

Aug. 18, 1931.

R. C. MATHES

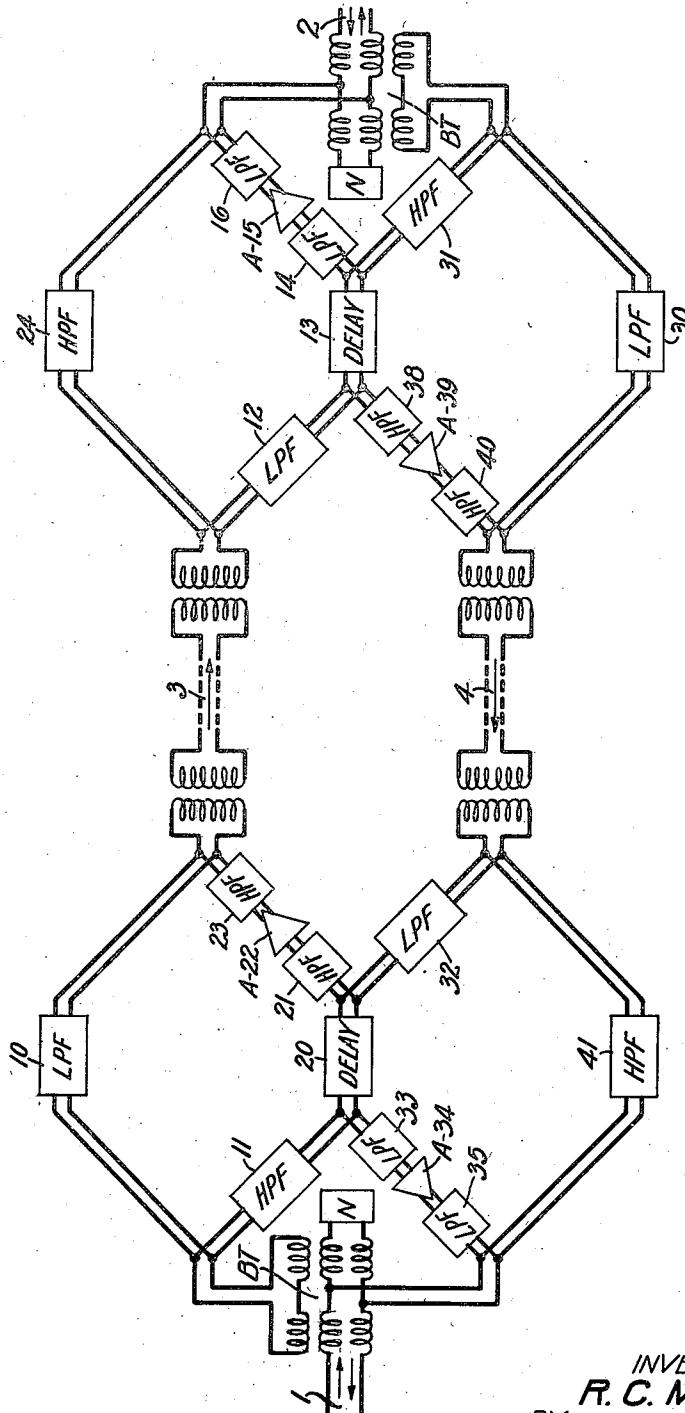
1,819,649

WAVE TRANSMISSION SYSTEM

Filed March 30, 1929

5 Sheets-Sheet 1

Fig. 1.



