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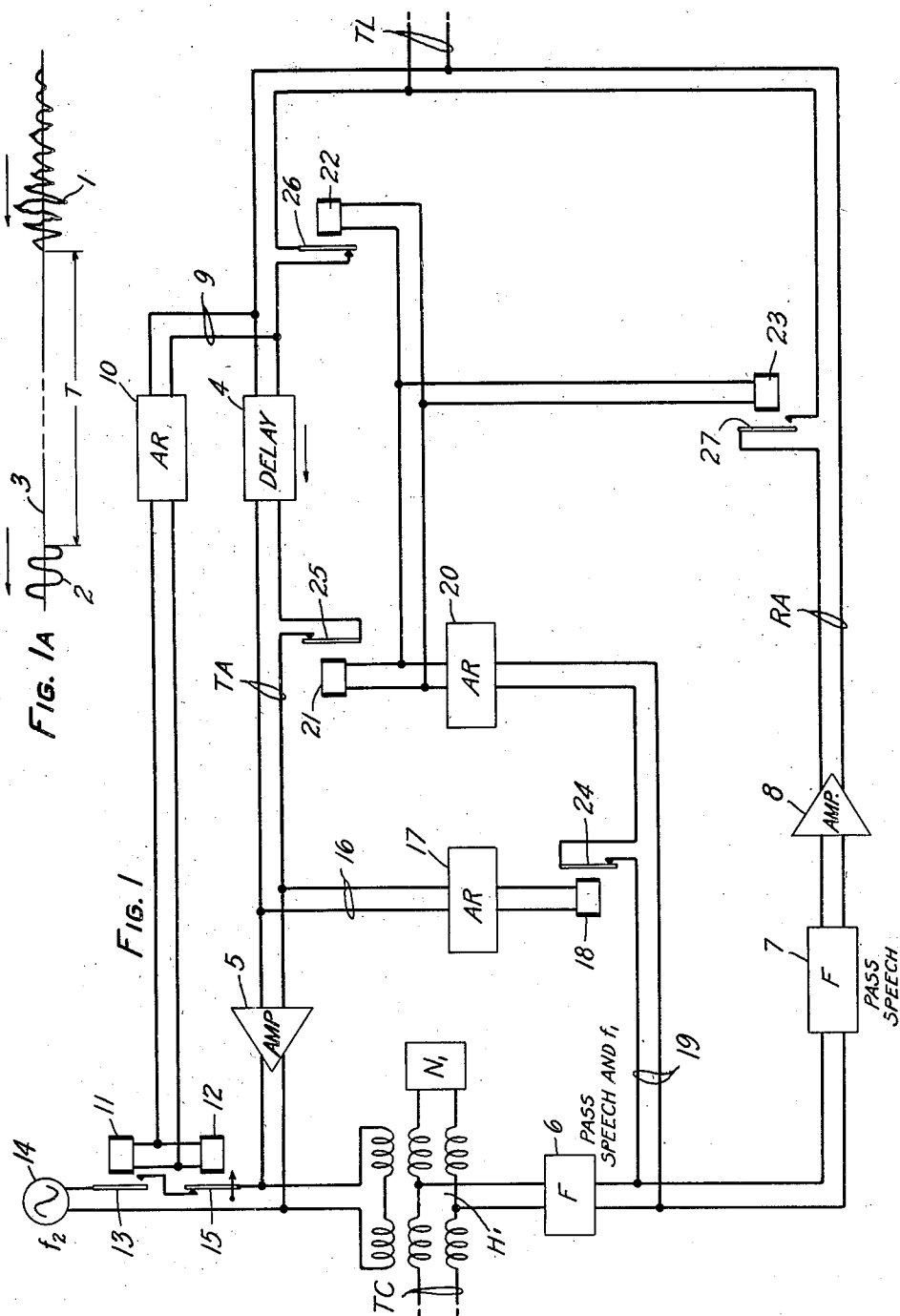
R. C. MATHES

1,829,806

TRANSMISSION CONTROL

Filed June 11, 1929

3 Sheets-Sheet 1



INVENTOR
R. C. MATHES
BY *H. A. Burgess*
ATTORNEY

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3 Sheets-Sheet 2

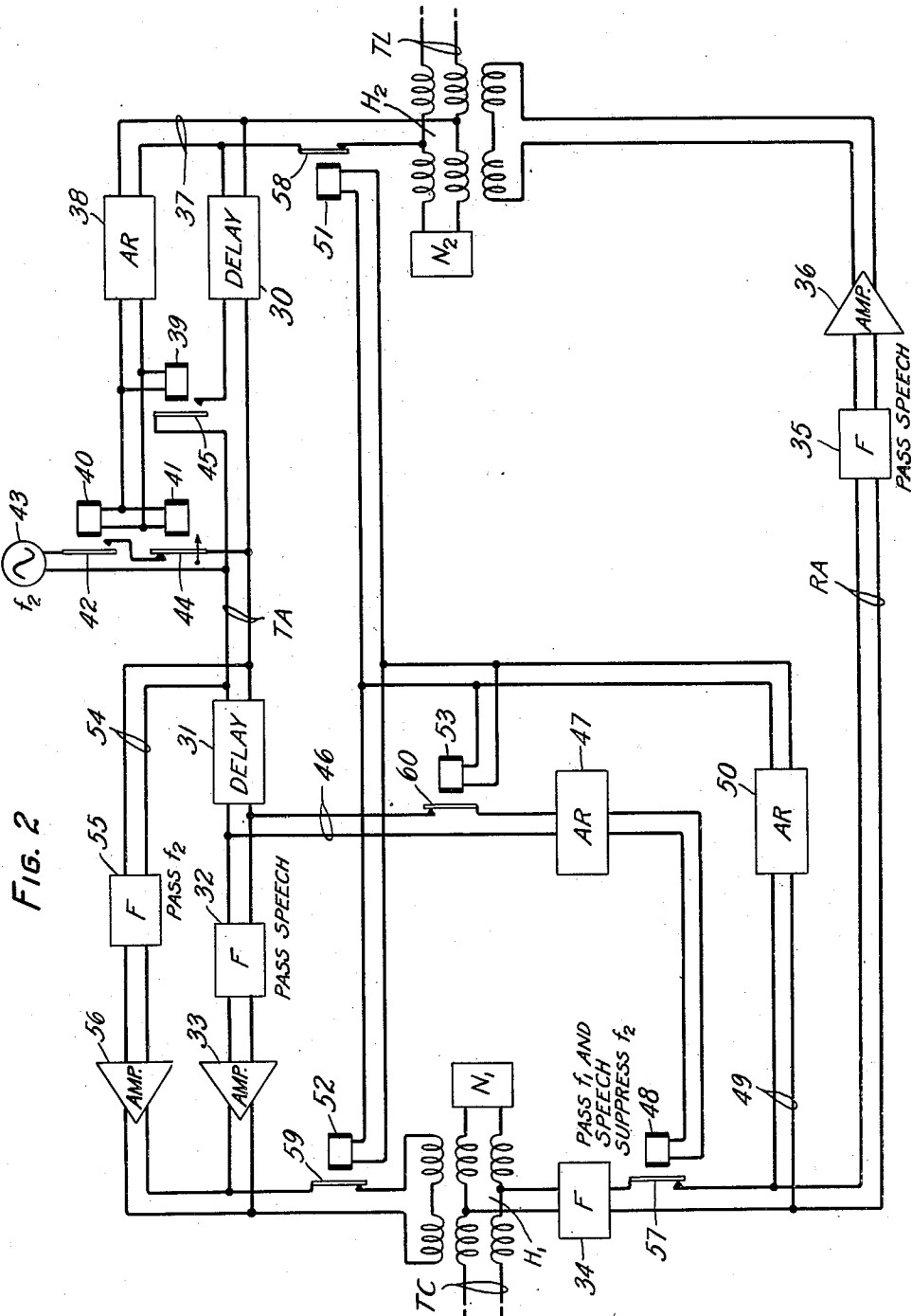


FIG. 2

INVENTOR
R. C. MATHES
BY *H. A. Burgess*
ATTORNEY

Nov. 3, 1931.

