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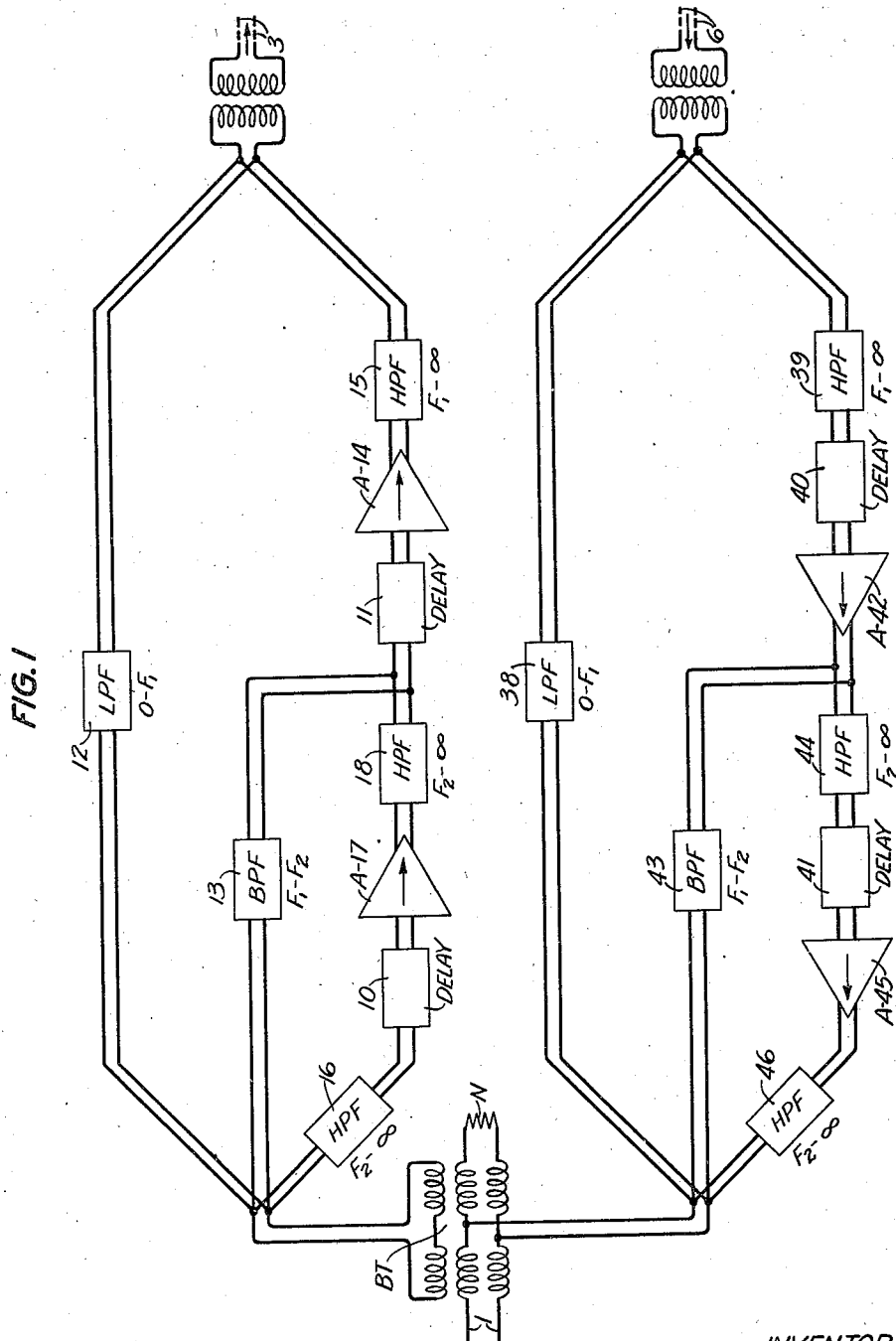
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1,819,648

WAVE TRANSMISSION SYSTEM

Filed March 30, 1929

5 Sheets-Sheet 1



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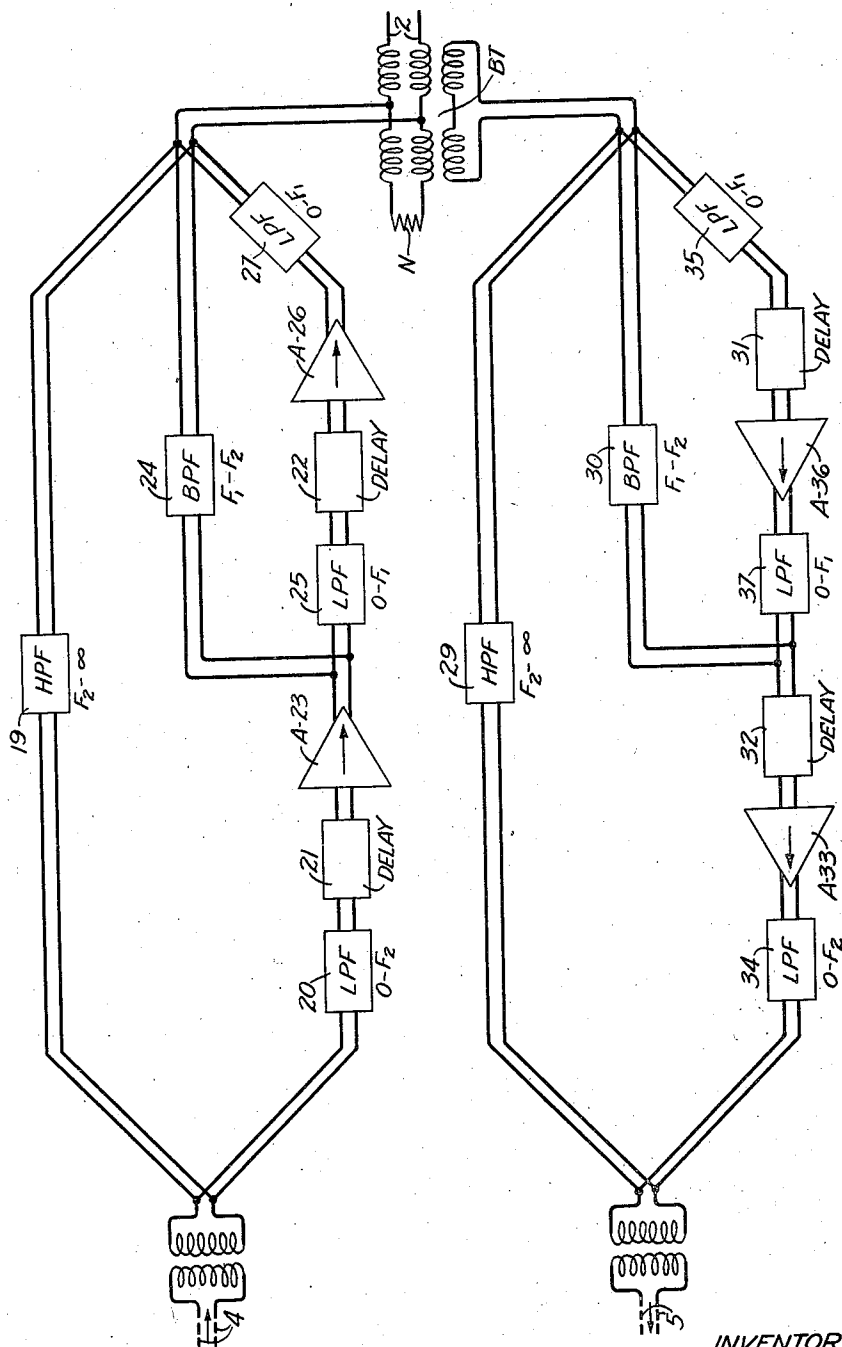
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WAVE TRANSMISSION SYSTEM