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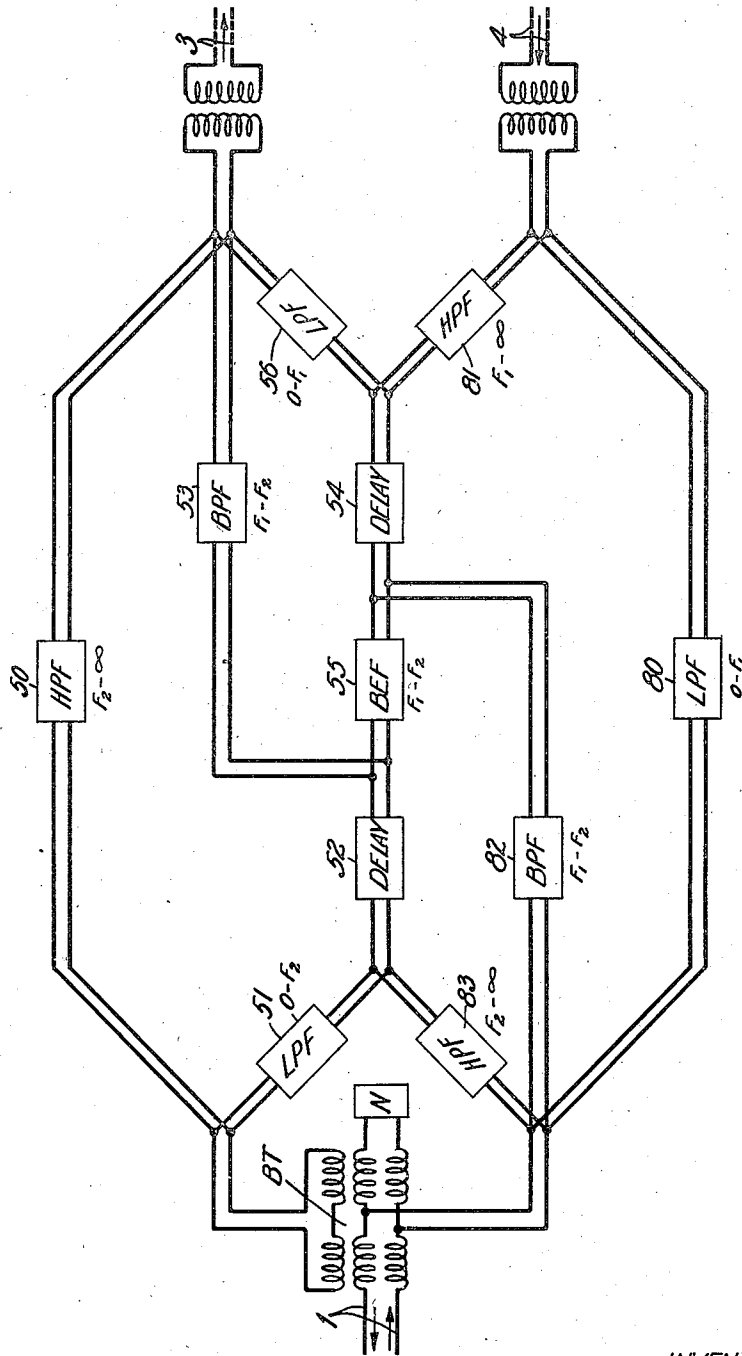
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FIG. 2.



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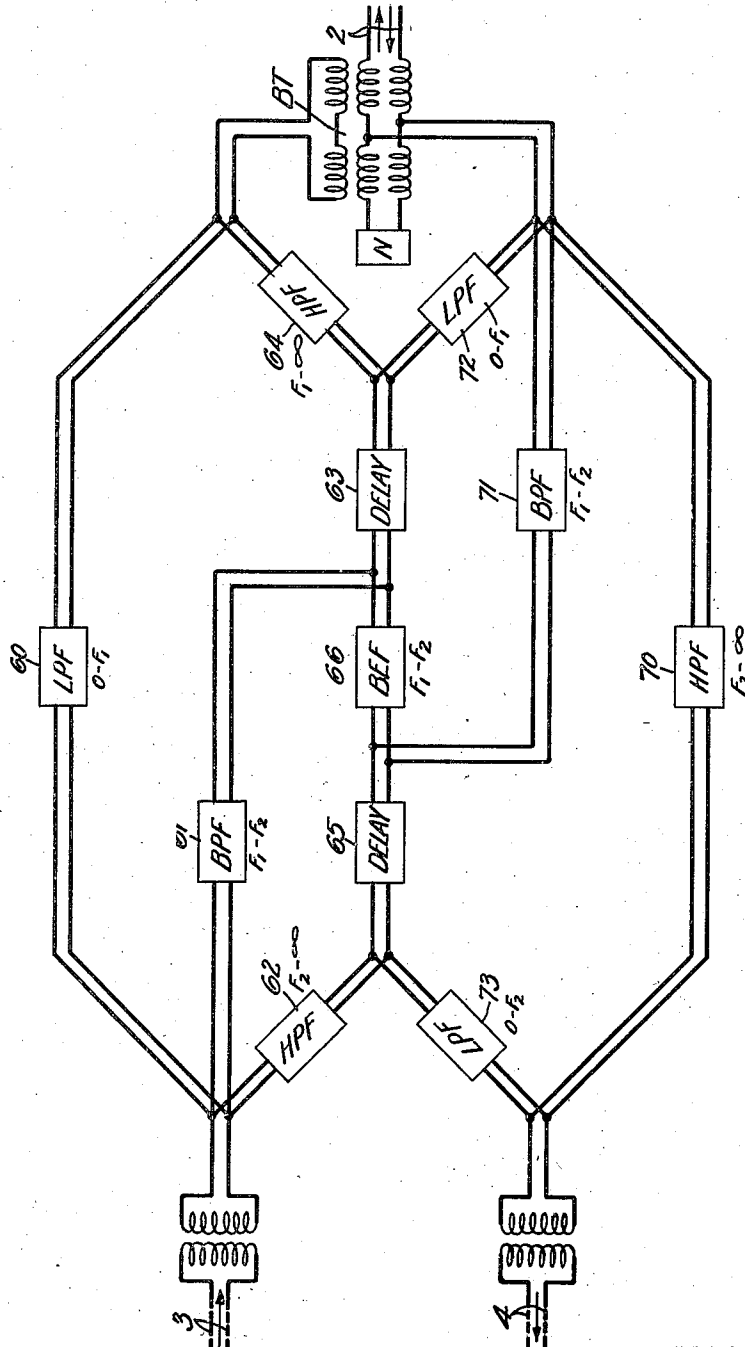
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WAVE TRANSMISSION SYSTEM