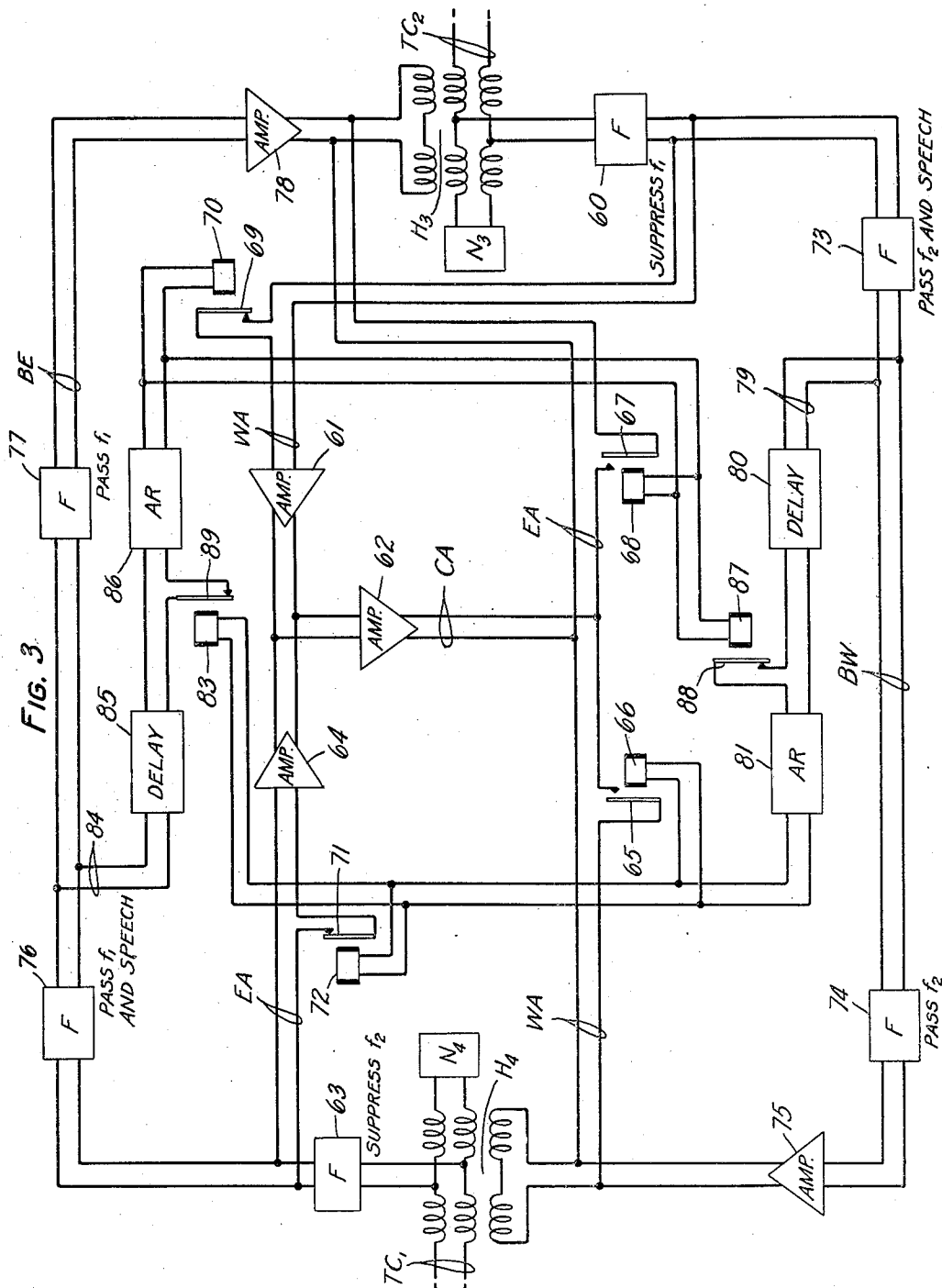
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3 Sheets-Sheet 3



INVENTOR
R. C. MATHES
BY *H. A. Burgess*
ATTORNEY

UNITED STATES PATENT OFFICE

ROBERT C. MATHES, OF WYOMING, NEW JERSEY, ASSIGNOR TO BELL TELEPHONE LABORATORIES, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK

TRANSMISSION CONTROL

Application filed June 11, 1929. Serial No. 370,035.

This invention relates to electric wave transmission systems, particularly to two-way electric communication systems.

The invention in its broad aspect relates to the controlling of transmission in a signal transmission system by control energy transmitted over the system under control of signals, and in advance of the signals, to operate circuit-control means at one or more points in the system.

An object of the invention is to improve the operation of a signal transmission system including circuit-control means operating under control of the signals transmitted over the system.

The invention is especially applicable to a system over which two-way transmission of signaling energy is required within the same frequency range, and including as a link therein a long section of two-way cable of high attenuation, such as a deep sea submarine cable. Signal-controlled circuit-control apparatus, for example, so-called singing and echo suppressors, are usually associated with the oppositely directed amplifying paths at each terminal of the cable in such a system to insure that the system is operative to transmit in only one direction at a time, so as to effectively suppress echoes, singing or both. This is usually accomplished by making the circuit-control apparatus at each terminal responsive to transmission in one direction to make the circuits thereat operative for transmission in that direction and to effectively disable the circuits for transmission in the opposite direction.

There are two main characteristics of such a system, the combination of which may introduce difficulties in the application of such signal-controlled, circuit-control apparatus thereto. One of these is the increased time of transmission over the cable due to its length and loading, and the other is the high attenuation of the cable.

The increased time of transmission over the cable greatly increases the chance that two subscribers at the ends of the system may both start talking within the time interval equal to the transmission time of the cable, resulting in each subscriber by means of his

circuit-control apparatus securing control of his own terminal for transmitting and locking out the transmission received from the other subscriber. In general, this condition may be avoided by circuits designed to give complete control of the system to that subscriber at one end of the system whose speech energy first reaches the cable. In the prior art, the U. S. Patent to Barton No. 1,574,781, issued March 2, 1926 and applicant's U. S. Patent No. 1,678,188, issued July 24, 1928 disclose certain methods for operating repeater circuits in tandem involving the sending out of a sustained alternating current wave, called the "courier", under the control of the speech waves, from either terminal over the cable or an auxiliary circuit ahead of the speech waves to condition the circuits for repeating in the direction of speech wave transmission. A method of this general nature is adapted for use in a cable system such as described above, but must be considerably modified because of characteristics peculiar to the system, such as the very high attenuation and the limited, useful frequency range and load capacity of the cable, to make it practicable for commercial use from the standpoint of quality and economy.

To operate such a system it is necessary to have information at both ends of the cable as to when talk is going in at either end, and this information may have to be positively received through talk going out from the other end. The direction of energy flow is of little value in giving such information as the weak speech energy incoming from the cable at one terminal may be completely lost among the reflected components of the outgoing speech. This information is preferably carried in accordance with the invention by auxiliary waves other than the speech waves. The difficulty associated with applying such auxiliary waves to the cable simultaneously with the speech waves whose presence they are to indicate is that they will use up part of the load carrying capacity of the transmitting amplifier and, more important still, of the load capacity of the cable, if interference through intermodulation is to be avoided.

The above mentioned difficulties in a system

of the type described have been substantially minimized in accordance with the invention by a modification of the "courier" method of control. In the method of the invention, the signal energy generated at each terminal of the cable or incoming from a land line connected thereto is made to control the sending out over the transmission circuit ahead of the signals, of a short train of alternating current control waves, which will be referred to hereafter as the courier, of frequency different for each terminal and outside the speech frequency range to operate circuit-control means to establish initial control in proper time relation of the transmitting and receiving circuits at each terminal of the system and of any intermediate repeater circuits, this control being maintained by the speech energy when it arrives at the controlling points. The first courier sent out will determine which terminal or talker gets exclusive control of the system.

