

Jan. 26, 1926.

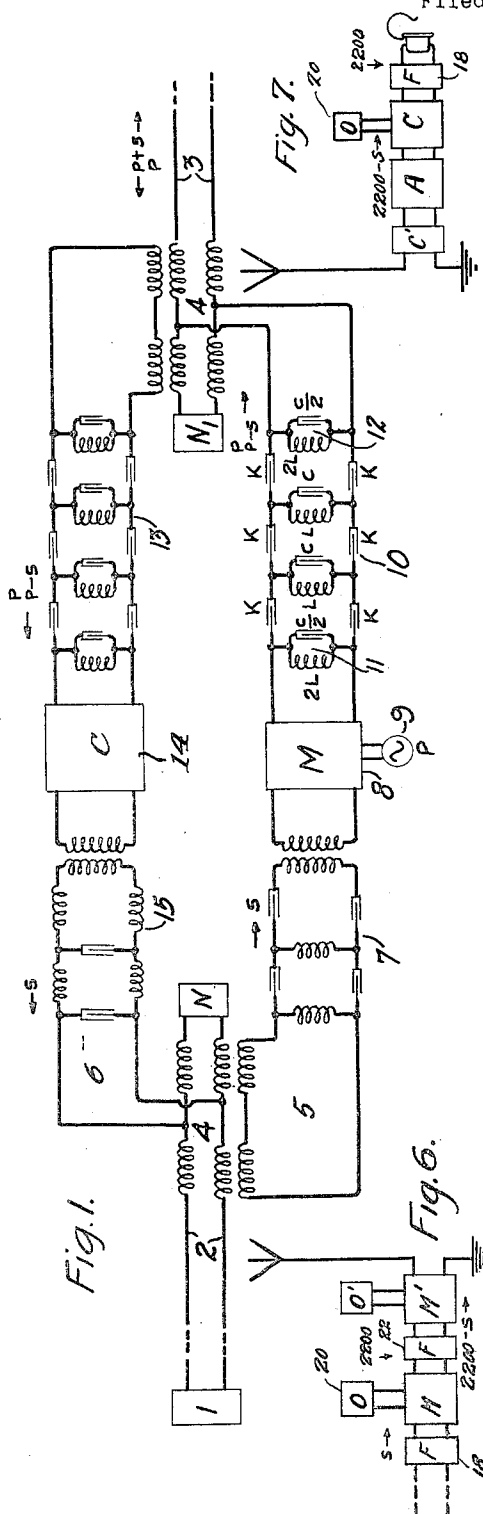
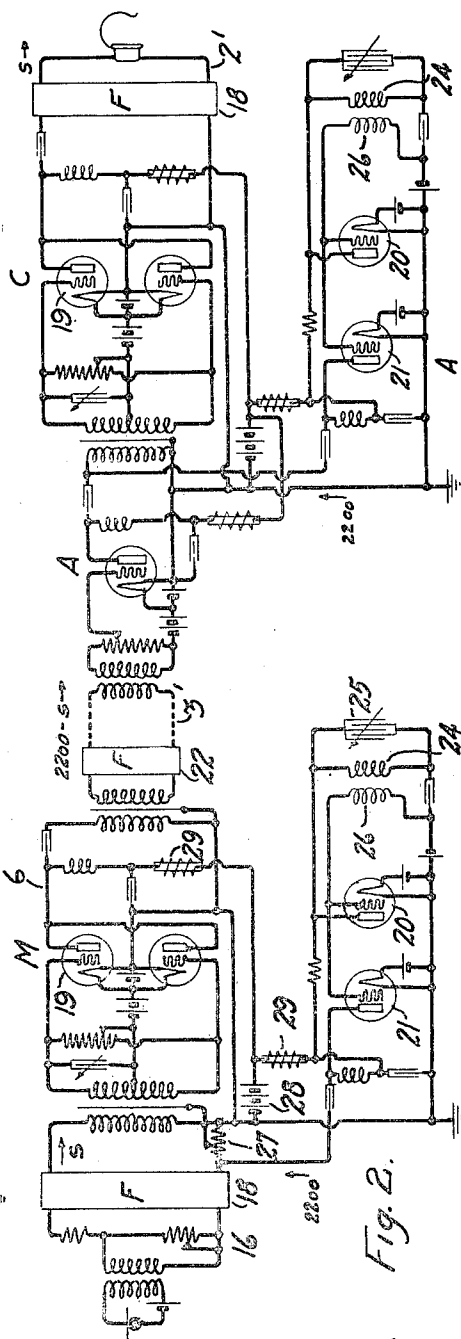
1,571,010

B. W. KENDALL

SECRET SIGNALING

Filed Dec. 23, 1920

4 Sheets-Sheet 1



Inventor:
Burton W. Kendall.

by C. A. Sprague. Att'y.

Jan. 26, 1926.