Filed March 30, 1929

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FIG. 3.



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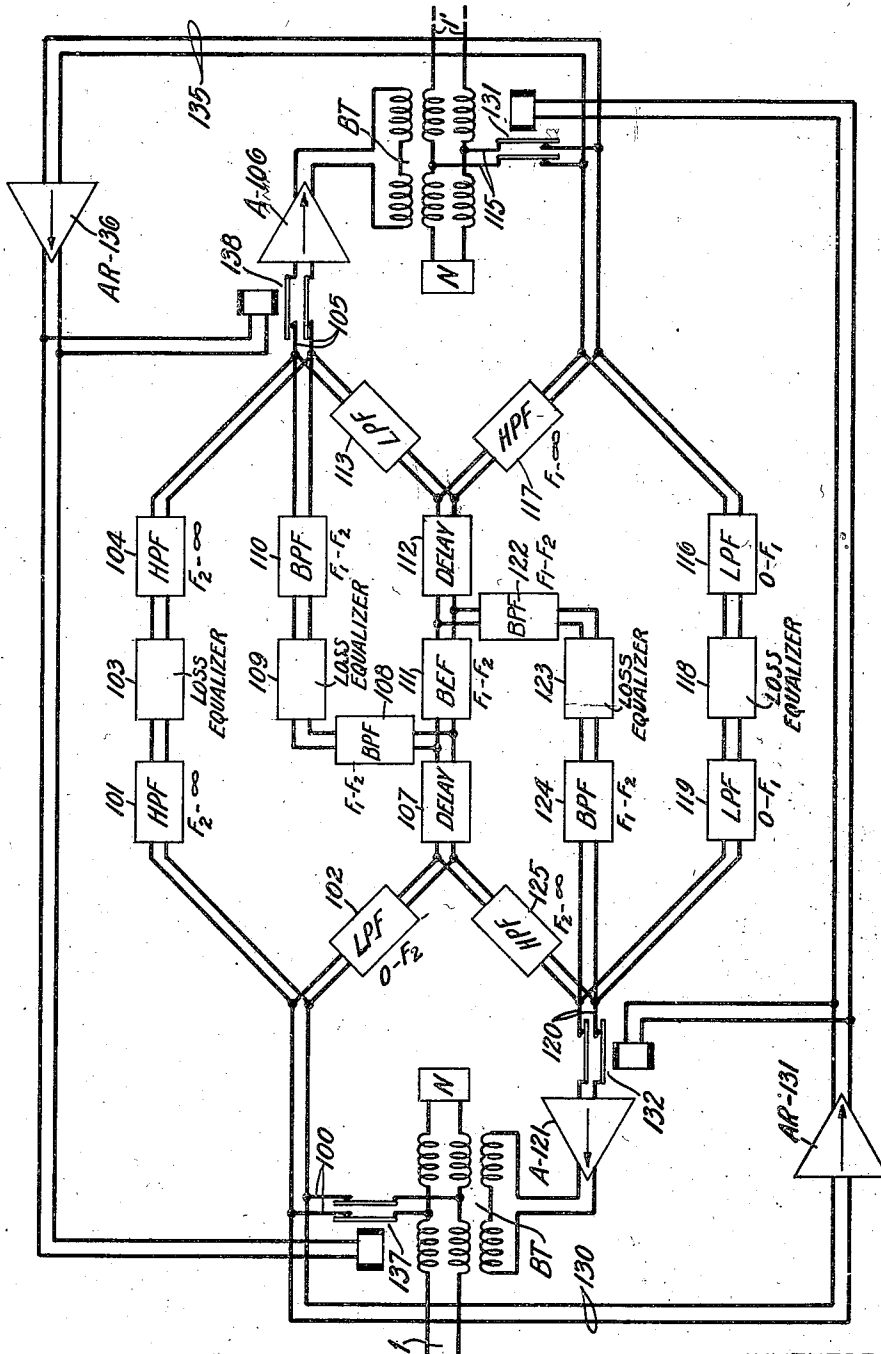
1,819,649