One type of terminal circuit utilizing the general method of control of the invention may be used in connection with a system having characteristics such that it is feasible therein to select the incoming courier in the presence of simultaneous outgoing speech energy, such as a system employing a short cable or one of lesser overall attenuation. Another type of circuit utilizing this general method of control may be used with a system having characteristics such that it is not feasible therein to select the courier in the presence of simultaneous outgoing speech energy, such as a system employing a very long cable or one of very high overall attenuation.

My copending application Serial No. 370,034, filed June 11, 1929, is specifically directed to circuits of the former type.

This application is specifically directed to circuits of the latter type, these circuits being arranged so that the courier is sent out far enough ahead of the speech so that initial control is established for one terminal or the other before speech energy is actually applied to the cable, thus preventing any interference with the courier by outgoing speech energy or loss of any part of the speech.

The exact nature and the objects and advantages of the invention will be better understood from the following detailed description thereof, when read in connection with the accompanying drawings, in which Fig. 1—A shows a schematic diagram illustrating the principle of the invention;

Figs. 1 and 2 show circuit diagrams of different types of cable terminal circuits embodying the invention; and

Fig. 3 shows a circuit diagram of an intermediate repeater station embodying the invention, which repeater station may be used to couple two sections of cable having

terminal stations such as shown in Fig. 2 or 3.

For convenience the invention will be described as applied to systems for the two-way transmission of speech waves, but it is apparent that the principles thereof apply equally well to systems for the transmission of signal waves in general comprising frequencies within or outside the speech frequency range, such as waves representing speech, entertainment programs comprising music as well as speech, etc.

The schematic diagram of Fig. 1—A illustrating the principle of the invention will be first described. In the system shown in that figure the speech wave 1 controls the sending out of a short train of control waves 2, which will be referred to hereafter as the "courier" ahead of the speech wave, over the cable 3 from one terminal thereof to the other. As indicated in the figure, the courier 2 precedes the speech wave 1 in transmission over the cable 3 by a time interval T . In the manner described in detail in connection with the circuits of the other figures, the transmitted courier 2 may be utilized to establish initial control of switching circuits at both terminals of the cable and at intermediate repeater points to condition the apparatus thereat for efficient transmission in the direction of the speech waves only, which control will be maintained by the speech wave 1 on its arrival at the control points. The time interval T is substantially equal to the full transmission time of the cable 3, so that the initial control of the switching circuits at the far terminal is established for one terminal or the other before any speech energy actually is applied to the cable.

Figs. 1 and 2 show alternative types of terminal circuits for a two-way cable system employing the general principle outlined in connection with Fig. 1—A to prevent transmission lockouts when two subscribers at opposite ends of the system both start talking within the time interval equal to the transmission time of the cable. Since the terminal stations at both ends of the cable system may be substantially identical in construction, except for the values of the frequencies of the courier currents transmitted from each station and the range of some of the filters employed, it has been deemed sufficient to illustrate the terminal station at one end of the system only, the east station, and in the following description the manner of the operation of the system will be clear from reference to the single station shown.

The terminal station of Fig. 1 comprises a transmitting circuit TA and a receiving circuit RA connected between a two-way circuit TL leading to a source of signals and signaling receiving apparatus, such as a two-way toll telephone line, and a two-way cable of high attenuation, such as a deep sea subma-

line cable. The output of the transmitting circuit TA and the input of the receiving circuit RA are connected to the east end of the cable TC by means of the three-winding transformer or hybrid coil H_1 , which co-operates with the cable TC and the balancing network N_1 to insure substantial conjugacy between the circuits TA and RA. The input of the transmitting circuit TA and the output of the receiving circuit RA are shown connected directly to the circuit TL, but may be coupled thereto and to each other by a hybrid coil arrangement or by any other means.

The transmitting circuit TA comprises reading from east to west, a one-way delay circuit 4 and the one-way transmitting amplifier 5. The receiving circuit RA comprises reading from west to east, the band pass filter 6, the band pass filter 7, and the one-way receiving amplifier 8. Connected to the transmitting circuit TA between the circuit TL and the input of delay circuit 4 is a control circuit 9 comprising the current-controlled relay-controlling device 10, and the fast-operating relay 11 and the slow-operating relay 12 connected in parallel to the output of the device 10. The normally open switch 13 connected to a generator 14 of alternating currents of frequency f_2 which may be any frequency outside the speech frequency range, is adapted to be closed by operation of the relay 11 to connect the generator 14 across the transmitting circuit TA in the output of the transmitting amplifier 5 therein. The normally closed switch 15 also connected to generator 14 is adapted to be opened by operation of the relay 12 to disconnect the generator 14 from the transmitting circuit TA.

Connected to the transmitting circuit TA between the output of the delay circuit 4 and the input of amplifier 5 is a second control circuit 16 comprising the current-controlled relay controlling device 17 and the relay 18 connected to the output of the device 17.

Connected to the receiving circuit RA between the band pass filters 6 and 7 therein is a third control circuit 19 comprising the current-controlled, relay controlling device 20 and the relays 21 to 23 connected in parallel to the output of the device 20.

A normally closed switch 24 in the input circuit of control device 20 in control circuit 19 is adapted to be opened by the operation of relay 18. A normally closed switch 25 in the transmitting circuit TA between the point of connection of control circuit 16 thereto and the output of delay circuit 4, and a normally closed switch 26 in transmitting circuit TA between the connection of control circuit 9 thereto and the circuit TL are adapted to be opened by operation of relays 21 and 22, respectively. A normally open switch 27 in receiving circuit RA between the output of amplifier 8 therein and the cir-

cuit TL is adapted to be closed by the operation of relay 23.

It is seen that the terminal circuit which has just been described is of the form which is known in the art as semi-biased, that is, the circuit is normally operative for transmission in one direction (in this case from east to west) and transmission in the opposite direction depends upon a switching operation.

The control devices 10, 17 and 20 may be vacuum tube amplifier-rectifier devices of the type well known in the art or any other devices which will respond to alternating current impressed on their inputs to control the operation of a relay or relays in the output thereof.

The one-way delay circuit 4 may be of any type for producing a delay of the required amount, which will be specified below, in alternating currents transmitted there-through, as for example, a low pass filter, such as disclosed in the U. S. Patents to Campbell 1,227,113 and 1,227,114, issued May 22, 1917, or a network such as disclosed for a similar purpose in Arnold Patent 1,565,302, issued December 15, 1925.

The filters 6 and 7 may be of the band pass type disclosed in the U. S. Patents to Campbell mentioned above. The filter 6 is designed to pass frequencies within the speech frequency range and the courier frequency f_1 generated at the west terminal station by a generator corresponding to the generator 14 at the east terminal station now being described. The frequency f_1 may be any frequency outside the speech frequency range and differing from the frequency f_2 . The filter at the west terminal station corresponding to the filter 6 at the east terminal station is designed to pass frequencies within the speech frequency range and the courier frequency f_2 .

The one-way amplifiers 5 and 8, the mechanical relays 11, 12, 18 and 21 to 23 and the generators utilized at the east and west terminal stations, respectively, for generating courier frequencies f_2 and f_1 may be of any of the types well known in the art.

As the system operates in similar manner when telephonic transmission is set up first in the direction from east to west as when telephonic transmission is set up first in the opposite direction, the operation of the system for the former case need only be described. It will be assumed that telephonic currents for transmission from east to west are first set up at the east terminal station (the station shown in Fig. 1), and that not more than T seconds later, where T is the total transmission time of the cable TC between the east and west terminal stations, telephonic currents are set up at the west terminal (not shown) for transmission from west to east.

The westwardly directed telephonic currents from the source TL are impressed directly upon the transmitting circuit TA. A small portion of the impressed currents are diverted into control circuit 9 and operate the control device 10 therein which causes the windings of relays 11 and 12 to be energized. The relay 11 will quickly operate to close the switch 13 so as to connect the source 14 of courier frequency f_2 across the transmitting circuit TA. Slow-operating relay 12 will operate an instant later to open the switch 15 so as to disconnect the generator 14 from the transmitting circuit TA. This will cause a short impulse of current of frequency f_2 , which we will refer to hereafter as the courier f_2 , to be transmitted over the transmitting circuit TA. The transmitted impulse may be made as short as is desired or as is necessary by the design of relays 11 and 12. The relays 11 and 12 are so designed that they will remain operated as long as speech waves from the source TL are being supplied to the control device 10. They are designed so that they will release only after a complete pause in a conversation and not for the usual pause between words or syllables.