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FIG. 2



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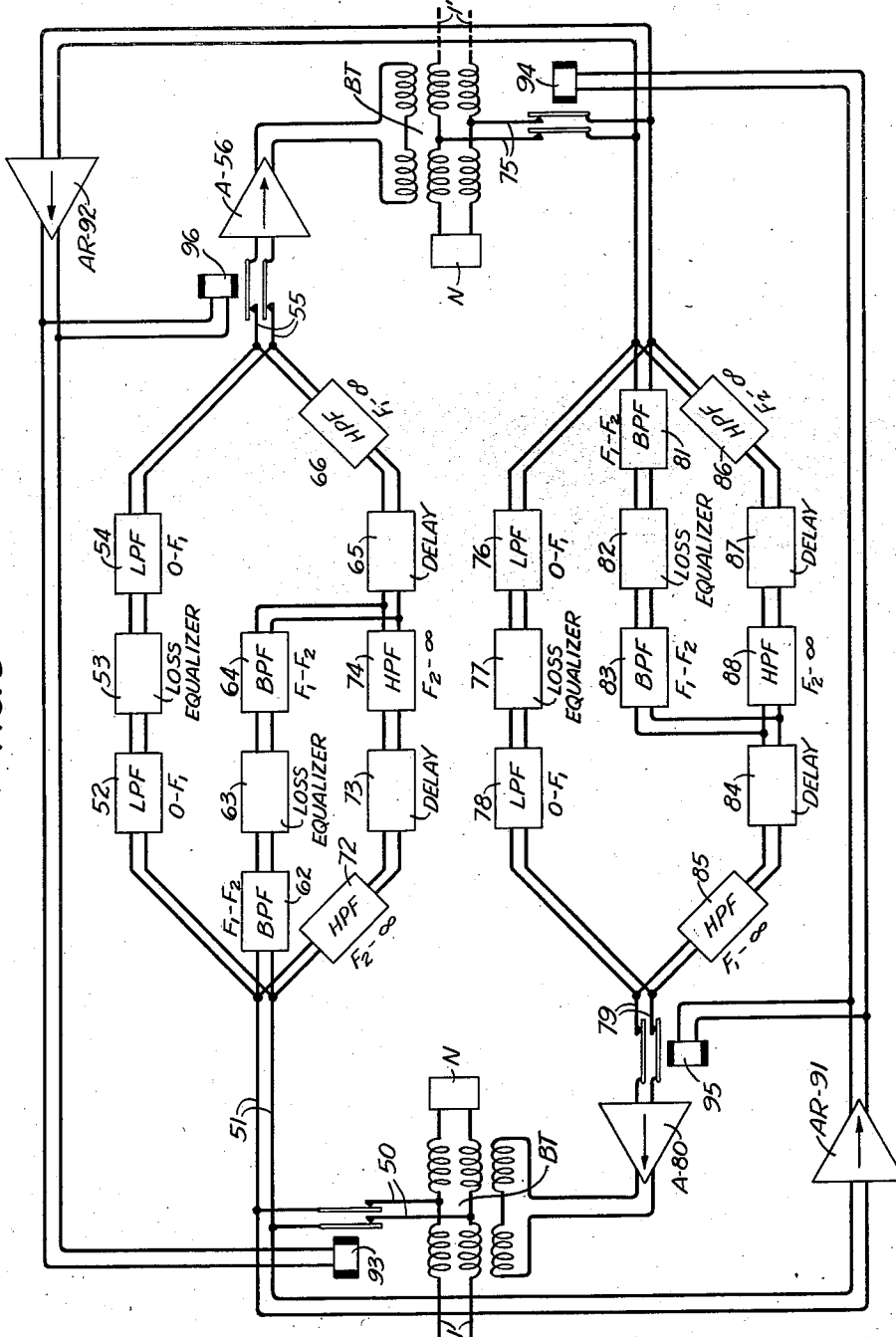
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WAVE TRANSMISSION SYSTEM