WAVE TRANSMISSION SYSTEM

Filed March 30, 1929

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Fig. 4.



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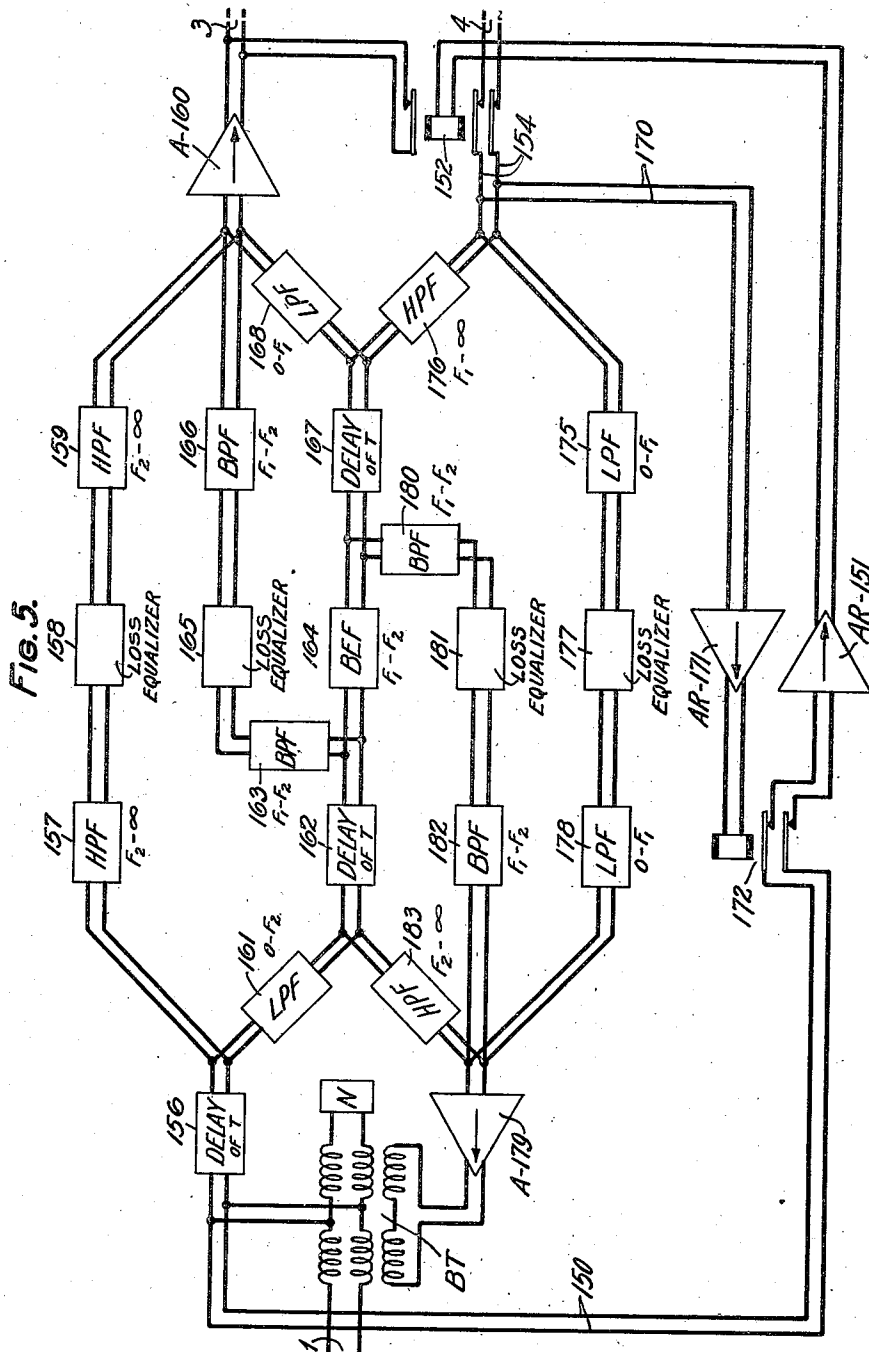
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WAVE TRANSMISSION SYSTEM