The courier f_2 will be impressed upon the cable TC by the hybrid coil H_1 and transmitted over the cable to the west terminal station, where it will establish initial control of the switching circuits thereat in a manner which will be described later.

The main portion of the telephonic currents impressed by the line TL upon the transmitting circuit TA will be passed through the one-way delay circuit 4 being delayed therein for a time interval of T seconds, where T is the total transmission time of the cable TC between the east and west terminal stations. The telephone currents passed by the delay circuit 4 will be divided between the control circuit 16 and the input of the transmitting amplifier 5. The main portion of the passed telephone currents will be amplified by the transmitting amplifier 5 and impressed by the hybrid coil H_1 on the cable TC following the courier f_2 in transmission thereover by the time interval T.

A small portion of the telephonic currents passed by the delay circuit 4 will be diverted into control path 16 and will operate the control device 17 therein, which in turn will energize the relay 18. The control device 17 should not operate unless control device 10 has been previously operated by the telephonic currents. The relative sensitivities of control devices 10 and 17, so that the latter will be operated in response to a wave transmitted over the path TA only when those waves have at the point in TA where the control circuit 9 is connected thereto an amplitude level sufficiently high to cause operation of the device 10 in control circuit 9. Another way of accomplishing this would be to

insert normally open contacts in the input of control device 17 and to utilize an additional relay controlled by the operation of control device 10 to close these contacts when the device 10 is operated.

Control devices 10 and 17 are both actuated by the telephonic currents, but with a time difference in operation of T seconds. The operation of relay 18 will therefore open normally closed switch 24 in the input of control device 20 in control circuit 19 substantially T seconds after the courier f_2 is transmitted out over the cable TC. The switch 24 will remain open as long as speech currents are being substantially continuously transmitted from the east terminal, and will prevent courier f_1 transmitted over the cable TC from the west terminal station in response to the west to east telephonic currents, after the courier f_2 is sent out from the east station, from reaching the input of the control device 20 which controls relays 21 to 23. The relays 21 to 23 cannot be operated, therefore, by courier f_1 or the following speech waves, respectively, to disable the transmitting path TA by opening switches 25 and 26 therein and to make operative the receiving path RA by closing switch 27. In the manner described the westwardly directed telephone currents at the east terminal have obtained complete control of the transmitting and receiving circuits at the east terminal station.

The manner in which complete control of the transmitting and receiving circuits at the west terminal is obtained by the westwardly directed telephonic currents from the east terminal will be clear by reference to the corresponding receiving circuits at the east terminal station. That the apparatus to be referred to is that of the west terminal station will be indicated by designating the apparatus thereat with the same characters as used for designating the corresponding apparatus at the east terminal, but followed by a prime (') mark.

The courier f_2 , which is transmitted over the cable TC in advance of the westwardly directed speech waves by T seconds, on arrival at the west terminal station is impressed on the receiving circuit RA' thereat by hybrid coil H_1' . The received courier f_2 will be passed by the band pass filter 6' and then, because the band pass filter 7' in the main receiving path RA' will not pass the frequency f_2 , it will be diverted into the control path 19' and initially operate control device 20' therein, thus causing the winding of relays 21' to 23' to be energized.

Relay 23' will operate to close the normally open switch 27' in receiving path RA' and thus make that path operative for transmission of the east to west speech waves from cable TC to the circuit TL'. Relays 21' and 22' will simultaneously operate to interrupt

Connected to the transmitting circuit TA at a point therein between the output of delay circuit 31 and the input of band pass filter 32 is a second control circuit 46 comprising the current-controlled relay controlling device 47, and the relay 48 connected to the output of device 47.

Connected to the receiving circuit RA between the output of filter 34 and the input of filter 35 therein is a third control circuit 49 comprising the current-controlled relay controlling device 50, and the relays 51 to 53 connected in parallel to the output of control device 50.

Connected between the input of delay circuit 31 and the output of the transmitting amplifier 33 in transmitting circuit TA is a by-pass circuit 54 comprising the filter 55 and the one-way amplifier 56.

A normally closed switch 57 located in the receiving circuit RA between the output of band pass filter 34 and the point of connection of control circuit 49 to receiving circuit RA is adapted to be opened by the operation of relay 48. A normally closed switch 58 located in transmitting circuit TA between the hybrid coil H_2 and the point of connection of control circuit 37 to transmitting circuit TA is adapted to be opened by operation of relay 51. Another normally closed switch 59 connected in transmitting circuit TA between the hybrid coil H_1 and the outputs of transmitting amplifiers 33 and 56 is adapted to be opened by operation of relay 52. A normally closed switch 60 located in control path 46 in the input of control device 47 therein is adapted to be opened by operation of relay 53.

The terminal circuit which has just been described is also of the semi-biased type, but in this case the circuit is normally operative for transmission in the direction from west to east, and transmission in the direction from east to west depends upon a switching operation.

The control devices 38, 47 and 50 are similar to the control devices 10, 17 and 20 in the circuit of Fig. 1.

The delay circuits 30 and 31 are similar to the delay circuit 4 in the circuit of Fig. 1.

The delay circuit 30 is designed to provide a delay of t seconds in the transmission of the alternating currents transmitted there-through where t is very small in comparison to the total transmission time T of the cable TC between the east and west terminal stations. The delay circuit 31 is designed to introduce a delay of T seconds in the transmission of alternating currents passed there-through.

The filters 32, 34, 35 and 55 are similar to the filters in the circuit of Fig. 1. The filters 32 and 35 are designed to pass frequencies within the speech frequency range and to suppress courier frequencies f_1 and f_2 .

The filter 55 is designed to pass the courier frequency f_2 generated by the generator 43 and to suppress other frequencies. Filter 34 is designed to pass the courier frequency f_1 generated at the west terminal station and frequencies within the speech frequency range, and to suppress the courier frequency f_2 . Amplifiers 33, 36 and 56 and the relays 39 to 41, 48 and 51 to 53 may be of any of the types well known in the prior art.

It will be assumed that telephonic currents for transmission from east to west are set up first at the east terminal station, and not more than T seconds later where T is the total transmission time of the cable, telephonic currents are set up at the west terminal station for transmission from west to east.

The westwardly directed telephonic currents from the source TL are impressed upon the input of transmitting circuit TA through hybrid coil H_2 . A portion of these impressed currents will be diverted into control circuit 37 and operate control device 38 therein causing the windings of relays 39, 40 and 41 to be energized. Relay 39 will operate to close normally open switch 45 in the transmitting circuit TA so as to make that circuit operative for transmission of the speech waves between source TL and the cable TC.

Fast-operating relay 40 operates to close switch 42, thus connecting the generator 43 of frequency f_2 across the transmission circuit TA. An instant later slow-operating relay 41 operates to open normally closed switch 44, thus disconnecting the generator 43 from transmitting circuit TA. The momentary connection of generator 43 to transmitting circuit TA will cause a short impulse of current of frequency f_2 , which will be designated hereafter as courier f_2 , to be transmitted over the transmitting circuit TA.

A portion of this courier f_2 will be diverted into by-pass circuit 54, passed by the filter 55 therein, amplified by amplifier 56, impressed by hybrid coil H_1 on cable TC and directly transmitted thereover to the west terminal station, where it will be effective to establish initial control of the circuit thereat in a manner which will be described later.

The portion of the courier f_2 not by-passed through circuit 54 will pass through delay circuit 31 being delayed therein for the time T , and, as filter 32 is designed not to pass the frequency f_2 , will be diverted into control path 46 to operate control device 47, causing the winding of relay 48 to be energized. The relay 48 will then operate to open the normally closed switch 57 in receiving circuit RA. Due to the delay produced in the diverted courier by delay circuit 31, the switch 57 will be open to disable path RA substantially T seconds after the courier f_2 has been

the transmitting path TA' by respectively opening normally closed switches 25' and 26' therein. The interruption of transmitting circuit TA' at the west terminal station on both sides of the delay circuit 4' is necessary to prevent false operation of the relay circuits at the station by unbalanced received energy or by energy stored in the delay circuit 4' prior to the operation of control device 20'.

