April 5, 1932. R. C. MATHES 1,852,584

TRANSMISSION CONTROL

Filed Jan. 25, 1930 2 Sheets-Sheet 1

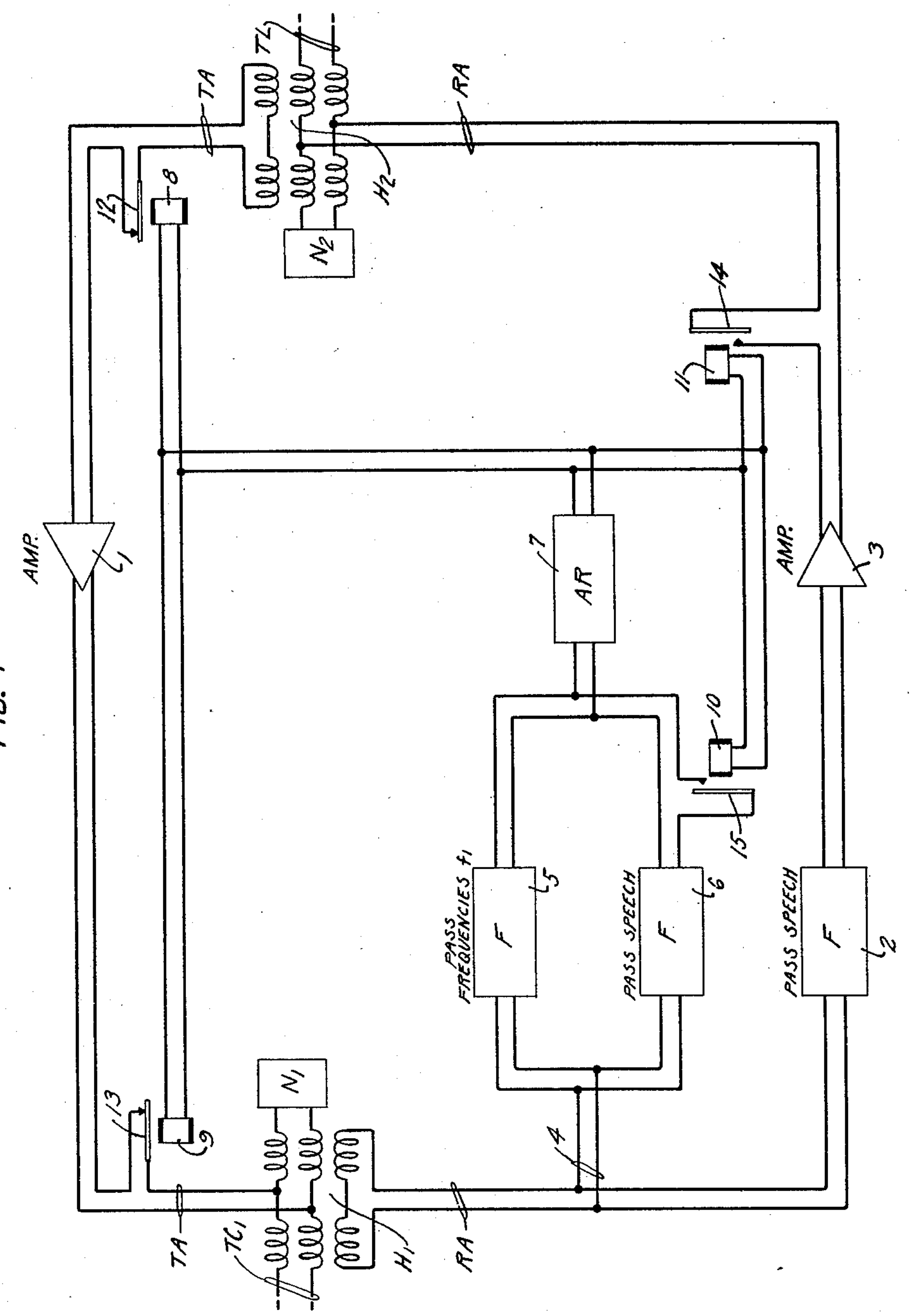

FIG. 1

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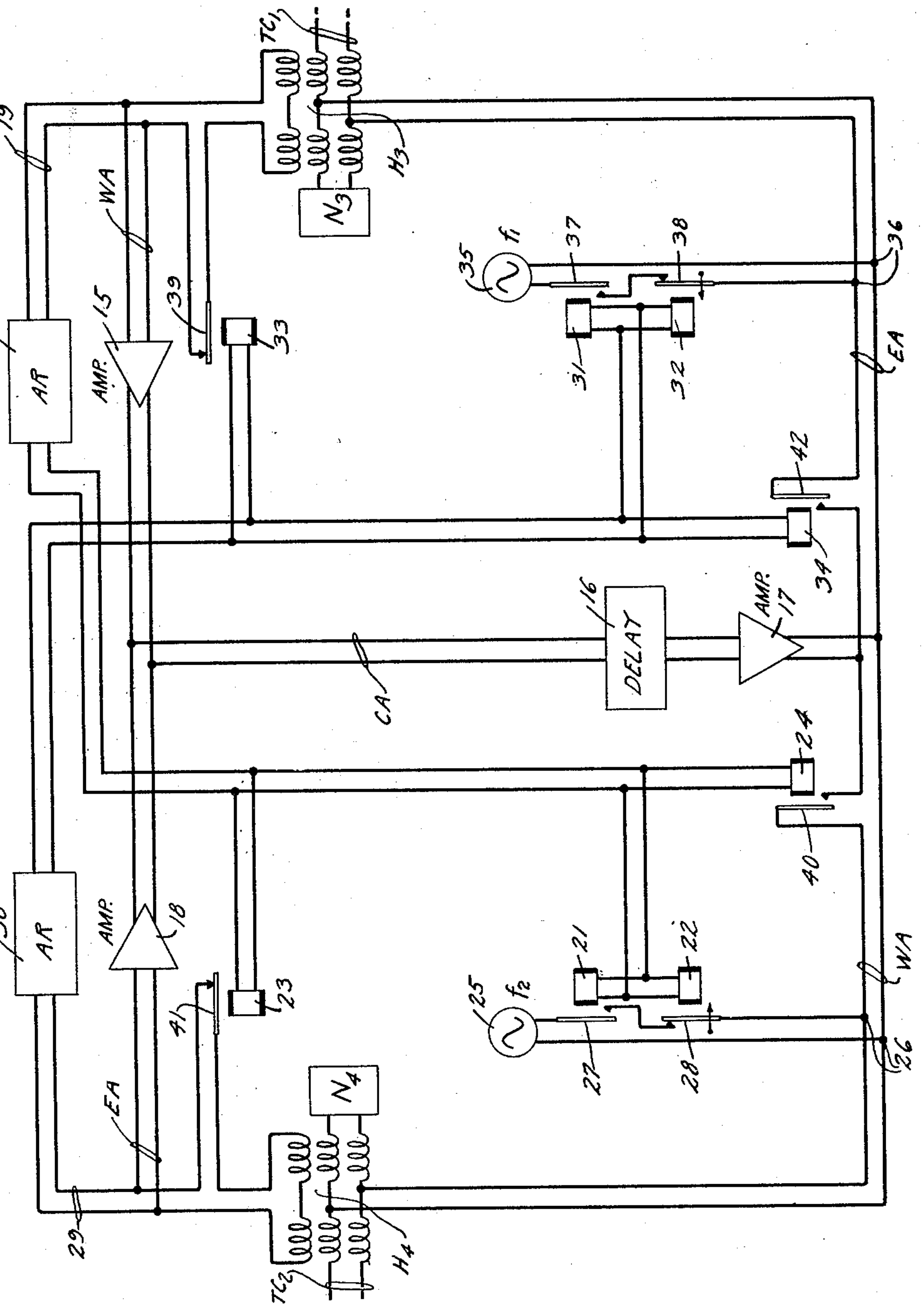
FIG. 2



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Patented Apr. 5, 1932

1,852,584

UNITED STATES PATENT OFFICE

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TRANSMISSION CONTROL

Application filed January 25, 1930. Serial No. 423,368.

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

An object of the invention is to improve the operation of a signal transmission system including therein circuit-control means operated 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, and including as a link therein a long section of two-way cable of high attenuation and high transmission-time constant, such as a deep sea submarine telephone cable. In such systems signal-controlled circuit-control apparatus, which in the prior art have been referred to under various names, such as reaction suppressors, singing suppressors, anti-singing devices or echo suppressors, are usually associated with the transmitting and receiving circuits at each terminal of the cable and at intermediate stations to insure that the system is operative to transmit in only one direction at a time, so as to effectively suppress singing, echoes, or both. This is usually accomplished by making the circuit-control apparatus responsive to transmission in either direction to render the circuits operative for transmission in that direction and to effectively disable the circuits for transmission in the opposite direction.