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FIG. 3



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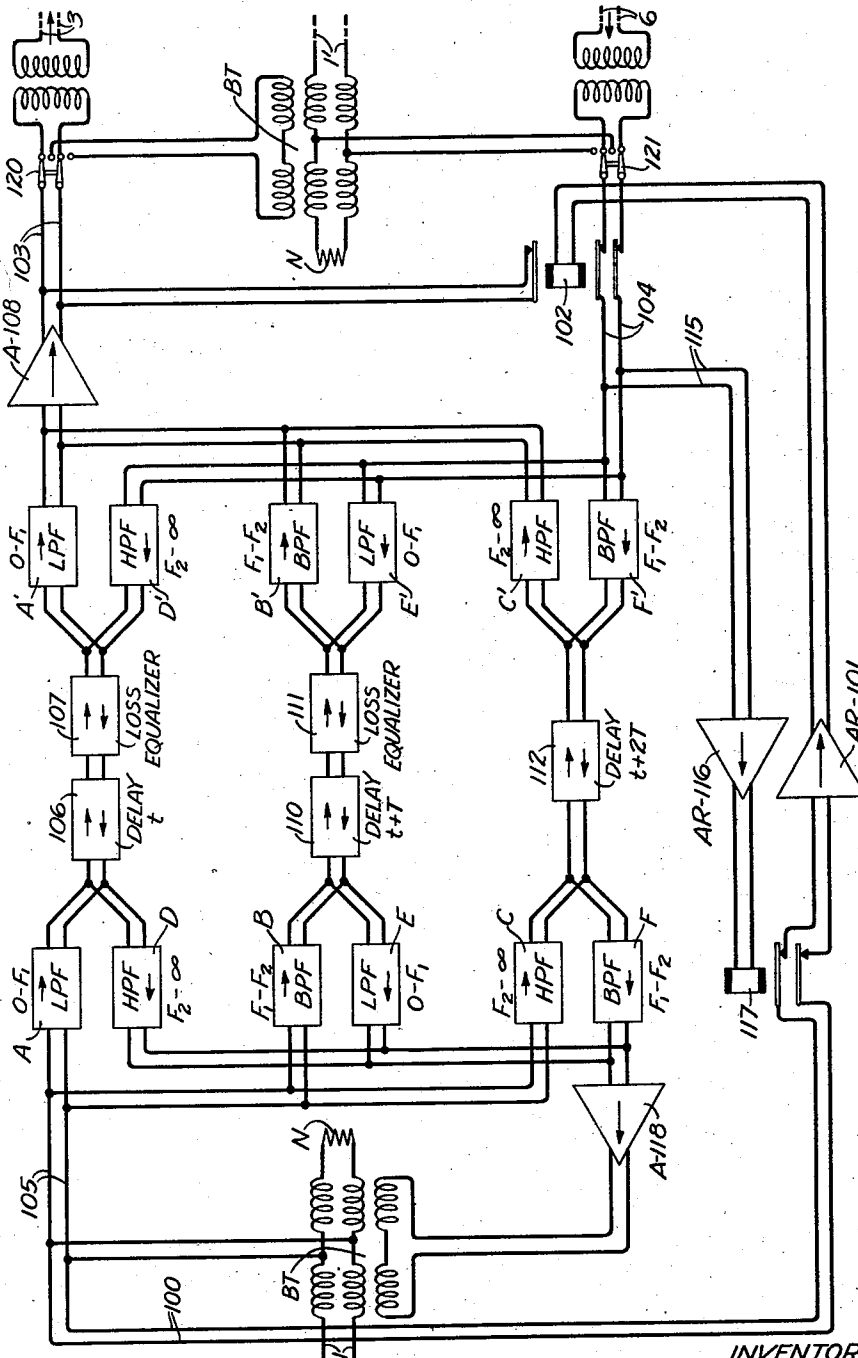
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WAVE TRANSMISSION SYSTEM

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5 Sheets-Sheet 4

FIG. 4



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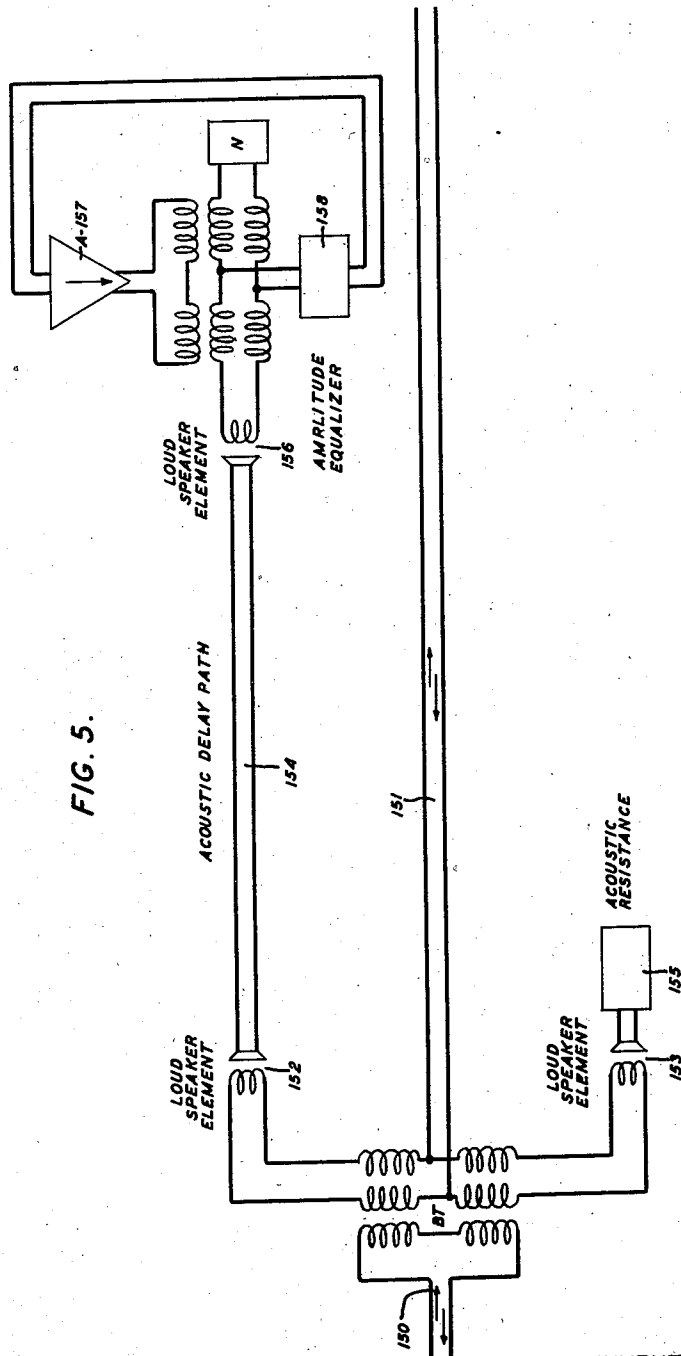
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WAVE TRANSMISSION SYSTEM

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5 Sheets-Sheet 5



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WAVE TRANSMISSION SYSTEM

Application filed March 30, 1929. Serial No. 351,415.