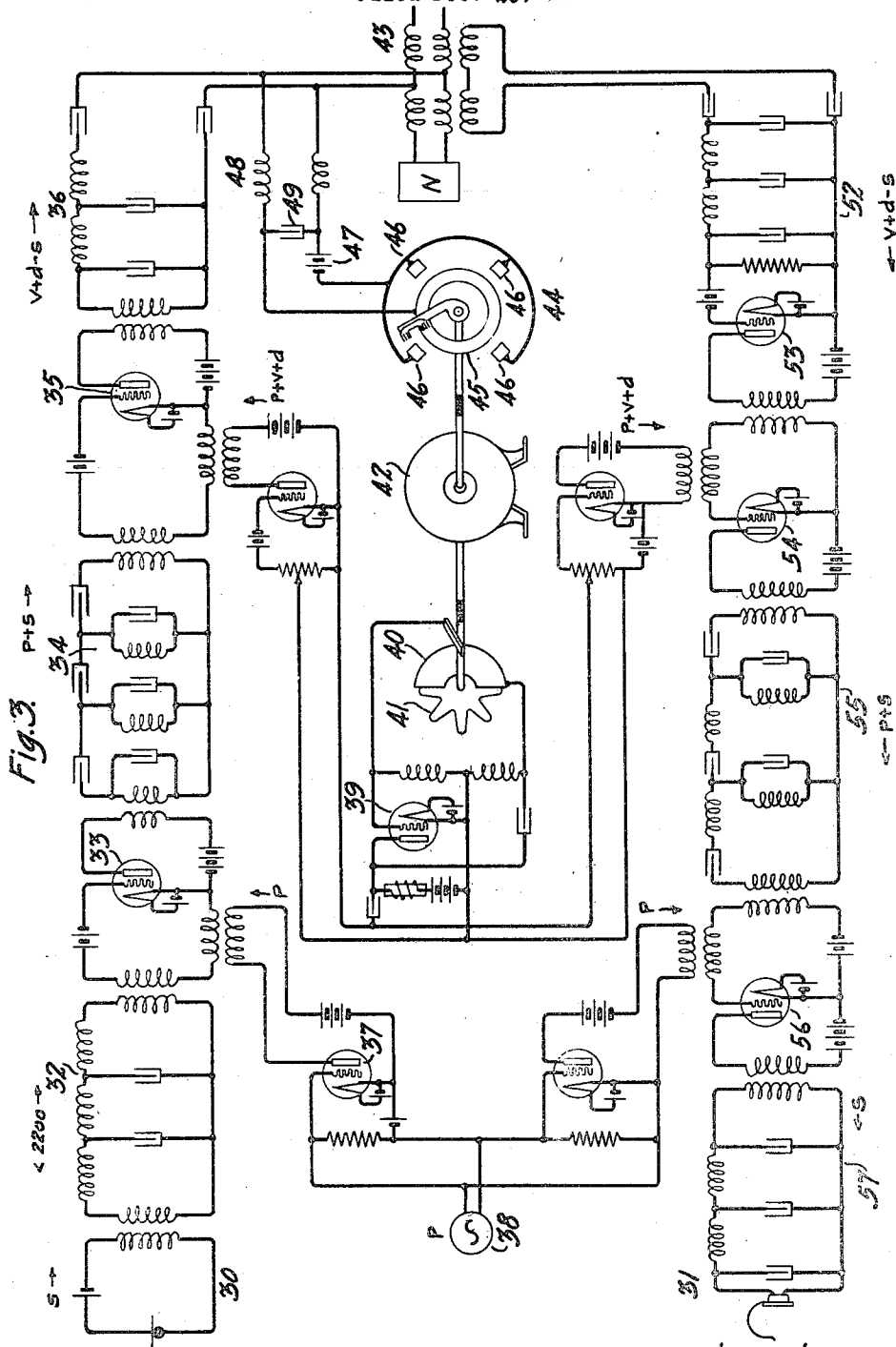
1,571,010

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SECRET SIGNALING

Filed Dec. 23, 1920

4 Sheets-Sheet 2



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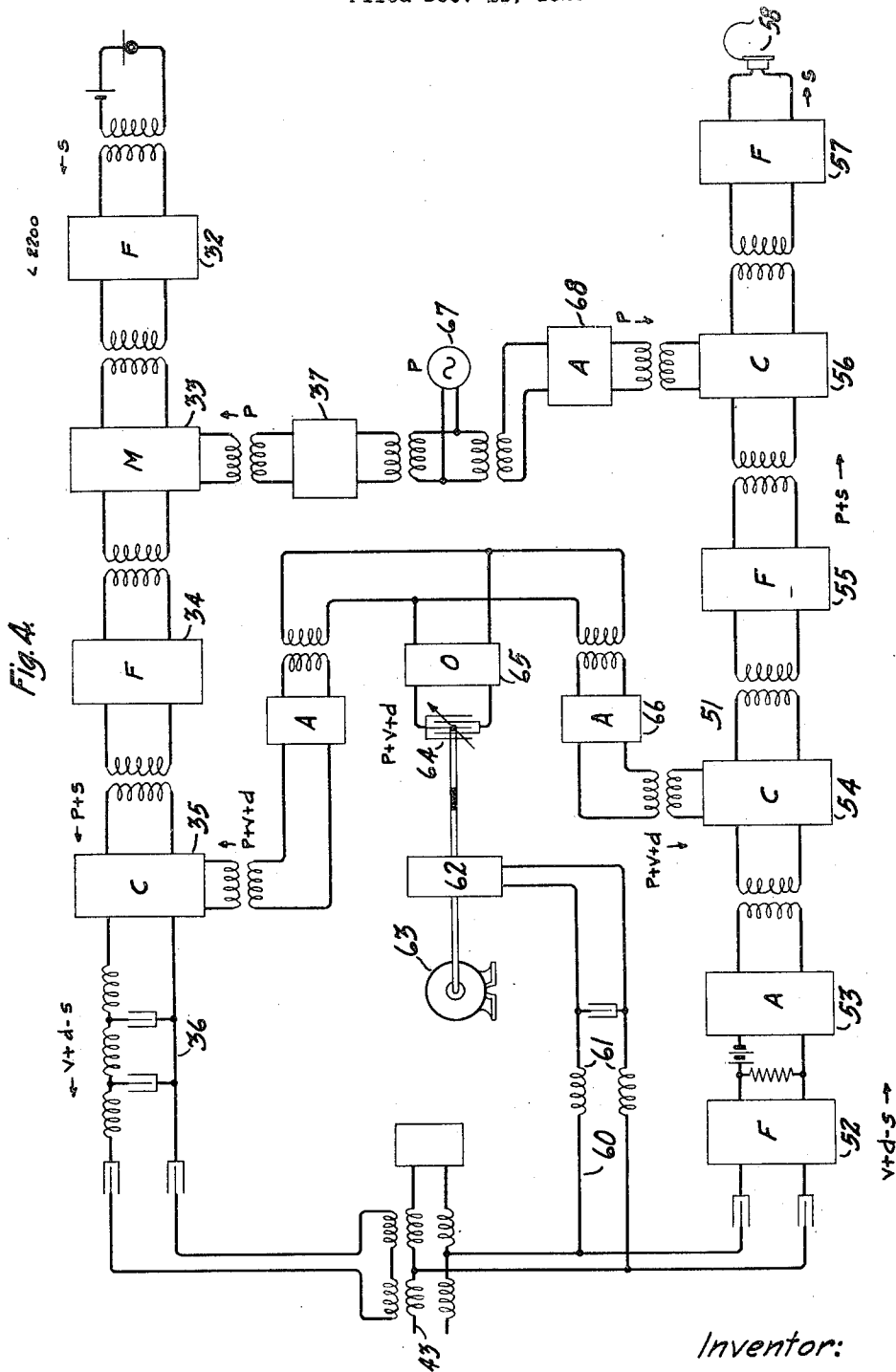
B. W. KENDALL

SECRET SIGNALING

Filed Dec. 23, 1920

1,571,010

4 Sheets-Sheet 3



Inventor:
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UNITED STATES PATENT OFFICE.

BURTON W. KENDALL, OF NEW YORK, N. Y., ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

SECRET SIGNALING.

Application filed December 23, 1920. Serial No. 432,680.

To all whom it may concern:

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

This invention relates to secret signaling and more particularly to secret transmission of speech or intelligible sounds by electrical waves. An object of the invention is to provide a method of and system for secret signaling. Another object of the invention is to provide a method of transmitting audible frequency waves which are unintelligible as speech, but from which intelligible speech waves may be derived.

One feature of the invention is the provision of means for altering the character of speech or other signaling waves in such a manner as to render them unintelligible in an ordinary telephone receiver, without varying their frequency range.

A further object of the invention is to enable secret transmission of speech by means of waves within the essential voice frequency range which are, accordingly, capable of transmission over ordinary loaded telephone circuits.

The present application contains subject matter also disclosed in my Patent No. 1,479,613, January 1, 1924, and as to such subject matter as is common to both, therefore, this application is a continuation of my patent.

Ordinary telephone transmission is accomplished by transmission of electric currents which correspond in their instantaneous amplitudes and frequencies to the simultaneous amplitudes and frequencies of the different sound wave components comprised in articulate speech. The essential speech frequencies may be considered to range from about 200 cycles to 2200 cycles. Accordingly, articulate speech is intelligible as such when it comprises the proper frequency components with their accompanying harmonics of the proper relative intensities. Any operation which destroys these essential relationships makes it impossible to receive intelligible speech until the relationships have been restored.