There are several characteristics of a system, such as described above the combination of which may introduce difficulties in the application of the signal-controlled circuit-control apparatus thereto. One is the increased time of transmission over the cable due to its length, another is the high attenuation of the cable to transmitted currents, and still another is the small load capacity of the cable.

The increased time of transmission over the cable greatly increases the chance that two subscribers at the opposite 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 the circuit-control apparatus, securing control of his own terminal for transmitting and locking out the transmission received from the other subscriber. The high attenuation of the cable necessitating the use of extremely high power levels at the input of the system, the special requirements as to quality and the load limitations of such a system have made necessary the use of new methods of operation and special control circuits.

In general, the above mentioned difficulties may be overcome by circuits designed to give exclusive control of the switching circuits of the system to that subscriber at one end of the system who first starts talking. My copending applications Serial Nos. 370,034 and 370,035, filed June 11, 1929, disclose various circuits of that type which utilize a method of control called the "courier" method. According to that method, the speech energy generated at each cable terminal, or incoming thereat over an associated circuit, is made to control the sending out over the transmission circuits, and in advance of the speech energy, of a courier comprising a short train of control waves of frequencies which differ for each terminal. This courier is utilized to initially seize control of the circuit-control apparatus at the cable terminals and at intermediate repeater points in the system for the first talker, this control being maintained by the speech waves when they arrive at the control points. The terminal which first starts its courier on the way obtains exclusive control of the talking circuits of the system.

The present invention relates to a modification of the courier circuits disclosed in the above mentioned applications, which modification is especially applicable to a system in which an intermediate repeater is used to connect two sections of the cable. In accordance with the invention, the couriers utilized for controlling the circuit-control apparatus for the two directions of transmission are sent out over the two sections of cable from the intermediate repeater station instead of from the terminal stations. The talker whose speech energy first reaches the intermediate repeater station will obtain exclusive control of the talking circuits of the system. In the system of the invention, the two couriers may have the same frequency which simplifies the design of means for selecting the courier through the transmitted speech energy.

The exact nature and the advantages of the invention will be clear from the following detailed description thereof when read in connection with the accompanying drawings, Fig. 1 of which shows a circuit diagram of a cable terminal station embodying the invention and Fig. 2 of which 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. 1.

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 system to be described comprises two terminal stations of the type illustrated in Fig. 1 connected by a two-way cable of high attenuation and high transmission-time constant, such as a deep sea submarine telephone cable, through an intermediate repeater station of the type shown in Fig. 2. The cable comprises two sections, an east section TC_1 connected between the east cable terminal station illustrated in Fig. 1 and the east end of the intermediate reepater station shown in Fig. 2, and a west section TC_2 connected between the west cable terminal station (not shown) and the west end of the intermediate repeater station. It will be assumed that the east cable section TC_1 has an over-all transmission-time of T_1 seconds and that the west cable section TC_2 has an over-all transmission-time of T_2 seconds.

Since the terminal stations at both ends of the cable system may be substantially identical in construction, except for a possible difference in the transmission frequency range of certain of the filters used therein necessitated by the fact that the courier frequencies transmitted in the two directions may be different, it has been deemed sufficient to illustrate the terminal station at one end of the system only, the east end, and in the following description the manner of the operation of the system will be clear from reference to the single terminal station shown and the intermediate repeater station.

The east terminal station of Fig. 1 comprises a transmitting circuit TA and a receiving circuit RA connected between a two-way signal circuit TL, such as a two-way toll telephone line, and the east section TC_1 of the two-way 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 section TC_1 by means of the three-winding transformer or hybrid coil H_1, which cooperates with the cable section TC_1 and the balancing network N_1 to insure substantially conjugacy between the circuits TA and RA. For a similar purpose the input of the transmitting circuit TA and the output of the receiving circuit RA are connected to the circuit TL through the hybrid coil H_2 having an associated balancing network N_2.

