscillations of transposed frequency bands having the low frequency band of the transmitted communication of a lower frequency range than the band to be retransposed to the low band position and each band being in spaced relation with its adjacent bands including a demodulating means, means connected with the demodulating means to produce a carrier frequency to demodulate the received oscillations, means to vary the carrier frequency at the same speed and the same frequency range as the transmitted communication was varied whereby the varying frequency range becomes unvarying, a plurality of circuits branching from the demodulator means including means in each circuit to separate the electrical oscillations into a plurality of frequency bands corresponding in number and frequency range with the frequency bands after transposition in the transmitter, and means in each branch circuit carrying a transposed frequency band to restore the same to its original frequency range whereby the frequency level is lowered and each band is brought into adjacent relation, the outputs of each of the parallel circuits being connected together to form the combined frequency band of the transmitted communication.

50. An apparatus for communication comprising a circuit carrying a communication in the form of electrical oscillations, a plurality of parallel circuits leading therefrom including means in each circuit to separate the electrical oscillations of the frequency range desired to be transmitted into a plurality of frequency bands including a low frequency band and at least one higher frequency band, means in the parallel circuit carrying the low frequency band to transpose the same to a higher frequency band and to a frequency range different from that in the output of any other parallel circuit and to transpose the same so as to raise the frequency level of the combined oscillations and to separate each band from its adjacent band, means connecting together the outputs of each of the parallel circuits to form a combined frequency band, modulating means connected with the next aforesaid means including an oscillator to produce a modulating frequency, means connected to the oscillator to vary the modulating frequency and hence the combined frequency band for transmission, a receiving circuit carrying the transmitted communication in the form of electrical oscillations of transposed frequency bands, demodulating means connected with the receiving circuit including an oscillator to produce a demodulating frequency, means to vary the aforesaid demodulating frequency at the same speed and over the same frequency range that the modulating frequency was varied, a plurality of parallel circuits branching from the demodulating means including means in each circuit to separate the electrical oscillations into a plurality of frequency bands corresponding in number and frequency range with the original transposed frequency bands, means in each receiving parallel circuit carrying a transposed frequency band to transpose and restore the same to its original frequency range thereby restoring the original frequency level and bringing each band into adjacent relation, and means connecting together the outputs of each of the receiving parallel circuits to form a restored combined frequency band.

51. An apparatus for communication comprising a circuit carrying an audible communication

in the form of electrical oscillations, a plurality of parallel circuits leading therefrom including means in each circuit to separate the electrical oscillations of the frequency range desired to be transmitted into a plurality of frequency bands including a low frequency band and a higher frequency band having a lower frequency range than the low band, means in the parallel circuit carrying the low frequency band to transpose the same to another frequency band, means in the parallel circuit carrying the aforesaid higher frequency band to transpose the same to the position occupied by the low frequency band and so as to raise the frequency level of the combined oscillations and to space each frequency band from its adjacent bands, each band having a frequency range different from that in the output of any other parallel circuit, means connecting together the outputs of the parallel circuits to form a combined frequency band, modulating means connected with the next aforesaid means including an oscillator to produce a modulating frequency, means to continuously vary the modulating frequency and hence the combined frequency band for transmission, a receiving circuit carrying the transmitted communication in the form of electrical oscillations of transposed frequency bands, demodulating means connected with the receiving circuit including an oscillator to produce a demodulating frequency, means to vary the demodulating frequency at the same speed and over the same frequency range that the modulating frequency was varied, a plurality of parallel circuits branching from the demodulating means including means in each circuit to separate the electrical oscillations into a plurality of frequency bands corresponding in number and frequency range with the transposed frequency bands in the transmitter, means in each parallel circuit carrying a transposed frequency band to transpose and restore the same to its original frequency range thereby restoring the original frequency level and bringing each band into adjacent relation, and means connecting together the outputs of each of the receiving parallel circuits to form a restored combined frequency band.

WILLIAM W. ROBERTS.