Filed March 30, 1929

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WAVE TRANSMISSION SYSTEM

Application filed March 30, 1929. Serial No. 351,416.

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

An object of the invention is to economize transmission delay apparatus where different delays are to be introduced in different transmission channels.

A further object is to economize privacy apparatus.

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 is made to serve for both directions of transmission in a two-way radio telephone system, and the total length of delay paths is economized by having one of two mutually exclusive frequency bands of speech energy that are transmitted in the same direction over the system pass through two portions of a delay path in tandem relationship, and having the other band pass through one only of the two portions instead of through a separate delay means of delay time equal to that of the one portion.

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

Fig. 1 shows a system embodying one form of the invention; Figs. 2 and 3 show the two terminals, respectively, of a system embodying a second form of the invention; Fig. 4 shows a terminal of a system embodying a third form of the invention; and Fig. 5 shows a terminal of a system embodying a fourth form of the invention.

Fig. 1 shows a four-wire type of system, which may be, for example, a telephone system transmitting speech between the two-wire lines 1 and 2 over the four-wire portion of this circuit which includes line 3, for transmission passing from line 1 to line 2, and line 5 for transmission passing from line 2 to line 1. For convenience, line 1 may be design-

ated the west two-wire line, and line 2 the east two-wire line, the apparatus connecting line 1 with lines 3 and 4 being designated the west terminal of the system and the apparatus connecting line 2 with lines 3 and 4 being designated the east terminal of the system. The use of dashes to represent lines 3 and 4 indicates that the lines may be of considerable extent and/or that a radio link or any desired apparatus may be included in them.

In the system of Fig. 1 speech is divided into two frequency bands. The upper band is delayed on transmission from the west end, but the lower band is the one delayed on reception at that end. Thus, the manner in which the speech is scrambled is the same for the two directions of transmission. Consequently, more than two stations can intercommunicate with secrecy apparatus which is identically alike for each of the stations.

Starting from line 1 speech passing through bridge transformer (hybrid coil) BT is divided into a lower frequency band and an upper frequency band by a low pass filter 10 and a high pass filter 11. The lower band passes from filter 10 to line 3 without delay, and from line 3 through low pass filter 12, delay circuit or path 13, low pass filter 14, amplifier A—15, low pass filter 16, and bridge transformer BT on the line 2. The upper band passes from filter 11 through delay circuit or path 20 of delay time equal to the delay time of circuit 13, high pass filter 21, amplifier A—22, high pass filter 23, line 3, high pass filter 24 and bridge transformer BT on to line 2.

For transmission in the opposite direction, speech passing from line 2 through bridge transformer BT is divided into a lower frequency band and an upper frequency band by a low pass filter 30 and high pass filter 31. The lower band passes from filter 30 through line 4, low pass filter 32, delay path 20, low pass filter 33, amplifier A—34, low pass filter

35 and bridge transformer BT on to line 1. The upper band passes from filter 31 through delay path 13, high pass filter 38, amplifier A—39, high pass filter 40, line 4, high pass filter 41 and bridge transformer BT on to line 1. All of the filters have the same cut-off frequency.

The feasibility of inserting the one-way amplifiers A—22 to A—34 to make up for the losses in the delay circuits facilitates the use of cheap forms of delay paths such as acoustic delay paths.

Figs. 2 and 3 show a four-wire type of system generally similar to that of Fig. 1, but differing in that the speech is divided into three frequency bands instead of two, in order to increase the degree of privacy or secrecy obtained. These three bands are designated $0-F_1$, F_1-F_2 and $F_2-\infty$.

Fig. 2 shows one terminal of the system, which for convenience may be designated the west terminal, and Fig. 3 shows the other or east terminal.