The transmitting circuit TA comprises a one-way transmitting amplifier 1 connected between the hybrid coil H_2 and the hybrid coil H_1. The receiving circuit RA comprises a band pass filter 2 and a one-way receiving amplifier 3 connected between the hybrid coil H_1 and the hybrid coil H_2. Connected across the receiving circuit RA between the input of the band pass filter 2 and the hybrid coil H_1 is a control circuit 4 comprising a band pass filter 5 and a band pass filter 6 in parallel branches thereof, a current-controlled, relay controlling device 7 connected across the outputs of the filters 5 and 6, and the windings of relays 8 to 11 connected in parallel to the output of the device 7.

In the input of the transmitting circuit TA between the input of the amplifier 1 therein and the hybrid coil H_2 is a normally closed switch 12 adapted to be opened by operation of relay 8. In the output of the transmitting circuit TA between the output of the amplifier 1 therein and the hybrid coil H_1 is a normally closed switch 13 adapted to be opened by operation of relay 9. In the output of the receiving circuit RA between the output of the receiving amplifier 3 therein and the hybrid coil H_2 is a normally open switch 14 adapted to be closed by operation of the relay 11. In one branch of the control circuit 4 between the output of the filter 6 therein and the input of the control device 7 is a normally open switch 15 adapted to be closed by operation of relay 10.

The intermediate repeater station of Fig. 2 comprises a westerly directed amplifying path WA and an easterly 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 to the west end of the east cable section TC_1 and in conjugate relation with 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 to the east end of the west cable section TC_2 and in conjugate relation to each other by the hybrid coil H^4 and its associated balancing newtork N^4.

The amplifying path WA comprises, connected in order between the hybrid coil H_3 and the hybrid coil H_4, the one-way amplifier

45, the delay circuit 16 and another one-way amplifier 17. The amplifying path EA comprises, connected in order between the hybrid coil H_4 and the hybrid coil H_3, the one-way amplifier 18, the delay circuit 16 and the one-way amplifier 17.

Connected to the input of the amplifying path WA between the input of the amplifier 15 therein and the hybrid coil H_3 is a control circuit 19 comprising a current-controlled, relay controlling device 20, and the windings of relays 21 to 24 connected in parallel across the output of the device 20. The relay 22 is relatively slow operating compared with relay 21.

A generator 25 of alternating current waves of frequencies f_2, which may be any frequencies outside the speech frequency range, is adapted to be momentarily connected across the output of the amplifying path WA at the points 26 by switches 27 and 28 controlled by operation of relays 21 and 22, respectively.

Connected across the input of the amplifying path EA between the input of the amplifier 18 therein and the hybrid coil H^4 is a control circuit 29 comprising a current-controlled, relay controlling device 30, and the windings of relays 31 to 34 connected in parallel to the output of the device 29. Relay 32 is relatively slow operating compared to relay 31.

A generator 35 of alternating current waves of frequencies f_1, which may be any frequencies outside the speech frequency range and different from the frequencies f_2, is adapted to be connected across the input of the amplifying path EA at the points 36 by means of switches 37 and 38 controlled by operations of relays 31 and 32 respectively.

In the input of the amplifying path WA between the point of connection thereto of control circuit 19 and the hybrid coil H_3 is a normally closed switch 39 adapted to be opened by operation of relay 33. In the output of the amplifying path WA between the output of the amplifier 17 and the points 26 is a normally open switch 40 adapted to be closed by operation of relay 24. In the input of amplifying path EA between the point of connection thereto of control circuit 29 and the hybrid coil H_4 is a normally closed switch 41 adapted to be opened by operation of relay 23. In the output of the amplifying path EA between the output of amplifier 17 and the points 36 is a normally open switch 42 adapted to be closed by operation of relay 34.

The current-controlled, relay controlling devices 7, 20 and 30 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 relays in the output thereof.

The delay circuit 16 may be of any type which will produce a delay of the required amount 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 delay circuit 16 is designed to produce a time delay in transmitted currents approximately equal to the over-all transmission time of the particular one of the cable sections TC_1 or TC_2 which has the longest over-all transmission time between the intermediate repeater station and the terminal station to which it is connected.