The westwardly directed speech wave which follows the courier wave in transmission over the cable TC by the time interval T seconds, on its arrival at the west terminal station will also be impressed by the hybrid coil H₁' on the receiving circuit RA' and passed by the band pass filter 6', which, as stated above, is designed to pass the speech frequency band as well as the frequency f_2 . A portion of the speech wave passed by the filter 6' will be diverted in the output thereof into control circuit 19' and will be impressed on the input of control device 20' so as to maintain that device in the operated condition initiated by the preceding courier f_2 . The relays 21' to 23' will therefore be maintained operated as long as speech is being received over the cable TC from the east terminal station, and thus will maintain the receiving circuit RA' operative and the transmitting circuit TA' disabled for that length of time.

The main portion of the speech currents in the output of the band pass filter 6' in receiving circuit RA' will be supplied to the band pass filter 7' therein, passed by that filter, amplified by the receiving amplifier 8' and transmitted from the output thereof to the circuit TL'.

It is readily seen that because of the particular relation of the delay produced in transmitted waves by delay circuits 4 and 4' at the east and west terminals, respectively, to the transmission time of the cable TC, that whichever terminal first sends out its courier impulse will gain exclusive control of both sets of terminal apparatus. Because the speech energy from each station is not impressed upon the cable TC until after the initial operation of the switching apparatus at the far terminal by the first courier to be transmitted, the incoming courier need not be selected in the presence of simultaneously outgoing speech energy and there will be no loss of speech because of interference therewith.

If there is not a positive switching interlock between the control devices 10 and 17 in the system of Fig. 2 to insure that control device 17 does not operate unless control device 10 has also operated, the sensitivities of control devices 10 and 17 will need to be very accurately maintained if the different rates of speech energy in the case of different words are not to introduce deviations in the

relative operating times of the two control devices.

Fig. 2 shows a modification of the circuits of the terminal station of Fig. 1 in which the device controlling the disabling of the receiving circuits in response to energy to be transmitted, corresponding to the control device 17 of Fig. 1, is operated under all conditions very positively and in a definite time relation with respect to the time in which the courier is sent out over the cable. This is accomplished by causing this control device to be initially operated by a local courier impulse suitably delayed with respect to the courier impulse sent out over the cable instead of by the delayed speech impulse only.

In the terminal station of Fig. 2 (which is the east station), the output of the transmitting circuit TA and the input of the receiving circuit RA are associated in energy transmitting relation with the cable TC and in conjugate relation with each other, as in the system of Fig. 2, by a hybrid coil H₁ and its associated balancing network N₁, and the input of the transmitting circuit TA and the output of the receiving circuit RA are coupled in conjugate relation with each other, and in energy transmitting relation with the circuit TL through the hybrid coil H₂ and its associated balancing network N₂. The transmitting circuit TA comprises, connected between the hybrid coil H₂ and hybrid coil H₁ reading from east to west, the one-way delay circuit 30, the one-way delay circuit 31, band pass filter 32 and the transmitting amplifier 33. The receiving circuit RA comprises, connected between the hybrid coil H₁ and the hybrid coil H₂ reading from west to east, the band pass filter 34, the band pass filter 35 and the receiving amplifier 36.

Connected to the transmitting circuit TA between the hybrid coil H₂ and the input of delay circuit 30 is a control circuit 37 comprising the current-controlled relay controlling device 38, and the relay 39, quick-operating relay 40 and slow-operating relay 41 connected in parallel to the output of device 38. The normally open switch 42 connected to a source 43 of alternating current of a frequency f_2 , which frequency is outside the speech frequency range, is adapted to be closed by operation of the relay 40 to connect the source 43 across the transmitting circuit TA at a point between the output of delay circuit 30 therein and the input of delay circuit 31 therein. A normally closed switch 44 connected to the circuit TA and source 43 is adapted to be opened by operation of relay 41 to disconnect the source 43 from the transmitting circuit TA. A normally open switch 45 located in the transmitting circuit TA between the output of delay circuit 30 and the point of connection of the source 43 to the transmitting circuit TA is adapted to be closed by operation of relay 39.

transmitted out over the cable TC, and therefore will prevent currents which are sent out over the cable TC from the west terminal station after courier f_2 has been transmitted thereover from the east terminal station from reaching the input of control device 50 in control path 49 and causing its operation, and therefore the operation of relays 51 to 53 to disable the transmitting path TA.

The main portion of the westwardly directed speech currents are delayed in transmission over the transmitting circuit TA for $t+T$ seconds due to the action of delay circuits 30 and 31 therein. The small delay of t seconds produced by delay circuit 30 insures that the switch 45 has been closed to make operative the transmitting path TA and that control device 47 in control path 46 has been operated by the preceding courier before the speech currents arrive thereat.

The portion of the delayed speech currents in the output of delay circuit 31 which is diverted into control circuit 46 and impressed on the input of control device 47 serves to maintain that device in the operated condition initiated by the preceding courier f_2 . Relay 48 controlled by control device 47 will therefore be maintained operated as long as speech currents are being transmitted into control circuit 46.

The main portion of the speech currents in the output of delay circuit 31 will be passed by the band pass filter 32 in transmitting circuit TA, amplified by the transmitting amplifier 33 therein, impressed by means of hybrid coil H_1 upon the cable TC and transmitted thereover to the west terminal station $T+t$ seconds behind the preceding courier f_2 .

The manner in which complete control of the transmitting and receiving circuits at the west terminal station is obtained for the east terminal station will be clear from the following description by reference to the receiving circuits at the east terminal station. The apparatus at the west terminal station corresponding to that at the east terminal station will be designated with the same characters as the latter but followed by a prime (') mark.

The portion of the courier f_2 transmitted over cable TC from the east terminal station, on arrival at the west terminal station will be impressed by hybrid coil H_1' on the receiving path RA' and passed by the band pass filter 34' therein, which filter is designed to pass frequencies within the speech frequency range and the courier frequency f_2 and to suppress the courier frequency f_1 (which is the courier frequency generated at the west station). As filter 35' is designed not to pass the frequency f_2 , the courier f_2 in the output of the band pass filter 34' is diverted into control circuit 49' and initially operates control device 50' causing the windings of relays 51' to 53' in the output thereof to be energized.

Relays 51' and 52' immediately operate to open normally closed switches 58' and 59', respectively located in the input and output of the transmitting circuit TA' making that circuit inoperative to transmit speech currents or the courier f_1 generated by generator 43' to the cable TC. Relay 53' simultaneously operates to open the normally closed switch 60' in control circuit 46'. The disabling of the transmitting circuit TA' in the several places is for the purpose of preventing false operation of control device 47' by unbalanced received energy or energy which may be stored in delay circuits 30' and 31' prior to the operation of control device 50'.

The speech wave from the east terminal station following the courier f_2 over the cable TC by the interval of time $T+t$ seconds on arrival at the west terminal station will also be impressed upon the receiving path RA' by the hybrid coil H_1' and passed by the band pass filter 34' in the input thereof. These speech waves in the output of the band pass filter 34' will be divided between the control circuit 49' and the main receiving path RA'. The portion diverted into control circuit 49' will be impressed upon the input circuit of control device 50' and serve to maintain that device in the operated condition initiated by the preceding courier frequency f_2 . The relays 51' to 53' in the output of control device 50' will therefore be maintained in the operated condition as long as speech waves from the east terminal station are being received by the receiving circuit RA' from the cable TC.

The main portion of the westwardly directed speech waves in the output of the band pass filter 34' will be transmitted over the main receiving path RA', passed by the band pass filter 35' therein, amplified by the receiving amplifier 36' and impressed by the hybrid coil H_2' upon the circuit TL'.

In the manner which has been described, complete control of the transmitting and receiving circuits at both east and west terminal stations has been obtained for the east terminal station. If the speech waves to be transmitted had been first set up at the west terminal station, the latter station would have obtained control of the transmitting and receiving circuits at both terminals in a similar manner.