This invention relates to wave transmission and especially to privacy systems of communication.

An object of the invention is economy of privacy apparatus.

Another object is to obtain greater privacy for signals transmitted in a given direction in a two-way signaling system than is obtained by merely the alteration of those signals which occurs before they are sent from their transmitting station.

In one specific form of the invention in which privacy in radio telephony results from relatively delaying frequency bands of speech energy in the general manner disclosed in Mathes Patent 1,542,566, June 16, 1925, the same delay apparatus serves for both directions of transmission in a two-way radio telephone system. Moreover, privacy is augmented by producing a given relative time displacement of the bands for one direction and a different relative time displacement of those bands for the other direction. This dissimilarity in the kinds of alteration introduced in sending signals from the two intercommunicating stations to reduce their intelligibility as sent out, requires that a listener-in have two separate receiving systems, and if the same frequencies be transmitted in both directions, each of the receiving systems will need to have a sharp directional selectivity, a requirement very difficult to meet except in limited areas in relation to the two transmitting stations.

Other objects and features of the invention will be apparent from the following description and claims.

Figs. 1 and 2 show the two terminals, respectively, of a four-wire type of circuit embodying one form of the invention;

Fig. 3 shows one terminal of a two-wire type of circuit embodying a second form of the invention;

Fig. 4 shows a terminal adapted for either a four-wire or two-wire type of circuit embodying the invention in still different form; and Fig. 5 shows an acoustic delay means suitable for use in the system of Fig. 4 and also in the systems of Figs. 1 to 3.

To make it more difficult for an outsider to

listen in on a two-way radio or other signaling system with provision for secrecy, there may be used dissimilar ways of rendering the transmission in the respective directions unintelligible. That is, privacy may be augmented by rendering the signals sent in one direction from one terminal unintelligible, in one manner, and rendering the signals sent in the opposite direction from the other terminal unintelligible, in another manner. The one manner may be by alteration of one characteristic of the signaling waves (as for example by use of frequency band inversion or transposition, or both, for the one direction of transmission), and the other manner may be by alteration of another characteristic (as for example by use of frequency band delay for the other direction); or the one manner may be by alteration of one characteristic in a given way and the other manner by alteration of the one characteristic in a different way. Three examples of this latter type of system are as follows: First, in the case of secrecy by frequency band inversion (as disclosed for instance by Mathes Patent 1,542,565, June 16, 1925), there may be dissimilarity, for the two directions of transmission, as to which bands are left normal and which are inverted. Second, in the case of secrecy by frequency band transposition (as disclosed for instance in Espenschied Patent 1,546,439, July 21, 1925), there may be dissimilarity, for the two directions of transmission, as to the specific transpositions made. Third, in the case of secrecy by frequency band delay (as disclosed for instance in Mathes Patent 1,542,566, mentioned above), there may be delay dissimilarity for opposite directions. This delay dissimilarity, is referred to above, and examples of it are described hereinafter.

In order that advantage may be taken of the optimum setting for the band edges in those secrecy schemes which involve splitting the speech energy into bands, various dissimilarities of operation for the opposite directions of transmission may be introduced while using the same band separation in the two directions. In the case of frequency band inversion some dissimilarity may be

introduced in the selection of which bands are left normal and which bands are inverted. A similar choice is possible in the case of frequency band transposition.

In the case of frequency band delay, dissimilarity may be introduced for example by selecting different bands to which are given the maximum and minimum delay on transmission. The following table shows how, if (as in the system of Figs. 1 and 2 about to be described) the speech energy be divided into three frequency bands and the higher bands be delayed most on transmission from one end, which for convenience may be called the west end, while the lower bands are delayed most on transmission from the other or east end, the amount of confusion caused to an outside listener adjusted for listening to west to east transmission would be increased for the transmission from east to west.

Transmission west to east				Outside listener adjusted for west to east transmission	
Sending band	Sending delay at west end	Receiving correction at east end	Total delay	Receiving correction	Total delay
O—F ₁ F ₁ —F ₂ F ₂ —F ₃	O T 2T	2T T O	2T 2T 2T	2T T O	2T 2T 2T
Transmission east to west					
Sending band	Sending delay at east end	Receiving correction at west end	Total delay		
O—F ₁ F ₁ —F ₂ F ₂ —F ₃	2T T O	O T 2T	2T 2T 2T	2T T O	4T 2T O

A listener-in would therefore need two separate receiving systems so that the transmission from each terminal could be individually picked up and corrected for; and in, for example, a radio telephone system sending the same frequency in both directions, each of those two receiving systems would need to have sharp directional selectivity, which, as noted above, is a requirement very difficult to meet except in limited areas in relation to the two transmitting stations.