The present invention relates to a method of and means for changing the frequencies of each of the components of speech currents in such manner that, although the changed speech currents will extend over a frequency range as wide as that of the original speech waves, the essential relationships for intelligible speech have been destroyed. This further involves transmission of the changed speech waves and restoration of the essential speech relationships at a receiving station.

According to the present invention speech waves are combined with a single wave of audio frequency to produce a modulated audio frequency wave with two side bands each having a frequency range coextensive with that of the original speech currents. One of these bands includes the sum of the frequencies of the speech current components and the audible wave component, the other, the difference of the audible wave frequency and the speech component frequencies. One of the two bands is selected and may be used to transmit speech energy, although the essential speech frequency relationships have been destroyed so that the transmitted energy, if directly applied to a receiver, produces merely an unintelligible noise. Preferably the difference frequency side band is selected for transmission since in this band the frequencies of the individual speech components have been inverted. If the audible wave combined with the speech wave has a frequency at approximately the upper limit of the essential speech frequency range, the difference frequency or inverse frequency band will occupy substantially the same absolute range of frequencies as the original speech. Increasing frequency in the speech will be represented by decreasing frequency in the inverse speech band and vice versa. The unintelligible audible band thus obtained may either be transmitted directly as in the case of simple electric telephony or it may be caused to modify a carrier wave for either radio or guided circuit transmission.