Fig. 3 shows the circuits of an intermediate repeater station which may be used for connecting two sections of the cable TC, an east section TC₂ leading to an east terminal station such as illustrated in Fig. 1 or 2 and a west section TC₁ leading to a similar west terminal station. The circuits of this intermediate repeater station are arranged so that the terminal station which first sends out its courier gets complete control of the intermediate repeater circuits as well as those of the two terminal circuits.

The circuits of the intermediate repeater station comprise a westwardly directed amplifying path WA and an eastwardly directed amplifying path EA having a portion CA in common. The input of the path WA and the output of the path EA are coupled in energy transmitting relation with the west end of the east cable section TC_2 and in conjugate relation to each other by means of the three-winding transformer or hybrid coil H_3 and associated balancing network N_3 . Similarly, the input of the path EA and the output of the path WA are coupled in conjugate relation to each other and in energy transmitting relation with the east end of the west cable section TC_1 by the hybrid coil H_4 and its associated balancing network N_4 . The westwardly directed amplifying path WA comprises between the hybrid coils H_3 and H_4 in order from east to west, the band pass filter 60, the one-way amplifier 61 and the transmitting amplifier 62, while the eastwardly transmitting path EA comprises connected between the hybrid coils H_4 and H_3 in order from west to east the band pass filter 63, the one-way amplifier 64 and the transmitting amplifier 62. The amplifying path WA is normally disabled in the output of the transmitting amplifier 62 by the normally open switch 65, which is controlled by a relay 66, while the output of the eastwardly directed amplifying path EA is similarly disabled in the output of the transmitting amplifier 62 by the normally open switch 67 controlled by the relay 68. A normally closed switch 69 controlled by relay 70 is located in the path WA between the output of filter 60 and the input of the amplifier 61 therein, and a normally closed switch 71 controlled by the relay 72 is located in the amplifying path EA between the output of filter 63 and the input of amplifier 64.

The one-way amplifier 64 in the path EA and the one-way amplifier 61 in the path WA are for the purpose of preventing transfer of speech currents between these paths at their junction with the common branch CA. This may be prevented by the use of other means, for example, a balanced bridge at the junction of paths EA, WA and CA, such as disclosed in Fig. 8 of my United States Patent No. 1,695,813, issued December 18, 1928.

A westwardly directed one-way by-pass circuit BW is connected between the output of filter 60 in amplifying path WA and points in the output of path WA between the switch 65 therein and the hybrid coil H_3 . Similarly, an eastwardly directed one-way by-pass circuit BE is connected between the output of filter 63 in the amplifying path EA and points in the output of said path between the switch 67 therein and the hybrid coil H_4 . The by-pass circuit BW comprises in order from east to west the band pass filter 73, the band pass filter 74, the one-way am-

plifier 75, while the by-pass circuit BE comprises in order from west to east the band pass filter 76, the band pass filter 77 and the one-way amplifier 78. Connected to the by pass circuit BW between the filters 73 and 74 therein is a control circuit 79 comprising the delay circuit 80, the current controlled relay controlling device 81, and the relays 66, 72 and 83 connected in parallel to the output of the control device 81. Similarly connected to the by-pass circuit BE between filters 76 and 77 therein is the control circuit 84 comprising a delay circuit 85, the current controlled relay controlling device 86, and the relays 68, 70 and 87 connected in parallel to the output of control device 86. A normally closed switch 88, which is controlled by the relay 87 is located in the control circuit 79 between the output of the delay circuit 80 and the input of control device 81 therein. Similarly, a normally closed switch 89 is located in the control circuit 84 between the output of delay circuit 85 and the input of the control device 86 therein.

The control devices 81 and 86 are similar to the control devices used at the terminal stations shown in Figs. 1 and 2.

The delay circuits 80 and 85 located in control paths 79 and 84, respectively, are similar to the delay circuits used at the terminal stations shown in Figs. 1 and 2. Delay circuit 80 is designed to produce a delay in the currents transmitted therethrough of substantially T_1 seconds where T_1 is the total transmission time of the west cable section TC_1 between the intermediate repeater station and the west terminal station. Similarly, delay circuit 85 is designed to introduce a delay in the currents transmitted therethrough of substantially T_2 seconds, where T_2 is the total transmission time of the east cable section TC_2 .

For proper operation of the system it is only necessary that the total time of transmission from the east terminal station to the control device 81 at the intermediate repeater is substantially equal to the total time of transmission from the west terminal station to the control device 86 at the intermediate repeater. If the transmission time T_1 of cable TC_1 is greater than the transmission time T_2 of cable TC_2 , the delay time of delay circuit 85 may be 0 seconds, that is, delay circuit 85 may be eliminated, and the delay time of delay circuit 80 made $T_1 - T_2$ seconds; or if T_2 is greater than T_1 , the delay time of delay circuit 85 may be made $T_2 - T_1$ seconds and the delay time of delay circuit 81 made zero, that is, the latter may be eliminated.

Filter 60 in the amplifying path WA, filter 63 in the amplifying path EA, filters 73 and 74 in the by pass circuit BW and filters 76 and 77 in the by pass circuit BE are similar to the filters used at the terminal stations shown in Figs. 2 and 3. The filter 60 is de-

signed to pass frequencies within the speech frequency range and the courier frequency f_2 generated at the east terminal station and to suppress courier frequency f_1 generated at the west terminal station. Similarly, filter 63 is designed to pass frequencies within the speech frequency range and courier frequency f_1 and to suppress courier frequency f_2 . Filter 73 is designed to pass frequencies within the speech frequency range and the courier frequency f_2 and to suppress waves of other frequencies, while filter 74 is designed to pass the courier frequency f_2 and to suppress waves of other frequencies. Filter 76 is designed to pass frequencies within the speech frequency range and the courier frequency f_1 and to suppress other frequencies, while filter 77 is designed to pass courier frequency f_1 and to suppress other frequencies.

The other pieces of apparatus at the intermediate repeater station of Fig. 3 are similar to the corresponding apparatus at the terminal stations shown in Figs. 1 and 2.

The operation of the intermediate repeater station of Fig. 3 will now be described. It will be assumed that the speech waves for transmission from west to east are first set up at the west terminal station, and not more than T seconds later where T is the total transmission time over both sections of the cable TC_1 and TC_2 and therefore equals $T_1 + T_2$ seconds, speech waves for transmission from east to west are set up at the east terminal station. It will be assumed that the transmission time T_1 of the cable section TC_1 is greater than that of the cable section TC_2 . The delay time of delay circuit 85, therefore, is zero seconds and the delay time of delay circuit 80 is $T_1 - T_2$. The speech waves set up at the west terminal station will cause the courier f_1 to be transmitted out over the cable section TC_1 T seconds in advance of the speech waves in the manner which has been described in connection with the terminal circuits of Figs. 1 and 2. The courier f_1 on arrival at the intermediate repeater station will be impressed by hybrid coil H_1 thereat upon the eastwardly directed amplifying path EA and passed by the filter 63 therein. In the output of the filter 63 the courier f_1 will divide. The portion transmitted over the path EA will be dissipated therein due to the normally open switch 67 in the output thereof. The other portion of courier f_1 will be passed by the band pass filter 76 in the by-pass circuit BE and will divide in the output thereof. A portion will be transmitted over the by-pass circuit BE being passed by filter 77 and amplified by amplifier 78 therein. The amplified courier f_1 will then be impressed on the east cable section TC_2 by hybrid coil H_2 and transmitted directly thereover to the east terminal station to initially operate the control appa-

ratus thereat in the manner previously described in connection with Figs. 1 and 2.

The other portion of the courier f_1 in the output of filter 76 will be diverted into the control circuit 84 and will be transmitted through delay circuit 85, which according to our assumptions will introduce zero delay, and then will initially operate control device 86, which in turn will cause the windings of relays 68, 70 and 87 to be energized. Relay 70 will operate to open the normally closed switch 69 in the input of amplifying path WA to disable that path for the transmission of currents from the output of filter 60 to amplifiers 61 and 62. Relay 68 will operate to close the normally open switch 67 in the output of the amplifying path EA, making that path operative for the transmission of currents in the west to east direction between cable sections TC_1 and TC_2 . Relay 87 will operate to open the normally closed switch 88 in the control circuit 79, making that circuit inoperative for the transmission of currents from the output of filter 73 in by-pass circuit BW to the input of control device 81 in control circuit 79.