The system of Figs. 1 and 2 may be, for example, a radio telephone system of the type referred to in connection with the table above. For convenience, the terminal shown in Fig. 1 will be designated the west terminal of the system and the terminal shown in Fig. 2 will be designated the east terminal. Correspondingly, two-wire line 1, which may be, for example, a voice frequency telephone line, will be designated the west two-wire line or line west, and line 2, which may be a similar line,

will be designated the line east. The four-wire portion of the circuit comprises line 3 to which the west terminal transmits signals, line 4 which delivers those signals to the east terminal, line 5 to which the east terminal transmits signals, and line 6 which delivers the latter signals to the west terminal. The use of dashes to represent these lines indicates that the lines may be of considerable extent and that any desired apparatus may be included in them or between lines 3 and 4 and between lines 5 and 6. For example, line 3 may connect with line 4, and line 5 may connect with line 6. Or, on the other hand, line 3 may terminate, at its east end, in a radio transmitter, and line 4 may have at its west end a radio receiver for receiving from that transmitter; and line 5 may terminate at its west end in a radio transmitter and line 6 may have at its east end a radio receiver for receiving from that transmitter. In the case of such a radio system, the carrier frequency employed for the two directions of transmission may be the same for both directions, in order that the signaling waves passing in opposite directions may be of the same frequency range for both directions, so that a listener-in will need directionally selective receiving systems as noted above.

The frequencies transmitted in lines 3, 4, 5 and 6 may be the same as those transmitted in lines 1 and 2.

This system illustrates the case in which speech is divided into three frequency bands that are sent at different relative times.

In this case two delay circuits on paths 10 and 11 are used for giving the three relatively different sending times, each delay introducing a delay of time T. The filters used for dividing the speech into frequency bands have their pass ranges indicated on the drawing. Starting from line 1 at the west terminal the low frequency band O—F₁, passes through a low pass filter 12 onto line 3 of the secrecy part of the system, with no delay. The mid-frequency band, F₁—F₂, passes through a band pass filter 13, the delay circuit or path 11, an amplifier A—14, and a high pass filter 15 onto line 3, and so is given a delay of time T relative to the low frequency band in getting to the secrecy part of the circuit. The high frequency band, F₂—∞, passes through a high pass filter 16, the delay circuit or path 10, an amplifier A—17, a high pass filter 18, the delay path 11, amplifier A—14 and filter 15, onto line 3, and so is given a delay of 2T relative to the low frequency band.

At the other end of the system in passing from the secrecy part of the circuit of the two-wire line 2 at the east terminal, the high frequency band passes through a high pass filter 19, but no delay path; the mid-frequency band passes through a low pass filter

20, a delay circuit or path 21 which introduces a delay of time T , an amplifier A—23, and a band pass filter 24 onto line 2; and the low frequency band passes through elements 20, 21, A—23, a low pass filter 25, a delay circuit or path 22 which introduces a delay of time T , an amplifier A—26 and a low pass filter 27 onto line 2. Thus, the high frequency band is given no additional delay, the mid-frequency band is given a delay of T , and the low frequency band is given a delay of $2T$, so that all three bands have been given the same overall delay of $2T$ and are back in normal time relation with respect to one another.

15 In the case of transmission from east to west the same delays are introduced in reversed order with respect to the three bands at the transmitting and receiving ends.

Starting from line 2 at the east terminal 20 the high frequency band, $F_2-\infty$ passes through a high pass filter 29 onto line 5 of the secrecy part of the system with no delay. The mid-frequency band, F_1-F_2 , passes through a band pass filter 30, a delay circuit or path 32 of delay time T , an amplifier A—33, and a low pass filter 34 onto line 5, and so is given a delay of time T relative to the high frequency band in getting to the secrecy part of the circuit. The low frequency band, $0-F_1$, passes through a low pass filter 35, a delay circuit or path 31 of delay time T , an amplifier A—36, a low pass filter 37, the delay path 32, amplifier A—33 and filter 34 onto line 5, and so is given a delay of $2T$ relative to the high frequency band.

At the other or west end of the system, in passing from the secrecy part 6 of the circuit to the two-wire line 1, the low frequency band passes through a low pass filter 38, but no delay path; the mid-frequency band passes through a high pass filter 39, a delay circuit or path 40 of delay time T , an amplifier A—42, and a band pass filter 43 onto line 1; and the high frequency band passes through elements 39, 40, A—42, a high pass filter 44, a delay circuit or path 41 of delay time T , an amplifier A—45 and a high pass filter 46 onto line 1. Thus, the low frequency band is given no additional delay, the mid-frequency band is given a delay of T , and the high frequency band is given a delay of $2T$, so that all three bands have been given the same overall delay of $2T$ and are back in normal time relation with respect to one another.

55 The gains of amplifiers A—14 and A—17 may be made such that all of the frequency bands suffer equal transmission losses in passing from line 1 to line 3. The gains of amplifiers A—23, A—26, A—33, A—36, A—42 and A—45 may be adjusted for a similar purpose.

It is sometimes desirable to have the secrecy apparatus in the two-wire portion of the transmission circuit, instead of in the four-wire portion. Fig. 3 shows one terminal, for 65 convenience say the west terminal, of a two-

wire type of secrecy system in general similar to the four-wire type of secrecy system shown in Figs. 1 and 2. This terminal circuit shown in Fig. 3 may be regarded as a 22-type repeater circuit, of zero loss or possible gain, 70 that gives secrecy. One end of this circuit is connected to line 1 by a hybrid coil and balancing network of the usual type, as in the case of the terminal circuit of Fig. 1, and the other end is connected to a two-way secrecy 75 line 1' which transmits the signals that have been so distorted as to be unintelligible. The use of dashes to represent this line indicates that it may be of considerable extent and/or that any desired apparatus, as for example, 80 the radio transmitters and receivers mentioned in connection with the system of Figs. 1 and 2 may be included in the link between the two terminals of the system. For such inclusion of a radio link, the usual manner 85 of connecting a two-wire line such as 1' to a four-wire type of circuit including a radio line can be employed, (and an illustration is found in the case of the connection of line 1 to lines 3 and 6 in Fig. 1 by means of bridge 90 transformer or hybrid coil BT and line balancing network N, considering the secrecy apparatus to be omitted from that figure).