As used herein, the term "combiner" is applied to devices of the character of modulators or detectors having the non-linear relation between applied input electromotive

force and resulting available output current commonly denoted by "curved characteristic". Such a device operates to produce in its output circuit sum and difference frequency components of the sinusoidal electromotive force frequencies simultaneously applied to the input circuit. In this definition input and output circuits are used merely to indicate the respective elements upon which the sinusoidal electromotive forces are impressed and from which the sum and difference frequency components are derived and may, therefore, be one and the same circuit. The capitals A, C, F, and M, as employed in the drawing are used to denote amplifier, combiner, filter and modulator respectively.

In the drawing, Fig. 1 illustrates a system embodying certain features of the invention in which speech currents from an ordinary telephone line are utilized to produce an equally extensive range of audible inverse frequency currents which are unintelligible as speech when supplied to an ordinary receiver; Fig. 2 illustrates a modified form of the invention in which the unintelligible inverse frequency currents lie within normal speech frequency range; Figs. 3 and 4 illustrate the transmitting and receiving terminals respectively of a variable frequency carrier system for transmitting inverse speech frequency waves; Fig. 5 a modification of the transmitting terminal of Fig. 3; Fig. 6 shows diagrammatically the invention applied to a radio transmitting system, and Fig. 7 shows a radio receiving station suitable for cooperating therewith.

Referring to Fig. 1, an ordinary subscriber's telephone set 1 representative of any speech current circuit is connected to speech frequency line 2 which terminates in the coil 4 and balancing net N of well known type. Associated with line 2 is another line 3 over which it is desired to transmit unintelligible waves of audible frequency to a distant receiving station not shown. Line 3 terminates in a coil 4 and a balancing network N₁ simulating its impedance at each of the frequencies of the waves transmitted over this line. The balanced transformers or hybrid coils 4 are connected in the well known fashion for repeaters to outgoing channel 5 and incoming channel 6 respectively. Outgoing channel 5 comprises a high pass filter 7 of the general type described in Campbell Patent 1,227,113, patented May 22, 1917. This filter passes with approximately negligible attenuation currents of frequencies higher than a fixed cut-off frequency of, for example, 160 cycles and substantially extinguishes currents of lower frequencies. This permits passage of the essential speech frequency components and somewhat decreases the total range of

the waves transmitted by eliminating the unessential components of frequency less than 160 cycles. The speech currents passed by filter 7 are supplied to a modulator 8 of any desired form and preferably of the well known vacuum tube type. A source 9 of audible frequency waves is also associated with the modulator 8 which serves to modulate the audible frequency waves in accordance with the impressed speech currents. Throughout this and the following figures of the drawing the frequency of the transmitted current through any portion of the circuit is indicated by the characters associated with arrows indicating direction of transmission. Modulator 8 supplies to the filter 10 connected thereto, currents of both speech frequency and of the frequency of source 9, as well as the two side bands produced by the combination or modulation of the two currents impressed upon the modulator. Filter 10 is of the band pass type and comprises condensers K in series with the line, and branches 11 and 12, each of which includes an inductance 2L in shunt of capacity $\frac{C}{2}$, in shunt to the line at the end section. The two mid shunts of this filter are similar and each comprises an inductance L in shunt to a capacity C. In case the frequency of the waves supplied by source 9 is 9600 cycles, the values of the capacity K, capacity C, both in microfarads, and the inductance L in millihenries may be as follows: K (.075); C (.2); L (.127). From the formulæ given in Campbell Patent 1,227,113 it may be readily determined that filter 10 serves to transmit to line 3, currents of a range of frequencies from approximately 10000 cycles down to 7500 cycles. It will be apparent that the filter 10 transmits to line 3 unmodulated current of the frequency 9600 cycles as produced by source 9 and also the inverse speech frequency or lower side band extending down from 9600 cycles by approximately the essential speech frequency range. At the distant terminal, not shown, of line 3 is a system which may be a substantial duplicate of that shown in Fig. 1. Connected to the hybrid coil 4 of the distant station is a receiving or incoming channel 6 including a filter 13 similar to filter 10, a detector or combiner 14, which may be of the amplifying type or may include a separate amplifier, and a low pass filter 15. The received inverse speech frequency currents and unmodulated wave of 9600 cycles are impressed together through filter 13 on detector 14 to reinvert the frequency of the transmitted band and produce ordinary speech current. This operation may be readily understood from the fact that the detector 14, like modulator 8, serves to yield both the sum

and difference frequency side bands produced by two impressed currents. The transmitted side band was obtained as the difference frequency component of the 9600 cycle wave and speech waves. Accordingly, the detector 14 which yields the difference frequency component of the 9600 cycle wave and the transmitted side band will yield speech currents. The band of currents transmitted over line 3 has the same frequency width as normal speech, that is, approximately 2000 to 2500 cycles. It is of considerably higher pitch than speech and in an ordinary receiver gives rise to totally unintelligible sound of resonant metallic quality. The detector 14 will also yield a sum frequency side band and will serve to some extent to transmit the received waves without combination. Low pass filter 15 will pass only the speech frequency currents and will suppress the sum frequency side band as well as components of the frequency of the received energy. It will accordingly be seen that ordinary telephone currents originating in line 2 may be repeated to and transmitted over line 3 as unintelligible audio frequency currents, and that corresponding unintelligible audio frequency currents received over line 3 from the distant station may be repeated to line 2 as intelligible speech currents.