Relays 68 and 70 should be relatively adjusted so that switch 69 in amplifying circuit WA opens to disable that circuit before switch 67 in amplifying circuit EA closes to make circuit EA operative, thus avoiding a singing path. The relays 72 and 66 associated with control circuit 79 should be similarly relatively adjusted for a similar purpose.

The eastwardly directed speech currents following the courier f_1 in transmission over the cable section TC_1 by the time interval of T seconds upon arrival at the intermediate repeater station will also be impressed by hybrid coil H_1 upon the eastwardly directed amplifying circuit EA and passed by the filter 63 in the input thereof. A portion of the speech currents in the output of filter 63 will be transmitted over the by-pass circuit BE and passed by the filter 76 therein. As the filter 77 is designed so as not to pass waves within the speech frequency range, this portion of the speech currents will be diverted into control circuit 84 and after passing through delay circuit 85 having a delay of zero seconds will be impressed on the input of control device 86 to maintain that device in the operated condition initiated by the preceding courier as long as the speech waves are being continuously transmitted from cable section TC_1 to cable section TC_2 in the eastwardly direction.

The main portion of the speech waves in the output circuit of filter 63 will be transmitted over the eastwardly directed path EA, amplified in amplifiers 64 and 62 therein, and, as the normally open switch 67 in path EA is now in the closed condition due to the action of the preceding courier frequency f_1 ,

will be impressed on the cable section TC_2 through hybrid coil H_3 , and transmitted thereover to the east terminal station where a portion thereof will be utilized to maintain the switching apparatus in the condition initiated by the preceding courier wave and the main portion transmitted to the receiving circuits of that station, in the manner described in detail in connection with the terminal circuits of Figs. 1 and 2.

The disabling of the amplifying path WA and the control path 79 in the manner which has just been pointed out will prevent the courier f_2 from the east terminal station, which according to our assumption, would not be started over cable section TC_2 until after the courier f_1 from the west terminal station has started out over the cable section TC_1 to the intermediate repeater station, from setting up a singing circuit, or being effective to operate control device 81 and thus to seize control of the intermediate repeater apparatus for the east terminal station.

The operation of the intermediate repeater station for the case when the speech waves for transmission from east to west are set up at the east terminal station before the speech waves for transmission from west to east are set up at the west terminal station is similar to the operation which has just been described. In this case the courier f_2 received over cable section TC_2 will be passed by filter 60 in the input of the amplifying path WA and filter 73 in by-pass circuit BW. A portion thereof will be passed by filter 74, amplified by amplifier 75, impressed on the west cable section TC_1 and transmitted thereover to initially operate the control of the switching apparatus at the west terminal station in the manner which was described in connection with Figs. 1 and 2. The other portion of the courier f_2 in the output of filter 73 in by-pass circuit BW will be diverted into the control circuit 79 and after being delayed therein for T_1 — T_2 seconds according to our assumptions, by the delay circuit 80 will operate control device 81 to initially operate the relays 72, 83 and 66 so as to first open the normally closed switches 71 and 89 in amplifying path EA and the control circuit 84, respectively, and then to close the normally open switch 65 in amplifying path EA. The speech waves transmitted from the west terminal station T seconds behind the courier f_2 on arrival at the intermediate repeater station will be impressed by the hybrid coil H_3 upon the amplifying path WA and passed by the filter 60 in the input thereof. A small portion of the speech waves in the output of the filter 60 will be passed by the filter 73 in the by-pass circuit BW and will be diverted into the control path 79 and after being delayed for T_1 — T_2 seconds in the delay circuit 80 will be impressed on the input of control device 81 so as to maintain that device in the operated

condition initiated by the preceding courier as long as speech waves are being continuously received for the cable section TC_2 . The repeater circuits having been conditioned in the manner described, the main portion of the speech currents in the output of filter 60 will be transmitted over the amplifying path WA amplified by amplifiers 61 and 62 therein and impressed on cable section TC_1 and transmitted thereover to the west terminal station, where a small portion thereof will be utilized to maintain the switching circuits thereat in the condition initiated by the preceding courier and the main portion will be delivered to the receiving circuits in the manner described in detail in connection with Figs. 1 and 2.

The disabling of the amplifying path EA and the control path 84 in the manner which has just been described will prevent the courier f_1 and the succeeding speech waves from the west terminal station from being effective to seize control of the intermediate repeater apparatus.

The relation of the delays produced by the delay circuits 80 and 85 in the control circuits 79 and 84, respectively, at the intermediate repeater station, to the transmission times of the two cable sections TC_1 and TC_2 insures that complete control of the intermediate repeater is given to that terminal which first starts its courier on its way.

It is to be understood that the invention is not limited to the particular circuits, and details of the particular terminal and intermediate repeater stations illustrated and described as numerous modifications thereof may be made by persons skilled in the art without departing from the spirit and scope of the invention. For example, although the terminal stations which have been illustrated and described comprise either a normally operative receiving circuit, a normally disabled transmitting circuit and switching means responsive to waves to be transmitted to disable the receiving circuit and make operative the transmitting circuit, or a normally operative transmitting circuit, a normally disabled receiving circuit and switching means responsive to received waves to render the receiving circuit operative and to disable the transmitting circuit, it is apparent that the invention may be applied to other types of terminal circuits; for example, to terminal stations comprising normally disabled receiving and transmitting circuits and switching means responsive to transmission in either direction to make the circuits operative for that direction.

Although the intermediate repeater station which has been illustrated and described comprises normally inoperative amplifying paths for the two directions of transmission having a portion in common, and switching circuits responsive to transmission in either

direction to make the amplifying path in that direction operative, it is apparent that the invention is not limited to that type of intermediate repeater station but may be applied equally well to a circuit in which the amplifying paths for the two directions of transmission have no portion in common, or in which one path is normally operative and the other path normally disabled and the switching circuits are responsive to transmission in either direction to make the amplifying paths operative to repeat the transmission in that direction only.

Although in the terminal circuits which have been illustrated and described, the receiving circuit or the transmitting circuit in some cases has been shown normally disabled, or adapted to be disabled, in a single place, because of the high gain which may be used in terminal circuits of this type it may be desirable to have the transmitting and receiving circuits normally disabled or adapted to be disabled in several places.

Although in the particular embodiments of the invention which have been illustrated and described mechanical relays have been employed for conditioning the transmission paths by operating movable switches to close or open circuit these paths, the invention is not limited to the particular means shown. For example within the scope of the invention the transmission paths may be effectively disabled by short circuits or loss networks inserted in the paths, controlled by current controlled relays. Stationary devices having no movable elements may be employed in place of the mechanical relays, for example, vacuum tube relays, such as disclosed in Crison United States Patent 1,647,212, issued November 1, 1927 or in the article by C. A. Beer and G. T. Evans, in the Institute of P. O. Electrical Engineers (London), vol. 20, pages 65 to 72 inclusive, published in 1920.

What is claimed is:

1. In a signal transmission system comprising a signal transmission path over which the time of transmission is appreciable and in which two-way transmission is secured by signal-controlled circuit-control means, the method of avoiding mutual lockouts of transmission and consequent loss of part of the signal transmission, which consists in establishing control of the circuit-control means by means of a short train of control waves sent over the system, and delaying the application of signals to the transmission path until such control is established.

2. The method of operating a signal-directed two-way transmission system including a signal transmission medium over which the time of transmission is appreciable, which consists in transmitting a short train of control waves over said medium under control of the signals to be transmitted, to condition the system for the transmission of said sig-

nals thereover, and delaying the application of the signals to the transmission medium by a time approximately equal to the overall transmission time of said transmission medium.

3. A transmission system comprising a signal transmission path supplied from a source of signal waves, control means for determining the operation of said path, means under the control of said signal waves for transmitting to said control means and in advance of the signals an impulse of current to initially operate said control means, means to delay the sending out of the signal waves over said path at least until said control means has been initially operated by said impulse of current, and means for utilizing the delayed signal wave when it arrives at the control point to maintain said control means in its initially operated condition.