In the system of Fig. 3, as in that of Figs. 1 and 2, the speech is divided into three 95 frequency bands that are sent at different relative times. The filters used for dividing the speech into frequency bands have their pass ranges indicated on the drawings. Starting from line 1 at the west terminal the low 100 frequency band, $0-F_1$, passes through bridge transformer BT, conductors 50, conductors 51, a low pass filter 52, loss equalizer 53, low pass filter 54, conductors 55, amplifier A—56, and bridge transformer BT onto line 1' with 105 no delay. The mid-frequency band, F_1-F_2 , passes through elements BT, 50, 51, a band pass filter 62, loss equalizer 63, band pass filter 64, delay circuit or path 65 of delay time T , high pass filter 66, and elements 55, A—56, 110 and BT, onto line 1', and so is given a delay of time T relative to the low frequency band in getting to the secrecy part 1' of the circuit. The high frequency band, $F_2-\infty$, passes through elements BT, 50, 51, a high 115 pass filter 72, delay circuit or path 73 of delay time T , high pass filter 74, and elements 65, 66, 55, A—56, and BT, onto line 1' and so is given a delay of $2T$ relative to the low frequency band. 120

The east terminal (not shown) is like the west terminal except that, as in the case of the system of Figs. 1 and 2, the low frequency band, instead of the high frequency band, is delayed in receiving, and the low frequency band, instead of the high frequency band, is delayed in sending. (In fact, a two-wire type of system generally similar to the four-wire type of system shown in Figs. 1 and 2 can be derived from the latter system by 130

merely converting the four-wire portion of the circuit at each terminal into a two-wire circuit by means of a hybrid coil in a manner illustrated in connection with the system of Fig. 4 described hereinafter.) Therefore, the distortion in the signals coming to the west terminal from line 1' is that the mid-frequency band F_1 — F_2 , is delayed by a time T relative to the high frequency band F_2 — ∞ , and the low frequency band 0 — F_1 is delayed by a time $2T$ relative to the high frequency band.

At the west terminal, in passing from the secrecy part 1' of the circuit to the two-wire line 1, the low frequency band passes through bridge transformer BT, conductors 75, low pass filter 76, transmission loss equalizer 77, low pass filter 78, conductors 79, amplifier A—80 and bridge transformer BT onto line 1. The mid-frequency band passes through elements BT, 75, a band pass filter 81, transmission loss equalizer 82, band pass filter 83, delay circuit or path 84 of delay time T , high pass filter 85, and elements 79, A—80 and BT onto line 1. The high frequency band passes through elements BT, 75, a high pass filter 86, a delay circuit or path 87 of delay time T , a high pass filter 88, and elements 84, 85, 79, A—80 and BT onto line 1. Thus, the low frequency band is given no additional delay the mid-frequency band is given a delay of T , and the high frequency band is given a delay of $2T$, so that all three bands have been given the same overall delay of $2T$ and are back in normal time relation with respect to one another.

The transmission loss equalizers 53 and 63 may be made to have such loss that all of the frequency bands suffer equal transmission loss in passing from line 1 to amplifier A—56. The loss of equalizers 77 and 82 may be adjusted to give zero transmission loss, or a desired gain, from line 1 to line 1' and vice versa.

In connection with the circuit shown in Fig. 3 two-wire echo suppressor arrangements may be applied. For example, the two control amplifier rectifiers AR—91 and AR—92 may have their input sides connected to the bridge points of the hybrid coils through contacts of relays 93 and 94, these contacts being included in conductors 50 and 75 respectively and these relays being operated by the amplifier rectifier AR—92 and AR—91 respectively. By also having AR—91 open the input circuit of A—80 at contacts of relay 95 which are included in the conductors 79 and having AR—92 open the input circuit of A—56 at contacts of relay 96 which are included in the conductors 55, the suppressor circuit will have characteristics part way between those of a two-wire suppressor circuit not provided with delay circuits and a two-wire suppressor

circuit with delay circuits as shown for example in Mathes Patent 1,693,955, December 4, 1928, or a four-wire echo suppressor circuit of the type shown for example in Fig. 1 of E. D. Johnson Patent 1,526,550, February 17, 1925, for two bands of the speech energy in the case of transmission in each direction are delayed between the two hybrid coils, corresponding to the time delay in the two halves of a four-wire circuit. Thus, reliability of operation is increased and the time during which circulating currents can build up is reduced.

Although in both of the systems described above, the dissimilarity of signal distortion for opposite transmission directions is dissimilarity with respect to relative time displacement of frequency bands, other kinds of dissimilarity may be employed, as indicated above. For example, the one-way system shown in Mathes Patent 1,542,565, June 16, 1925, in which secrecy is obtained by inversion of frequency bands, may be used with an oppositely directed one-way system like that of Mathes Patent 1,542,566 referred to above, in which secrecy is obtained by relative time displacement of those frequency bands; or transmission in one direction may be in accordance with Espenschied Patent 1,546,439, July 21, 1925, in which secrecy is obtained by frequency band transposition and by frequency band inversion and transposition, and transmission in the opposite direction may be with the system of the Mathes Patent 1,542,566, so that secrecy will be augmented by having delay of frequency bands in transmission in one direction and either transposition or inversion, or both transposition and inversion, of those bands in transmission in the other direction; or in case secrecy is obtained in one direction of transmission by inversion of frequency bands as in Mathes Patent 1,542,565, for transmission in the opposite direction, the system can be duplicated except as to the particular ones of those frequency bands that are left normal and the particular ones that are inverted; or in the two-way system of the Espenschied Patent 1,546,439, in which secrecy is obtained by transposing frequency bands, dissimilarity can be introduced, for the two directions of transmission, as to the specific transposition of those bands that is made. Moreover, where the dissimilarity for transmission in opposite directions is dissimilarity with respect to relative time displacement of frequency bands, the dissimilarity need not be obtained by assignment of delays changing with frequency in one order for one direction of transmission and in the reverse order for the opposite direction, as in the system of Figs. 1 and 2 and the system of Fig. 3. For example, the relative delays given to the bands may differ for opposite directions of

transmission in the manner pointed out hereinafter in the description of Fig. 4.

Fig. 4 will be described first as operating as one terminal, for convenience say the west terminal, of a four-wire type of system which may be like the four-wire type of system of Figs. 1 and 2 except that voice operated repeater switching means is employed, and except that a different type of secrecy apparatus is employed between the two wire line 1 and the lines 3 and 6 and correspondingly such different type of secrecy apparatus is employed at the east terminal (not shown) between the two-wire line and the four-wire or secrecy portion of the system.