In Fig. 2 two stations at the opposite terminals of line 3' are illustrated, one having an outgoing channel only and the other having an incoming channel. In practice each station would usually be arranged for two way transmission and would accordingly have both an incoming channel and an outgoing channel connected to line 3' by balanced hybrid coils as in the circuit arrangement of Fig. 1. As illustrated the outgoing channel 6 comprises potentiometer 16, a low pass filter 18, a balanced modulator 19, a vacuum tube oscillator 20 and amplifier 21, and a second low pass filter 22 similar to filter 18. The low pass filters are of the general type disclosed in Campbell Patent 1,227,113 and are so designed as to transmit with practically uniformly negligible attenuation, currents of all frequencies less than a fixed cut-off frequency as for example 2200 cycles while substantially extinguishing all currents of higher frequencies. The oscillator 20 comprises the well known three-element electric discharge device having a frequency determining tuned loop consisting of inductance 24 and variable capacity 25 in its plate filament circuit and having its grid filament circuit coupled by an inductance 26 to inductance 24 in well known manner to enable the device to produce continuous oscillations. The grid filament circuit of thermionic amplifier 21 is connected directly to that of the oscillator which accordingly impresses the generated

oscillations upon the amplifier which in turn impresses amplified oscillations across the variable resistance 27. The amplifier, oscillator and balanced modulator are each supplied with space current from the common source 28 through choke coils 29 which exclude the oscillatory current, thus preventing direct high frequency coupling through the common space current supply. The various filamentary cathodes of the modulator, oscillator and amplifier may likewise receive heating current from a common source, but individual sources have been shown to simplify the drawing. The modulator is of the balanced type disclosed in Hartley Patent No. 1,419,562, patented June 13, 1922, and as is well known, serves to pass only the modulated side bands or sum and difference frequency components of the currents impressed on the input circuit while substantially preventing transmission of unmodulated currents corresponding to the impressed waves. If the oscillator 20 supplies a wave of 2200 cycles frequency, the two side bands produced by modulation with the speech currents will both be within the audible range and the lower side band will occupy substantially the same range as the original speech, but will be unintelligible because it consists entirely of inverse frequencies. For example, the frequencies 800, 1000 and 1200 of the original speech components will have become inverse frequencies 1400, 1200 and 1000 respectively. An increasing pitch tone of speech will become an unintelligible decreasing pitch noise in the inverse frequency band. The filter 22 suppresses the upper side band and permits transmission of only the inverse frequency band. The receiving channel comprises substantially the same general arrangement of apparatus, namely, receiving amplifier, an oscillator and second amplifier connected to supply oscillations to the receiving amplifier output circuit, a balanced combining device, and a low pass filter. These elements correspond in tuning to those of the outgoing channel.

The inverse frequency speech currents as received are combined with oscillations of 2200 cycles frequency to produce two side bands, the lower of which is intelligible speech current. The speech currents are selected and transmitted to the telephone circuit 2' by the low pass filter which suppresses the upper side band. The balanced combining device of the outgoing channel at one terminal of the line 3', as already explained, prevents transmission to the line of ordinary speech currents. The balanced combining device at the incoming channel at the opposite terminal of line 3' similarly prevents transmission of the inverse frequency currents to the telephone line 2'. It follows that while both lines 2' and 3' trans-

mit the same frequency range of currents, the currents of line 2' are intelligible in any ordinary receiver while those of line 3' are not. The line 3', since it transmits speech frequencies may be any type adapted for ordinary speech transmission as for example a loaded line.

In Fig. 3, the individual telephone transmitting circuit 30 and receiving circuit 31 are illustrated but these may obviously be interconnected for the two-way low frequency telephone line in the well known manner illustrated in the preceding figures. The outgoing or transmitting channel connected to transmitting circuit 30 comprises a low pass filter 32, a modulator 33, a band pass filter 34, a combiner 35 and a low pass filter 36. Associated with the input circuit of modulator 33 by means of a substantially unidirectionally conducting thermionic amplifier 37 is an oscillator 38. Associated with the input circuit of combiner 35 by means of an asymmetric device is a variable frequency thermionic oscillator 39, the frequency determining circuit of which includes a variable condenser having a fixed plate 40 and a rotatable plate 41 operated by a motor 42 to cyclically vary this capacity and hence the frequency of the oscillator in any arbitrary and irregular manner. Assume, for example, that speech currents are impressed by filter 32 on modulator 33. This filter is preferably designed to transmit only currents of less than 2200 cycles frequency which we may designate by a typical frequency s . The source 38 preferably produces oscillations of frequency much greater than essential speech frequency, for example, 10000 to 50000 cycles. If the frequency of this source be represented by p , the modulator 33 will yield in its output circuit, components of the combination or side band frequencies $p+s$ and $p-s$. If now the band filter 34 be designed to pass a range of currents of substantially the same extent as that passed by filter 32 as may be done by designing it to have its lower cut-off frequency somewhat above p and its upper cut-off frequency at somewhat above the maximum frequency of $p+s$, this band filter will transmit freely currents of the band of frequencies extending between the two cut-off frequencies, but will prevent transmission of the currents of speech frequency, unmodulated currents of frequency p and all harmonics of either not lying within the limited range selected for transmission. Assume now that the minimum frequency of oscillator 39 is $p+v$ where v is preferably approximately the cut-off frequency of filter 32, for example, 2200 cycles. The frequency of the oscillator 39 at any time may differ from its minimum value $p+v$ by an amount d due to the frequency variation which condenser 40-41 introduces. Oscillations

of this variable frequency $p+v+d$ are supplied to the input circuit of combiner 35 together with the side band of frequency $p+s$ giving rise among other components to a difference frequency component of frequency $v+d-s$ in the output circuit of combiner 35. Considering this component alone and neglecting the term " d " it will be obvious that $v-s$ represents the inverse frequency speech current band such as was obtained in the arrangement of Fig. 2. The side band $v+d-s$ is an inverse frequency speech current with an additional variation d introduced.