The system will be sufficiently described by tracing the operation at the west and east ends of the circuit. Speech transmitted from west to east passes from line 1 by way of the series winding of bridge transformer (hybrid coil) BT to the junction of a high pass filter 50 and a low pass filter 51. The pass ranges of the low pass, high pass and band pass filters, and the elimination ranges of the band elimination filters employed in Figs. 2, 3, 4 and 5 of the drawings are indicated on the drawings. The half of the speech energy which passes by way of the bridge windings of the bridge transformer is lost in the receiving part of the circuit. The upper frequency band passes through the high pass filter 50, line 3 of the four-wire transmitting part of the circuit. The two lower bands pass through the low pass filter 51 and through delay circuit or path 52 of delay time T. From the output of this delay circuit the mid-band goes to the transmitting branch 3 of the four-wire circuit through band pass filter 53 and is kept from going to delay circuit or path 54 by band elimination filter 55. The low frequency band then passes through filter 55 to a branch of the four-wire circuit by way of delay path 54 of delay time T and low pass filter 56.

On receiving by the circuit of Fig. 3 a similar process takes place except that the amounts of delay are reversed as regards the low frequency band and the upper frequency band. Thus when speech from line 3 passes to the junction of low pass filter 60, band pass filter 61 and high pass filter 62, the low frequency band passes through filter 60 and bridge transformer BT on to line 2. The mid-frequency band passes through filter 61, delay circuit or path 63 of delay time T, high pass filter 64 and bridge transformer BT on to line 2. The high frequency band passes

through filter 62, delay circuit or path 65 of delay time T, band elimination filter 66, and the delay path 63, filter 64 and bridge transformer BT on to line 2.

Speech transmitted from line 2 passes by way of bridge transformer BT to the junction of high pass filter 70, band pass filter 71 and low pass filter 72. The upper band passes through filter 70 on to line 4. The mid-band passes through filter 71, delay path 65 and low pass filter 73 on to line 4. The low band passes from filter 72, delay path 63, filter 66, delay path 65 and filter 73 on to line 4.

On receiving at the west end of this system by the circuit shown in Fig. 2 a similar process takes place except that the amounts of delay are reversed as regards the lower frequency band and the upper frequency band. Thus speech from line 4 passes to the junction of low pass filter 80 and high pass filter 81. The low band passes through filter 80 and bridge transformer BT on to line 1. The two upper bands pass through filter 81 and delay path 54. From the output of this delay path the mid-band goes to bridge transformer BT and line 1 by way of band pass filter 82 and is kept from going to delay circuit 52 by filter 55. The high frequency band then passes to bridge transformer BT and line 1 by way of filter 55, delay path 52 and high pass filter 83.

No transmission loss equalizers and amplifiers are shown in Figs. 2 and 3 for making the overall transmission equivalent of the secrecy apparatus at each terminal the same and of the desired absolute value, for the three transmission bands, at each terminal of the system. However, a manner in which they can be applied to the system of these figures will be clear from the description hereinafter of Fig. 5, which shows a terminal circuit like that of Fig. 2 but equipped with such equalizers and amplifiers and with voice operated switching apparatus. Instead of using such equalizers and amplifiers there may be used, in the circuits of any of the figures of the drawings, two-way delay circuits of zero loss, or possible gain, such as are disclosed in Clark Patent 1,672,057, June 5, 1928 or two-way electrical, mechanical or acoustic delay paths giving zero loss or a gain, such as are disclosed in my copending application, Serial No. 351,417 filed on even date herewith.

Although the circuit shown in Fig. 3, as the east terminal of the system, is slightly different from that shown in Fig. 2 as the west terminal, either circuit may be used for either or both terminals.

Fig. 4 shows one terminal, for convenience say the west terminal, of a two-wire type of system in which speech is divided into three bands, as in the case of the system of Figs. 1 and 2. The terminal circuit shown in Fig. 4 is a two-wire secrecy circuit which can have

zero transmission loss, or can give a gain. This circuit is derived from the terminal circuit shown in Fig. 2 by coupling the two four-wire parts of the circuit of Fig. 2 together with a bridge transformer (hybrid coil) and inserting the necessary amplifiers and loss equalizers. The east terminal corresponding to the circuit of Fig. 4 may similarly be derived from the four-wire terminal of Fig. 3; or if desired the east terminal may be the same as the west terminal.