4. A system for the two-way transmission of signaling currents including current-controlled means at a point therein for conditioning the system for efficient operation in the direction of transmission, means at another point in said system and controlled by the signaling currents when they arrive thereat for causing a momentary impulse of control current to be transmitted over the system in the direction of the controlling signaling currents to initially actuate said current-controlled means, means for delaying the transmission of the signaling currents over said system from said other point for an interval of time at least equal to the wave transmission time of said system from said other point to the control point, and means for utilizing the delayed signaling currents when they arrive at the control point to maintain said current-controlled means in its initially operated condition.

5. A system for the two-way transmission of telephonic currents comprising a two-way line, stations at various points along said line and comprising oppositely directed amplifying paths for said currents, current-controlled means at said stations responsive to transmission of waves in one direction for conditioning the amplifying paths thereat for efficient transmission in said one direction only, and responsive to transmission of waves in the opposite direction for conditioning said paths for efficient transmission in said opposite direction only, means at one of said stations and controlled by the transmission of telephonic currents in the amplifying path thereat for said one direction, for causing a momentary impulse of control current to be transmitted over the system in the direction of the controlling telephonic currents to initially operate the current-controlled means at another of said stations, means to delay the transmission of said telephonic currents from said one station to said line for an interval of time at least equal to the trans-

mission time over said system from said one station to said other station, and means for utilizing the delayed telephonic currents when they arrive at said other station to maintain the current-controlled means thereat in the condition initially produced by the preceding impulse of current.

6. A system for the two-way transmission of telephonic currents comprising a two-way line connecting stations each comprising oppositely directed amplifying paths for said currents, means at each station responsive to transmission over the system in one direction for conditioning said paths for efficient operation in said one direction only, and responsive to transmission over the system in the other direction for conditioning said paths for efficient operation in said other direction only, and means for insuring complete control of the conditioning means at both stations to the one of said stations at which telephonic current transmission first starts, the last mentioned means comprising at each station means controlled by the telephonic currents to be transmitted therefrom for sending out over said line an impulse of current to initially operate the conditioning means at the other station, means for delaying the transmission of the telephonic currents to said line for an interval of time after said impulse has been sent out thereover which is substantially equal to the transmission time of said two-way line between said stations, means for utilizing the delayed telephonic currents as they arrive at said other station for maintaining the conditioning means thereat in their initially operated condition, and means for preventing incoming currents from the other station, if started therefrom over said line later than the impulse from the first station, from being effective to operate the conditioning means at said first station until transmission of the telephonic currents initiating the impulse, from said first station is interrupted for a time interval at least equal to the usual pause between sentences.

7. The system of claim 6, and in which the last mentioned means is controlled by the delayed telephonic currents at said first station.

8. In a system for the two-way transmission of signaling waves, a two-way line having an overall transmission time of T seconds and a station comprising a normally operative transmitting circuit and a normally disabled receiving circuit connected to said line, a source of signaling waves connected to said transmitting circuit, means responsive to waves received by said transmitting circuit from said source, for causing a momentary impulse of control current to be impressed on said line for transmission thereover, means for delaying transmission of said signaling waves to said line for transmission thereover for substantially T seconds after said impulse

of current has been transmitted thereto, means responsive to currents received by said receiving circuit from said line for effectively disabling said transmitting circuit and making operative said receiving circuit, and means responsive to the delayed signaling waves for disabling the last mentioned means for operation by said received currents until substantially continuous transmission of signaling waves from said source to said transmitting circuit has been interrupted for an appreciable interval of time.

9. In a system for the two-way transmission of signaling waves comprising a two-way line having an overall transmission time of T seconds and a station comprising a normally disabled transmitting circuit and a normally operative receiving circuit connected to said two-way line, a source of signaling waves connected to said transmitting circuit, means responsive to waves received by said transmitting circuit from said source for making said transmitting circuit operative to transmit said waves and for causing a momentary impulse of control current to be transmitted over said transmitting circuit in advance of the signaling waves, means for impressing a portion of said impulse of control current upon said line for transmission thereover, means for delaying transmission of said signaling waves to said line for transmission thereover for substantially $T+t$ seconds after said portion of control current has been transmitted thereto, where t is very small in comparison to T , means responsive to currents received from said line by said receiving circuit for effectively disabling said transmitting circuit for the transmission of waves from said source to said line, means for utilizing the other portion of said control impulse for disabling said receiving circuit and said transmitting circuit, for operation by said received currents, substantially T seconds after the first portion of said control impulse has been transmitted to said line and means responsive to the delayed signaling waves for maintaining said receiving circuit and said transmitting circuit, disabling means disabled until transmission of signaling waves over said transmitting circuit has been interrupted for an appreciable interval of time.

10. In a system for the two-way transmission of signals, a repeater connecting a west section of a two-way line having an overall transmission time of T_1 seconds and an east section of a two-way line having an overall transmission time of T_2 seconds, said repeater comprising an eastwardly directed one-way amplifying path and a westwardly directed one-way amplifying path for said signals, both paths being normally disabled in their outputs, an eastwardly directed one-way circuit for by-passing a small portion of the signals and waves of certain characteristic

frequencies outside the frequency range of said signals received over said west section of line around said repeater to said east section of line, a westwardly directed one-way circuit for by-passing a portion of the signals and other waves of characteristic frequencies different from said certain frequencies and outside the frequency range of said signals, around said repeater to said west section of line, a control path connected to the eastwardly directed by-pass circuit for diverting a portion of the waves transmitted thereover and including means for delaying the diverted waves therein T_2 seconds, another control path connected to the westwardly directed by-pass circuit, for diverting a portion of the waves transmitted thereover and including means for delaying the diverted waves therein for T_1 seconds, means responsive to the delayed, diverted waves in the first mentioned control path for disabling said westwardly directed amplifying path in its input, and said other control path, and for making said eastwardly directed amplifying path operative, and means responsive to the delayed, diverted waves in said other control path for disabling said eastwardly directed amplifying path in its input, and the first mentioned control path and for making operative the westwardly directed amplifying path.

11. In a signaling system in which exclusive control of a station for transmitting or for receiving is seized through the agency of the signaling waves entering the system, the method comprising directly seizing control of a transmitting and a receiving station in response to signal waves, and delaying transmission, between the seized stations, of the signals until such control has been established.

12. In a two-way system for transmitting and receiving signals over a transmission path of appreciable overall transmission time, a transmitting and a receiving branch at a station, one of which is normally operative and the other normally inoperative, signal controlled means to make operative the normally inoperative branch and to make inoperative the normally operative branch to condition the station for transmitting over said path or receiving from said path, means at said station controlled by signals to be transmitted over said path for operating said signal controlled means to condition the station so that it can transmit signals to but cannot receive signals from said path, means for delaying transmission of said signals to said path for substantially the overall transmission time of the path, and means for delaying conditioning of the station so that it cannot receive for a time substantially equal to the overall transmission time of said path after the conditioning of the circuit so that it can transmit to said path.

13. A system according to claim 12 in which said station is maintained in condition for transmitting to said path and disabled to receive from said path by signals at said station to be transmitted over said path.

14. A system according to claim 12 in which said station is maintained in condition to receive from said path but is disabled to transmit to said path by signals received over said path.

15. In a two-way system for transmitting and receiving signals over a wave transmission path of appreciable overall transmission time, a station having connected to said path a transmitting circuit and a receiving circuit one of which is normally operative and the other normally disabled, signal-controlled means to make operative the normally disabled circuit and to disable the normally operative circuit to condition the station for receiving from said path or transmitting to said path, means at said station controlled by waves received over said path for operating said signal-controlled means to condition the station so that it can receive waves from said path but cannot transmit waves thereto, and means for delaying transmission of signals to said path for substantially the overall transmission time of said path.

16. A system according to claim 15 and in which said station is maintained in condition to receive waves from said path and disabled for transmitting signals to said path by the signals received thereover.

In witness whereof, I hereunto subscribe my name this 10th day of June, 1929.

ROBERT C. MATHES.