The low pass filter 36 must extinguish unmodulated currents of frequency $v+d$ at its minimum value, yet must pass currents of the frequency of the maximum value of $v+d-s$ representing the variable inverse frequency speech current. The minimum value of $v+d$ is, of course, v when d is zero. The maximum value of $v+d-s$ occurs when d is at its maximum and s is the lowest essential speech frequency. This requires that the maximum value of d shall not exceed the lowest essential voice frequency, a combination which maintains maximum $v+d-s$ below minimum $v+d$ and enables an upper cut-off frequency to be determined for filter 36 so as to pass the component of the former frequency and to suppress the component of the latter frequency. Frequency v is preferably chosen so that the minimum value of $v+d$ exceeds the cut-off frequency of filter 36. Under these conditions the impressed waves of frequencies $p+s$ and $p+v+d$ will not be transmitted nor will any unmodulated current of frequency $v+d$. There are, therefore, transmitted to line 43 inverse speech frequency currents of variable frequency which, however, occupy substantially the same frequency range as ordinary speech currents.

Motor 42 also drives a rotary distributor 44 of conventional type to periodically transmit synchronizing impulses to line 43. These impulses serve at the distant receiving station to control the operation of a synchronizing apparatus and thus to maintain a motor at the distant station in step with motor 42. Ring 45 and conducting segments 46 are connected to opposite sides of the transmitting or outgoing channel and accordingly serve to connect battery 47 in a bridge path thereacross whenever the distributor brush engages a segment thus electrically connecting it to the ring. The series inductance 48 and the shunt capacity 49 act as a low pass filter permitting the transmission of the correcting impulses, but tending to exclude the signaling energy of the outgoing channel from the bridge path of the rotary distributor. This filter also has an effect in improving the transmission of the synchronizing impulses by absorbing the

energy of transients occurring at the beginning and termination of an impulse. These impulses are merely phase correcting impulses and have no significance whatever so far as the signals transmitted are concerned. Since the number of impulses transmitted for each revolution of the condenser plate may be varied at will as may be also the number of scallops on the condenser plate, the gear ratio, etc., these correcting impulses give no clue to the manner of variation of a transmitted wave.

The inverse speech frequency currents of the band of frequencies $v+d-s$ are received over the line 43 and supplied to the receiving channel 51 at the receiving station, Fig. 4. This receiving channel includes in tandem a low pass filter 52, an amplifier 53, a combiner 54, a band pass filter 55, a second combiner 56 and a low pass filter 57 to which the receiver or indicating instrument 58 is connected. A bridged synchronizing circuit 60 provided with a low pass filter 61 selects the received synchronizing impulses and supplies them to a synchronizer element 62 which may introduce phase shifts between the motor 63 and the mechanism which this motor drives so as to correct for small differences in speed between motors 42 and 63. Apparatus of this character is well known and is indicated diagrammatically only in the drawing. Motor 63 is arranged to rotate the movable plate of a variable condenser 64 associated with an oscillator 65 which, with its variable condenser is the counterpart of oscillator 39. It follows that whatever irregularities are introduced into the frequency of oscillator 39 are simultaneously introduced into that of oscillator 65. Source 65 is connected to supply oscillations of variable frequency $p+v+d$ to combiner 54 through an asymmetric amplifier 66 similar to element 37. A local alternating current source 67 likewise supplies oscillations of constant frequency p through asymmetric amplifier 68 to combiner 56. Source 38 at the transmitting station and source 67 at the receiving station may be mechanical generators driven by synchronized motors 42 and 63 respectively, but the mechanical connections are omitted in the drawing to avoid unnecessary complication. Where vacuum tube oscillators are provided it is merely necessary to have their frequency the same and to have this frequency maintained constant.

The received inverse speech frequency band of frequency $v+d-s$ is transmitted by low pass filter 52 similar in every respect to filter 32 and is then impressed through amplifier 53 upon combiner 54 which is also supplied with variable frequency oscillations of frequency $p+v+d$. The difference frequency side band which results is of frequency $p+s$ and is, therefore, readily separ-

able from the impressed waves by filter 55 which has an upper cut-off frequency just lower than the minimum value of $p+v$ and a lower cut-off frequency at approximately p . The band of currents of frequency $p+s$ lying between these cut-off frequencies is accordingly readily transmitted by the filter and impressed upon combining device 56 together with oscillations of frequency p , thus giving rise to speech currents of the difference frequency band. Low pass filter 57 which is similar to filter 52 supplies the speech currents to receiver 58. Return transmission over line 43 in the direction opposite to that which has been considered is accomplished in precisely the same manner. Similarly designated parts at the two stations of Figs. 3 and 4 will, therefore, be understood to function in similar manner.