The terminal circuit shown in Fig. 4 may be regarded as a two-wire type repeater circuit of zero loss or possible gain. One end of this circuit is connected to line 1 by bridge transformer (hybrid coil) BT and balancing network N of the usual type, as in the case of the terminal circuit of Fig. 2, and the other end is connected to a two-way secrecy line 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, the radio link mentioned in connection with the systems of the preceding figures may be included in the link between the two terminals of the system.

The system will be sufficiently described by tracing the operation at the west end. Transmission from west to east passes from line 1 through bridge transformer BT and conductors 100 to the junction of high pass filter 101 and low pass filter 102. The upper band passes through filter 101, transmission loss equalizer 103, high pass filter 104, conductors 105, amplifier A—106, the bridge transformer BT on to line 1. The two lower bands pass through filter 102 and through delay circuit or path 107 of delay time T. From the output of this delay path the mid-band passes through band pass filter 108, transmission loss equalizer 109, band pass filter 110 and the conductors 105, amplifier A—106 and bridge transformer BT on to line 1'. The low frequency band passes from delay path 107 through band elimination filter 111, delay circuit of path 112 of delay time T, low pass filter 113 and the elements 105, A—106 and BT on to line 1'. On receiving by the east terminal a similar process takes place except that the amounts of delay are reversed as regards the lower frequency band and the upper frequency band as will now be described in connection with reception by the west terminal.

For transmission from east to west, speech from line 1' passes through bridge transformer BT and conductors 115 to the junction of low pass filter 116 and high pass filter 117. The low frequency band passes from filter 116 through transmission loss equalizer 118, low pass filter 119, conductors 120, amplifier A—121 and bridge transformer BT on to line 1. The two upper bands pass through filter 117 and through delay path 112. From the output of this delay path the mid-band passes through band pass filter 122, low transmission loss equalizer 123, band pass filter 124 and elements 120, A—121 and BT on to line 1. From the output of delay path 112 the high frequency band passes through filter 111, delay path 107, high pass filter 125 and elements 120, A—121 and BT on to line 1.

In connection with the terminals of this system two-wire echo suppressor arrangements may be applied. Thus, for transmission from west to east speech taken from conductors 100 through conductors 130 operates amplifier rectifier AR—131 which in turn operates relays 131 and 132. For transmission from east to west speech taken from conductors 115 through conductors 135 operates amplifier rectifier AR—136 which in turn operates relays 137 and 138. Relay 131 opens conductors 115, and relay 137 opens the conductors 100. By also having AR—131 open the input circuit of A—121 at the contacts of relay 132 which are included in the conductors 120, and having AR—136 open the input circuit of A—106 at contacts of relay 138 which are included in the conductors 105, 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.

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 trans-Atlantic 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. 5 and will appear as the description of that figure proceeds.

Fig. 5 shows one terminal, for convenience say the west terminal, of a four-wire type of system which may be like that of Figs. 2 and 3, except for the addition of voice operated switching means and the addition of such amplifiers and transmission loss equalizers as are shown in Fig. 4. The two terminals may be the same, as regards construction and operation. The system will be sufficiently described by explanation of the operation of the west terminal.

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 150 to amplifier-rectifier AR—151 which operates relay 152 for opening a short circuit through its upper contacts across line 3 and for opening the circuit through conductors 154 at its lower contacts. The other portion passes through delay circuit or path 156 of delay time T and then divides into a high frequency band of range $F_2-\infty$ which passes through high pass filter 157, and a band $0-F_2$ which passes through low pass filter 161. From filter 157 the high frequency band passes through transmission loss equalizer 158, high pass filter 159 and amplifier A—160 on to line 3. From filter 161 the band $0-F_2$ passes through delay circuit or path 162 of delay time T and is then separated by band pass filter 163 and band elimination filter 164 into mid-frequency band F_1-F_2 and low frequency band $0-F_1$. The mid-band F_1-F_2 , after passing through filter 163, goes through transmission loss equalizer 165, band pass filter 166 and amplifier A—160 on to line 3. The low band $0-F_1$, after passing through filter 164, goes through delay circuit or path 167 of delay time T, low pass filter 168 and amplifier A—160 on to line 3.

The operation of receiving at the east terminal may be the same as at the west terminal, and so will be apparent from the explanation now to be given of the latter operation.