In circuits where voice operated repeater switching is desired together with conversion to secrecy, as for example, in the circuits at the two terminals of the present commercial transatlantic radio telephone system in which (as in the disclosure in Nyquist Patent 1,607,687, November 23, 1926) the receiving apparatus is normally on and the transmitting apparatus is only connected in when outgoing speech comes along, delay circuits or paths may be used for conversion to secrecy and the same delay means may serve to assist in reducing clipping or elimination of portions of the signals because of the time required to effect switching. A way in which the voice operated control circuits and the delay circuit to avoid clipping on transmitting can be introduced is shown in Fig. 4 and will appear as the description of that figure proceeds.

Systems in which some outgoing talk passes through delay circuits in tandem at one terminal, such for example as the systems in Figs. 1, 2 and 3, provide for economical use of delay circuit material, which is of importance when electrical delay circuits are used in which the cost goes up in proportion to the amount of delay. On the other hand, if acoustic or mechanical delay circuits or paths are used the distortion of the apparatus for converting from electrical to mechanical vibrations and back again piles up and may become too large, especially in cases in which bands of speech energy must pass through a number of such conversions and back again at the two terminals of the circuit.

The circuit of Fig. 4 avoids such cumulative distortions. In this type of circuit the total length of delay path is increased, the amount of conversion equipment is the same, while the number of conversions any one band of speech energy must pass through at both ends of the secrecy system is reduced to two. In the case of acoustic delay paths the increased cost of increased total length of path will probably be negligible.

To function with the minimum amount of equipment as shown, dissimilar transmission in the two directions may be used with the increasing delays being assigned to opposite di-

rection of transmission, not in reverse order as in the system of Figs. 1 and 2 or the system which has a terminal such as is shown in Fig. 3, but by a cyclical shift in the frequency band assignment to the delay circuits, as will now be explained.

Speech energy starting from line 1 for delivery to line 3 passes through bridge transformer BT and then divides into two portions, one of which passes through conductors 100 to amplifier-rectifier AR—101 which operates relay 102 for opening a short circuit through its upper contact across conductors 103 and for opening the circuit through conductors 104 at its lower contacts. The other portion passes through conductors 105 and then divides into three frequency bands, of ranges $0-F_1$, F_1-F_2 and $F_2-\infty$. The low frequency band passes through low pass filter A, delay path 106 of delay time t , transmission loss equalizer 107, low pass filter A', amplifier A—108 and conductors 103 onto line 3. (The pass ranges of the filters shown in Fig. 4 are indicated on the drawings. The delay paths shown in the figure may be electrical delay circuits or acoustic or other mechanical delay paths.) The mid-frequency band passes through band pass filter B, delay path 110 of delay time $t+T$, transmission loss equalizer 111, band pass filter B', amplifier A—108 and conductors 103 onto line 3. The high frequency band passes through high pass filter C, delay path 112 of delay time $t+2T$, high pass filter C', amplifier A—108, and conductors 103 onto line 3.

Speech energy coming from line 6 for delivery to line 1 passes through the lower contacts of relay 102 and then divides into two portions, one of which passes through conductors 115 to amplifier-rectifier AR—116 which operates relay 117 for opening the input circuit of AR—101. The other portion divides into three frequency bands of ranges $0-F_1$, F_1-F_2 , and $F_2-\infty$. The high frequency band passes through high pass filter D', transmission loss equalizer 107, delay path 106, high pass filter D, and amplifier A—118 which feeds into line 1 through bridge transformer BT. The low frequency band passes through low pass filter E', transmission loss equalizer 111, delay path 110, low pass filter E, and amplifier A—118 which feeds through BT to line 1. The mid-frequency band passes through band pass filter F', delay path 112, band pass filter F, and amplifier A—118 which feeds through BT to line 1.

The east terminal of the system (not shown) is like the west terminal except that the delays introduced in the three frequency bands are as indicated in the following table under Condition I. The table also shows that with the three frequency bands, there can be obtained a second condition of operation

based on delaying the low frequency band by time t on transmission.

Delay	Filters	Condition I		Condition II	
		West set	East set	West set	East set
t	AA' (send) DD' (rec.)	low	mid	low	low
$t+T$	BB' (send) EE' (rec.)	high	high	mid	high
$t+2T$	CC' (send) FF' (rec.)	mid	low	high	mid
		high	high	low	low

Four additional conditions may be gotten by cyclically shifting the time delays with respect to these filter combinations. The feature of additional secrecy due to dissimilar transmission appears here in the form that, if a station receives the opposite terminal to that which it is adjusted to translate, the several bands appear with delays of $2t+T$, $2t+2T$, and $2t+3T$ and the degree of time shifts which produce secrecy remains unchanged.

This differs from the case in which the time lags are applied in reverse order to the frequency bands in which case such reception doubles the time lag differences.

The delay t is determined by the degree of clipping permissible. The delay t prevents clipping of the low frequency band of energy transmitted through filters A and A'. The energy passing through filters B and B' and through filters C and C' has additional time delay protection, against clipping, of times T and $2T$. If switching is not to be combined with this circuit the time t may be made zero, i. e., the delay path designed to give the delay of time t can be omitted.

The transmission loss equalizers 107 and 111 may be made to have such loss that all of the frequency bands suffer equal transmission loss in passing from line 1 to line 3 and also in passing from line 6 to line 1. The gains of amplifiers A—108 and A—118 may be adjusted to overcome those losses and give zero overall transmission losses, or desired gains, from line 1 to line 3 and from line 6 to line 1.

By closing switches 120 and 121 to connect with bridge transformer BT, the terminal shown in Fig. 4 may be operated as a terminal of a two-wire type of system which may be generally like that of which Fig. 3 shows one terminal.