Fig. 5 shows a modification of the station of Fig. 3. Its similarly functioning elements are correspondingly designated and it will be evident that its outgoing channel 30 is substantially identical with that of Fig. 3. The receiving channel is slightly modified and comprises in tandem a low pass filter 70, amplifier 71, combiner 72, band filter 73, combiner 74, low pass filter 75 and receiver 76. Received oscillations of frequency $v+d-s$ are selected, amplified and impressed on the combiner 72 to be combined with oscillations of frequency p from source 38. The sum frequency side band of frequency $p+v+d-s$ is selected and transmitted by filter 73 to the exclusion of other frequency components, the lower cut-off frequency of the filter being approximately the minimum value of $p+d$ and the upper cut-off frequency slightly exceeding the maximum value of $p+v+d$. The band of frequencies $p+v+d-s$ thus transmitted is applied to combiner 74 for combination with oscillations of frequency $p+v+d$ from variable frequency source 39. The resulting speech frequency currents from this combining operation are selectively transmitted by a low pass filter 75 similar to filter 52 to receiver 76. The remote station cooperating with that of Fig. 5 for communication purposes differs only in the receiving arrangement for synchronizing and therefore needs no further description.

In Fig. 6 the elements 18, 20, M and 22 may be the same as the corresponding elements of Fig. 2. The filter 22 feeds into a second modulator M' of any suitable type which is supplied also by a radio frequency wave from an oscillator O' which may be of the same type as oscillator 20, but its constants are adjusted so that it produces a wave of a frequency suitable for radiation.

In Fig. 7, the elements A, C, 20 and 18 may be the same as the corresponding elements of Fig. 2. Coupled between the an-

tenna and the amplifier A is a demodulator or combiner C' of any suitable type.

The operation of Figs. 6 and 7 is as follows:

5 The filter 18 of Fig. 6 receives a speech wave from any desired speech-transmission circuit and limits the frequencies transmitted to some definite range such as 0 to 2200 cycles. This band of frequencies modulates at M a sustained wave of 2200-cycle frequency from the source 20, and the resulting lower side band comprising unintelligible inverted speech components of speech frequency range are selectively passed through the filter 22 to the radio-transmitting modulator M'. Here the inverted speech band modulates the wave of radio frequency from the source O' and the resulting modulated wave is radiated from the antenna shown.

20 If the wave so radiated were received on an ordinary detecting set it would yield only unintelligible noises since the modulating wave comprises only inverted speech components. However, the wave, when received on the antenna of Fig. 7, is detected at C', and after amplification is treated in exactly the same manner as at the receiving terminal in Fig. 2, that is, the detected inverted speech band is combined at C with a wave of frequency near the upper limit of the band, say 2200, from source 20 and the resulting lower side band, which is normal speech, is passed through filter 18 to the telephone receiver so that understandable speech is received.

Preferred forms of embodiment of the invention, containing, however, many limitations unessential to the invention itself, have been illustrated and described by way of example. For the exact scope of the invention the appended claims are referred to.

What is claimed is:

1. The method of transmitting a band of audio frequency waves of given frequency range which comprises inverting the frequencies of the components thereof to produce resultant audio frequency waves restricted to a frequency range substantially equal to that of the band of waves to be transmitted.

2. The method of secret telephony, which consists in producing a speech wave and in utilizing only the components present in said speech wave to produce a wave which contains substantially all of the essential components of said speech wave but which is unintelligible and which continuously occupies the speech frequency range.

3. The method of transmitting waves of a band of different audio frequencies which comprises inverting the frequencies of the individual components thereof to produce a band of audio frequency waves of approximately the same frequency range as that of said first mentioned band, and overlapping

the frequency range of the original band of audio frequencies.

4. The method of transmission of a band of audio frequency waves which comprises modulating an audio frequency carrier wave in accordance with said waves and selecting from the resulting modulated band the lower side band.

5. The method of transmission of a band of audio frequency waves which comprises modulating a carrier wave of substantially the upper limiting frequency of said band in accordance with said audio frequency waves and selecting from the resulting modulated wave the lower side band comprising components of approximately the same range of frequencies as said band of audio frequency waves.

6. The method of secret telephony which comprises modulating an audio frequency carrier wave in accordance with speech and selecting from the modulated wave the lower side band comprising audible but unintelligible inverse frequency speech waves.

7. The method of telephony which comprises inverting the frequencies of the various components of speech to produce an unintelligible inverted frequency band of components occupying substantially the same range of frequencies as the original speech components.

8. In a secret telephone system, means for producing a wave of speech frequencies, and means to produce from the components present in said speech wave, a second wave which contains substantially all of the essential components of said speech wave but which is unintelligible and continuously occupies the speech frequency range.

9. The method of transmitting a band of audio frequency waves of given frequency range which comprises inverting the frequencies of the components thereof to produce a band of audio frequency waves of frequency range substantially equal to that of the band of waves to be transmitted, transmitting to a distant point energy corresponding to that of said inverted frequency band, receiving said transmitted energy and reinverting the frequencies of the frequency components of the received energy to reproduce the first mentioned band of audio frequency waves.

10. The method of transmitting waves of a band of different audio frequencies which comprises inverting the frequencies of the individual components thereof to produce a band of audio frequencies waves of approximately the same frequency range as that of the first mentioned band, and overlapping the frequency range of said first mentioned band, transmitting energy corresponding to said inverted frequency waves, receiving said transmitted energy at a distant point, and reinverting the fre-

quencies of the components of said received wave energy to reproduce the first mentioned band of audio frequency waves.