The band pass filters 2, 5 and 6 at the east terminal station shown and the corresponding band pass filters at the west terminal station (not shown) may be of the type disclosed in the U. S. patents to Campbell mentioned above. The filters 2 and 6 at the east terminal station are designed to pass waves of frequencies within the signal frequency range, in this case the speech frequency range, and to suppress the frequencies generated by the generator 35 at the intermediate repeater station. The filters at the west terminal station corresponding to the filters 2 and 6 at the east terminal station are designed to pass waves of frequencies within the speech frequency range, and to suppress the frequencies f_2 generated by the generator 25 at the intermediate repeater station. The filter 5 at the east cable terminal station is designed to pass the frequencies f_1 generated by the generator 35 at the intermediate repeater station. The filter at the west cable terminal station (not shown) corresponding to the filter 5 at the east cable terminal station is designed to pass the frequencies f_2 generated by the generator 25 at the intermediate repeater station.

The one-way amplifiers 1, 3, 15, 17 and 18, the mechanical relays 8 to 11, 21 to 24 and 31 to 34, and the alternating current generators 24 and 34 and the similar apparatus at the west terminal station may be any of the types well known in the art.

It will be assumed that speech waves for transmission from east to west are being received over the circuit TL at the east cable terminal station shown in Fig. 1. The received speech waves are impressed by the hybrid coil H_2 on the transmitting circuit TA and are amplified by the transmitting amplifier 1 therein. The amplified currents are impressed by the hybrid coil H_1 upon the east cable section TC_1 and transmitted thereover to the intermediate repeater station shown in Fig. 2.

At the intermediate repeater station the received speech waves are impressed by the hybrid coil H_3 upon the westerly directed amplifying path WA, and will be divided therein between the input of the amplifier 15 in the main path and the input of the control circuit 19 connected thereto. The portion of the amplified waves diverted into control circuit 19 will operate control device 20 therein causing the windings of relays 21 to 24 to be energized.

Relay 21 will quickly operate to close the switch 27 so as to connect the generator 25 of the waves of frequencies f_2 across the output of the path WA at the points 26. The relatively slow operating relay 22 will operate a given instant later to open the switch 28 so as to disconnect the generator 24 from the path WA. The momentary connection of generator 25 to the path WA will cause a short train of waves of the frequencies f_2, which I will refer to hereafter as the courier f_2, to be transmitted over the path WA towards the west cable section TC_2. The courier f_2 may be made as short as is desired or as is necessary by the design of relays 21 and 22. The relays 21 and 22 are so designed that they will remain operated as long as speech waves from the cable section TC_1 are being substantially continuously impressed upon the input of control device 20 in control circuit 19, and so that they will release only after a complete pause in the transmission of said waves such as would occur at the end of the sentence, and not for the usual pause between words or syllables.

The courier f_2 will be impressed by the hybrid coil H_4 upon the west cable section TC_2 and transmitted thereover to the west terminal station where it will establish initial control of the switching circuits thereat in a manner which will be described later.

At the intermediate repeater station relay 23 will operate substantially at the same time as relays 21 to 22 to open the normally closed switch 41 in the input of the easterly directed amplifying path EA making that path inoperative at that time to transmit waves from the west cable section TC_2 to the input of amplifier 18 in the path EA or to the input of the relay controlling device 30. Relay 24 will operate substantially at the same time as relay 23 to close the normally open switch 40 in the output of the westerly directed amplifying path WA, making that path operative to transmit waves from the output of amplifier 17 to the west cable section TC_2.

Meanwhile, at the intermediate repeater station the main portion of the east to west speech waves received, from the east cable section TC_1 will be amplified by the amplifier 15 in the path WA. The amplified waves in the output of amplifier 15 then will be transmitted through the delay circuit 16, which, as stated above, is designed to delay them at least for a period of time equal to the over-all transmission time of that cable section TC_1, or TC_2, whichever has the longest over-all transmission time. The delayed waves in the output of delay circuit 16 are amplified by amplifier 17 and, the switch 40 in the output thereof having been previously closed by the operation of relay 24, will be transmitted out over the path WA to the hybrid coil H_4 and impressed by that hybrid coil upon the west cable section TC_2. The impressed east to west speech waves will be transmitted over the west cable section TC_2 following the preceding courier f_2 by a time interval equal to the delay time produced by the delay circuit 16 at the intermediate repeater station.

The manner in which complete control of the transmitting and receiving circuits at the west terminal is obtained by the east and west speech waves transmited from the east terminal will be clear from the following description 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 it with the same characters as used for designating the corresponding apparatus at the east terminal station, but followed by a prime (′) mark.