Speech energy coming from line 4 for delivery to line 1 passes through the lower contacts of relay 152, which are included in conductors 154, and then divides into two portions, one of which passes through conductor 170 to amplifier-rectifier AR—171 which operates relay 172 for opening the circuit of AR—151 to prevent false operation of AR—151 by unbalance currents or echo currents received from the bridge points of the bridge transformer BT. The other portion divides into a low frequency band of range $0-F_1$ which passes through low pass filter 175, and a band $F_1-\infty$ which passes through high pass filter 176. From filter 175 the low frequency band passes through transmission loss equalizer 177, low pass filter 178, amplifier A—179 and bridge transformer BT on

to line 1. From filter 176 the band $F_1-\infty$ passes through delay circuit or path 167 and is then separated by band pass filter 180 and band elimination filter 164 into mid-frequency band F_1-F_2 and high frequency band $F_2-\infty$. The mid-frequency band, after passing through filter 180, goes through transmission loss equalizer 181, band pass filter 182, amplifier A—179 and bridge transformer BT on to line 1. The high frequency band $F_2-\infty$, after passing through filter 164, goes through delay path 162, high pass filter 183, amplifier A—179 and bridge transformer BT on to line 1.

The control circuit fed from the bridge points of the bridge transformer BT through conductors 150 does two things. It opens a short circuit on the output side of the amplifier A—160 that transmits to the sending line 3; and it disconnects the terminal from the receiving line 4 and thereby prevents operation of the receiving amplifier-rectifier AR—171 in the other control circuit, fed from line 4 through conductors 154 and 170. The latter control circuit opens the control circuit fed from the bridge points of the bridge transformer. The delay time T introduced by delay path 156 prevents clipping of the energy of the upper frequency band. The energy of the two lower frequency bands has additional time delay protection, of times T and 2T, against clipping.

In the circuit of Fig. 5, as well as in that of Fig. 4, the transmission loss equalizers shown may be given such losses, and the amplifiers shown may be given such gains, as to cause the overall transmission loss or gain for the three frequency bands, through the circuit, to be the same, and of the desired value.

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, mechanical and acoustical delay paths that may be employed in these systems are disclosed in Mathes patent 1,696,315, December 25, 1928.

What is claimed is:

1. In combination, a wave transmission path, a second wave transmission path, a third wave transmission path, two transmission delay paths, and means for transmitting selected waves between said first and second paths through said delay paths in tandem, to the exclusion of other waves, and transmitting said other waves between said first and third paths through one, only, of said delay paths.

2. Means for altering the time relation of waves transmitted therethrough, comprising paths in opposite directions through said means, said paths in opposite directions having portions least common, transmission delay means included in said common portions,

and means for transmitting waves of certain frequencies through each of two portions of said delay means and transmitting waves of other frequencies in a given direction through one only of said two portions.

3. Means for altering the time relation of waves transmitted therethrough, comprising paths in opposite directions through said means, said paths in opposite directions having portions at least common, transmission delay means included in said common portions, and means, including filters, for transmitting waves of certain frequencies through each of two portions of said delay means in tandem relationship and transmitting waves of other frequencies in a given direction through one only of said two portions.

4. Means for altering the time relation of waves transmitted therethrough, comprising paths in opposite directions through said means, said paths in opposite directions having portions at least common, transmission delay means included in said common portions, and means, including a band elimination filter, for transmitting certain frequencies in one direction only through both of two portions of said delay means in tandem relationship and transmitting other frequencies in only the opposite direction through both of said two portions and transmitting still other frequencies in one direction only through one of said two portions and in the opposite direction only through the other of said two portions.

5. A two-way transmission system comprising a two-way, two-wire line, two circuits, a Wheatstone bridge network connecting said two circuits to said line in conjugate relation to each other, and means connected in said two circuits for altering the time relation of waves transmitted therethrough, comprising, in combination, paths in opposite directions through said means, said paths in opposite directions having portions at least common, transmission delay means included in said common portions, and means, including filters, for transmitting waves of certain frequencies through each of two portions of said delay means in tandem relationship and transmitting waves of other frequencies in a given direction through one only of said two portions.

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 relatively delaying frequency bands of energy of said signals, and a delay path common to said two means, said means for relatively delaying the frequency bands comprising, in combination, a wave transmission path, a second wave transmission path, a third wave transmission path, two transmission delay paths, and means for transmitting selected waves be-

tween said first and second wave transmission paths through the two last mentioned delay paths in tandem, to the exclusion of other waves, and transmitting said other waves between said first and third wave transmission paths through one, only, of the two latter delay paths.

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

ROBERT C. MATHES.