11. The method of secret telephony which comprises inverting the frequencies of the various components of speech to produce an unintelligible inverted frequency band of components occupying substantially the same range of frequencies as the original speech components, transmitting energy corresponding to that of said inverted frequency band, receiving said energy at a distant point and reinverting the frequencies of the components of said received energy to reproduce speech waves.

12. The method which comprises modulating a carrier wave of substantially the frequency of the upper limit of essential speech frequencies in accordance with speech, selecting the lower side band of said modulated wave, transmitting the energy of said side band to a distant point, receiving said transmitted energy and combining therewith energy of the frequency of said carrier wave to reproduce speech.

13. A system for transmitting a band of audio frequency waves of given frequency range comprising means for inverting the frequencies of the components thereof to produce resultant audio frequency waves restricted to the same frequency range as that of the band of waves to be transmitted.

14. A system for transmitting waves of a band of different audio frequencies comprising means for inverting the frequencies of the individual components thereof to produce a band occupying audio frequency waves of approximately the same frequency range as that of said first mentioned band.

15. A system for transmitting a band of audio frequency waves which comprises means for modulating an audio frequency carrier wave in accordance with said waves and means for selecting the lower side band from the resulting modulated wave.

16. A system for transmission of a band of audio frequency waves which comprises means for modulating a carrier wave of substantially the upper limiting frequency of said band in accordance with said audio frequency waves and means for selecting from the resulting modulated wave the lower side band comprising components of approximately the same range of frequencies as said band of audio frequency waves.

17. A secret telephone system which comprises means for modulating an audio frequency carrier wave in accordance with speech and means for selecting from the modulated wave the lower side band comprising audible but unintelligible inverse frequency speech waves.

18. A telephone transmission system comprising means for inverting the frequencies of the various components of speech to pro-

duce an unintelligible inverted frequency band of components occupying substantially the same range of frequencies as the original speech components.

19. A system for transmitting a band of audio frequency waves of given frequency range comprising means for inverting the frequencies of the components thereof to produce a band of audio frequency waves of frequency range substantially equal to that of the band of waves to be transmitted, means for transmitting to a distant point energy corresponding to that of said inverted frequency band, means for receiving said transmitted energy, and means for reinverting the frequencies of the frequency components of the received energy to reproduce the first mentioned band of audio frequency waves.

20. A system for transmitting waves of a band of different audio frequencies which comprises means for inverting the frequencies of the individual components thereof to produce a band of audio frequency waves of approximately the same frequency range as that of said first mentioned band, means for transmitting energy corresponding to said inverted frequency waves, means for receiving said transmitted energy at a distant point and means for reinverting the frequencies of the components of said received wave energy to reproduce the first mentioned band of audio frequency waves.

21. A system for secret telephone transmission comprising a source of speech currents, means for inverting the frequencies of the various components of said currents to produce an unintelligible inverted frequency band of components occupying substantially the same range of frequencies as the original speech components, means for transmitting energy corresponding to that of said inverted frequency band, means for receiving said energy at a distant point and means for reinverting the frequencies of the components of said received energy to reproduce speech currents.

22. A signaling system comprising a source of carrier waves having a frequency of substantially the upper limit of essential speech frequencies, means for modulating said waves in accordance with speech, means for selecting the lower side band of said modulated waves, means for transmitting the energy of said side band to a distant point, means for receiving said transmitted energy, and means for combining therewith energy of the frequency of said carrier waves to reproduce speech.

23. The method of transmission of waves comprised of a band of frequencies, which consists in converting each frequency component of the band into a component having a frequency equal to a constant minus the respective frequency of the original band,

the frequencies so converted being included between substantially the same frequency limits as the original band, and transmitting the resultant band.

5 24. A wave combining and selecting circuit comprising electrodes for providing a pair of discharge spaces and for controlling the discharge currents therein, said electrodes comprising cathode, anode and control electrodes, circuits for applying the waves to be combined to said control electrodes in a sense to produce simultaneously similar variations of opposite phase in the discharge current through said discharge spaces, said anodes being connected by a substantially impedanceless path, an outgoing circuit, a connection from said path to said cathode electrodes including means for coupling to said outgoing circuit, and a filter in said outgoing circuit having its ranges of suppression and transmission respectively proportioned to suppress a portion of the combination frequency components from said combining circuit and to selectively transmit other components.

25. A wave combining and selecting circuit comprising two similar discharge devices, each having a cathode, a control element and an anode, said cathodes being connected directly together, a circuit for caus-

ing equal and opposite instantaneous variations of the potentials of said control elements by a wave to be modulated and a modulating wave, a single substantially non-reactive connection between said circuit and said cathodes, a common outgoing circuit for said devices, and a filter in said outgoing circuit having its ranges of suppression and transmission respectively proportioned to suppress a portion of the frequency components from said devices and to selectively transmit other components.

26. The method of secret telephony comprising producing a speech wave and rearranging the frequency components of said wave to produce a wave occupying in part the same absolute frequency range as the original wave but having a different characteristic order of occurrence of its frequency components, whereby the resultant wave is unintelligible, transmitting the resultant wave to a distance and there rearranging the frequency components of the wave so transmitted to restore the order of occurrence of the frequency components to that of the original wave.

In witness whereof, I hereunto subscribe my name this 18th day of December A. D., 1920.

BURTON W. KENDALL.