The courier f_2 transmitted over the cable section TC_2 in advance of the east to west speech waves on arrival at the west terminal station is impressed on the receiving circuit RA′ thereof by hybrid coil H_1'. The band pass filter 2′ in the main receiving path RA′, and the band pass filter 6′ in the lower branch of controlled circuit 4′ are both designed to suppress the courier f_2. Therefore, the courier f_2 will be diverted into the upper branch of the control circuit 4′ and will pass through the band pass filter 5′ therein (the band pass filter 5′ being designed to transmit the waves of the frequencies f_2). The passed courier f_2 will operate control device 7′ causing the windings of the relays 8′ to 11′ in the output thereof to be energized. Relay 8′ operates to open the normally closed switch 12′ in the input of the transmitting circuit TA′, and the relay 9′ operates to open the normally closed switch 13′ in the output of the same circuit, thus making the transmitting circuit TA′ inoperative from that time to transmit westerly directed waves from the circuit TL′ to the cable section TC_2. Relay 10′ operates substantially at the same time as relays 8′ and 9′ to close the normally open switch 15′ in the lower branch of control circuit 4′, thus making that branch operative to transmit speech waves from the cable TC_2 through the band pass filter 6′ to the input of control device 7′. Relay 11′ operates substantially at the same time as relays 8′ to 10′ to close the normally open switch 14′ in the output of the receiving circuit RA′, thus making that path operative to transmit waves from the output of amplifier 3′ to the circuit TL′.

The east to west speech waves, which follow the courier f_2 over the cable section TC_2 by a time interval equal to the delay time of the delay circuit 16 at the intermediate repeater station, on arrival at the west terminal station are also impressed upon the receiving path RA′ by the hybrid coil H_1'. The impressed speech waves will divide between the input of band pass filter 2′ in the main receiving circuit RA′ and the input of control circuit 4′. The portion diverted into the control circuit 4′ will be passed by the band pass filter 6′ therein in the lower branch thereof and, the switch 15′ in the output thereof having been previously closed by the operation of relay 10′ under the control of the preceding courier f_2, will be impressed upon the input of control device 7′. The impressed speech waves will serve to maintain control device 7′ in the operated condition initiated by the preceding courier f_2 as long as the east to west speech waves are being substantially continuously transmitted over the cable section TC_2 and impressed upon the input of control device 7′. The relays 8′ to 11′ will therefore be maintained energized causing the transmitting circuit TA′ to be maintained disabled and the receiving circuit RA′ and the control circuit 4′ maintained operative for transmitting speech waves for the same interval of time.

The portion of the east to west speech waves passed by the band pass filter 2′ in the main receiving circuit RA′ will be amplified by the amplifier 3′ therein. The amplified waves will be impressed by hybrid coil H_2' upon the circuit TL′ and transmitted thereover to the listening subscriber.

In the manner which has just been described the east to west speech waves have obtained complete control of the circuits at both terminal stations and at the intermediate repeater station.

At the complete cessation in the supply of east to west speech waves to the intermediate repeater, or at each pause in the supply thereto corresponding to the usual pause at the end of a sentence, the control device 20 will return to its unoperated condition and relays 21 to 24 will release. Later when the supply of speech waves to the west terminal over the cable section TC_2 has ceased or paused temporarily, control device 7′ will also return to its unoperated condition causing the release of relays 8′ to 11′. The circuits of the system are then in condition to be seized by the speech waves set up first at either terminal.

Now let it be assumed that speech waves to be transmitted from west to east are generated at the west cable terminal station or received thereat over the associated circuit TL′ at a time which is appreciably later than the time at which speech waves for transmission from east to west are generated at the east cable terminal station or received thereat over the associated circuit TL, but not more than T seconds later where T is the total over-all transmission time over the system between the east and west terminal stations. The later generated west to east waves will be impressed by the hybrid coil H_2' on the transmitting circuit TA′ of the west terminal station and amplified by the transmitting amplifier 1′ therein. The amplifying waves will be impressed by the hybrid coil H_1' upon the west cable section TC_2 and transmitted thereover to the intermediate repeater station.

At the time these west to east speech waves have arrived at the intermediate repeater station the east to west speech waves have already arrived there and seized control of the circuits thereat. The received west to east speech waves cannot be transmitted through the repeater circuits to the east cable section TC_1, or cannot be impressed upon the input of control device 30 thereat to cause false operation of relays 31 to 34 in the output thereof, because of the open circuit in the input of the easterly directed amplifying path EA caused by the opening of switch 41 by the earlier arriving east to west speech waves.