Where desired the delay paths in any of the systems described herein may be of the mechanical or acoustic types, instead of electrical delay circuits. Examples of electrical delay paths that may be employed in these systems, and of mechanical and acoustic delay paths that may be employed in systems such as those of Figs. 1, 2 and 3 which do not require two-way delay paths, are disclosed in Mathes Patent 1,696,315, December 25, 1928. Examples of two-way electrical, me-

chanical and acoustic delay paths that have zero transmission loss (or a gain if desired) and are suitable for use in the delay paths in Fig. 4, as well as for use as the delay paths in Figs. 1, 2 and 3, are disclosed in my copending application, Serial No. 351,417, filed of even date herewith, and an example of such an electrical delay circuit is disclosed in Clark Patent 1,672,057, June 5, 1928, and such an acoustic delay path is shown in Fig. 5 described below and is claimed in my application just mentioned. Where such lossless paths are used as the delay paths in Fig. 4, the amplifiers and transmission loss equalizers shown in that figure can be omitted from the system.

The delay circuit of Clark Patent 1,672,057 mentioned above, involves the addition of a 21-type telephone repeater to the system of Nyquist Patent 1,607,687, November 23, 1926 for getting twice the delay out of the particular delay circuit by a reflection process. Fig. 5 shows a similar system using an acoustic delay circuit of the general type disclosed in my Patent 1,696,315, mentioned above, instead of an electrical delay circuit. The delay path is shown connected between sections 150 and 151 of a two-way two-wire circuit or line.

Speech energy comes from line section 150 into the hybrid coil or bridge transformer circuit BT and divides between two loud speaker elements 152 and 153, one coupled to an acoustic delay path 154 and the other coupled to an acoustic resistance 155. This acoustic resistance, which is to imitate or simulate the impedance of an infinite length of the acoustic delay path, might consist of a substantially infinite pipe, or a pipe decreasing exponentially in diameter, or a composite group of open and short-circuited pipes as disclosed in the copending application of W. P. Mason, Serial No. 221,261, filed September 22, 1927, which issued as Patent No. 1,795,874, March 10, 1931. At the far end of the acoustic delay path the speech energy is reconverted to the electrical form by another loud speaker element 156 after which it is amplified by a 21-type telephone repeater A—157. Half of the amplified energy is sent on and lost in the balancing network N, the other half returning via the acoustic delay path 154 to the hybrid coil BT where half of it goes to the two-wire line section 151 and half is fed back to the two-wire line section 150. The process for transmission from line section 151 to line section 150 is exactly similar. This system not only has the property of a 21-type repeater circuit that energy is fed back to the subscriber talking as well as on to the subscriber listening, but furthermore has the property that a certain amount of direct transmission will pass between line sections 150 and 151 through the hybrid coil BT, its magnitude

depending upon the degree of balance obtainable, and travel on down the circuit ahead of the delayed transmission. The system shown has been devised with a view to keeping this unbalance component as small as possible compared to the delayed main component. If desired, an amplitude equalizer 158, which compensates for non-uniform frequency-response characteristics of the loud speaker elements 152 and 156 and the delay path 154, can be included in circuit with amplifier A—157, as shown.

What is claimed is:

1. A message path for altering the intelligibility of waves transmitted therethrough, and means for transmitting subdivided portions of message waves in opposite directions throughout the length of said path to increase the intelligibility of the messages in one direction and decrease the intelligibility of the messages in the other direction, the portions of said path in which said increase and said decrease are effected being at least partly common.

2. A message distorting path for altering the time relation between waves transmitted therethrough to alter their intelligibility, and means for transmitting messages in opposite directions therethrough to increase the intelligibility of the messages in one direction and decrease the intelligibility of the messages in the other direction, the portions of said path in which said increase and said decrease are effected being at least partly common, and said path comprising parallel connected channels having their transmission frequency ranges mutually exclusive.

3. The combination with a two-way wave transmitting path comprising means having all of its parts at the same geographical location for altering the time relation of waves transmitted in one direction therethrough and means, at least partly common with said first means but having all of its parts at said location, for altering the time relation of waves transmitted in the opposite direction therethrough, of means for transmitting waves representing a message in one direction through said path, and means for transmitting waves representing a message in the opposite direction through said path, said path comprising channels having their transmission frequency ranges mutually exclusive.

4. A two-way signaling system comprising two intercommunicating stations, each station comprising a message path for altering the intelligibility of waves transmitted therethrough, and means for transmitting message waves in opposite directions throughout the length of said path to increase the intelligibility of the messages in one direction and decrease the intelligibility of the messages in the other direction, the portions of said path in which said increase and said de-

crease are effected being at least partly common, said path comprising channels having their transmission frequency ranges mutually exclusive, and said means at said two stations decreasing the intelligibility of messages in different manners for the two directions, respectively.

5. A message path for altering the intelligibility of waves transmitted therethrough, and means for transmitting message waves in opposite directions therethrough to increase the intelligibility of the messages in one direction and decrease the intelligibility of the messages in the other direction, the portions of said path in which said increase and said decrease are effected being partly common and partly separate.

6. A two-way signaling system comprising means responsive to signals transmitted in one direction in the system for preventing transmission of those signals in the opposite direction in the system, means for producing relative time delay of frequency bands of energy of said signals, and a delay path common to said two means.

7. A signaling system comprising means responsive to signals transmitted in one direction in the system for rendering the system operative to transmit said signals in that direction through a portion of the system, means for relatively delaying frequency bands of energy of said signals in their transmission, and a delay path common to said two means.

8. In combination, a message path for altering the intelligibility of waves transmitted therethrough, and means for transmitting message waves in opposite directions throughout the length of said path to increase the intelligibility of the messages in one direction and decrease the intelligibility of the messages in the other direction, the portions of said path in which said increase and said decrease are effected being at least partly common, and means responsive to message waves transmitted through said path for preventing simultaneous transmission in opposite directions therethrough.

9. A two-way signaling system comprising signal transmitting means for distorting signals transmitted in one direction over the system to render them unintelligible, signal transmitting means for differently distorting signals transmitted in the opposite direction over the system to render them unintelligible, and means responsive to signals transmitted in said system for preventing simultaneous transmission in opposite directions through either of said two signal transmitting and distorting means.

In witness whereof, I hereunto subscribe my name this 27th day of March, 1929.

ROBERT C. MATHES.