From the above description it is apparent that the speech waves which first arrive at the intermediate repeater station from a terminal station first gain control of the circuits of the whole system, and maintain that control until complete cessation of the speech transmission in that direction or a partial pause therein sufficient to allow the controlled relay to release, for example, a pause equivalent to the pause which ordinarily occurs in the end of a sentence.

The operation of the system for the case when speech waves for transmission from west to east are set up at the west terminal station before the speech waves for transmission from east to west are set up at the east terminal station is similar to the operation which has just been described for the opposite case. In that case the west to east speech waves arriving first at the intermediate repeater station will make the easterly directed amplifying path EA thereat operative to transmit them to the east cable section TC_1, and cause a courier of frequencies f_1 to be transmitted out over the east cable section TC_1 in advance of the speech waves by a time interval equal to the delay time of the filter 16 and to seize control of the circuit-control apparatus at the east terminal station, which control will be maintained by the west to east speech waves when they arrive at the latter terminal.

If the two cable sections TC_1 and TC_2 have nearly equal over-all transmission times, and the delay time of the delay circuit 16 at the intermediate repeater station is made substantially equal to the over-all transmission time of the longest of the two cable sections, the speech waves will follow the courier control wave with sufficient lag to permit any transmitted speech energy to be discharged after the courier has obtained control of the distant station. It is apparent that, as the two couriers f_1 and f_2 are transmitted over different parts of the system, that they may be made of the same or of different frequencies. If they are made of the same frequency the problem of designing the selective arrangement so that each courier can be received at the terminal stations through outgoing speech energy is simplified.

It is to be understood that the invention is not limited to the particular circuits and the details of the particular terminal and intermediate repeater stations illustrated and described as numerous modifications thereof may be made without departing from the spirit and scope of the invention by persons skilled in the art; for example, the intermediate repeater station which has been described comprises normally inoperative amplifier paths for the two directions of transmission having a portion in common, and control circuits responsive to transmission in either direction to make the amplifying path in that direction operative. It is apparent that the invention may be applied equally well to an intermediate repeater circuit in which the amplifying paths for the two directions of transmission have no portions in common, or in which one path is normally operative and the other path normally disabled and the control 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 particular embodiments of the invention which have been illustrated and described mechanical relays have been shown for conditioning the transmission paths by operating movable switches to close or open circuit these paths, the invention is not limited to the particular conditioning 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 shown, for example, vacuum tube relays, such as disclosed in Crisson Patent 1,647,212, issued November 1, 1926 or in the article by C. A. Beers 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. A signaling system comprising a transmission path connecting terminal stations, circuit-control means at said terminal stations, and means at a point in said path intermediate said terminal stations and responsive to signal waves transmitted over said path from one terminal station for sending over said path, and in advance of said signals, a control wave to actuate the circuit-control means at the other of said terminal stations.

2. A signaling system comprising a transmission path connecting terminal stations, circuit-control means at said terminal stations, means at a point in said path intermediate said terminal stations and responsive to signal waves transmitted over said path from one terminal station for sending over said path, and in advance of said signals, a control wave to actuate the circuit-control means at the other of said terminal stations, and means for utilizing the signals when they arrive at said other terminal station to maintain the circuit-control means thereat actuated.

3. A signaling system comprising a two-way signal transmission path connecting terminal stations, circuit-control means at said terminal stations, means at a point in said path intermediate said terminal stations and responsive to signal waves transmitted over said path for transmitting a control wave over said path, and in advance of said signals, to actuate the circuit-control means at the other terminal station, and means for preventing signal waves transmitted from said other terminal station after the signal waves have been transmitted from the first-mentioned station from reaching the first-mentioned station or from disturbing the operation of said control wave transmitting means.

4. In a telephone system having terminal stations and an intermediate station, directional switching means at each terminal station, and means including a source of control waves at said intermediate station controlled by speech waves sent from a terminal station for sending control wave energy to certain of the terminal stations to control said switching means thereat.

5. A signaling system comprising a signal transmission path connecting terminal stations, a repeater station for repeating the transmitted signals, connected intermediate said terminal stations, circuit-control means at said stations, means at the intermediate repeater station under control of the signals received from one of said terminal stations for sending over said path, and in advance of the signals, a control wave to operate the circuit-control means at the other of said terminal stations.

6. A signaling system comprising a signal transmission path connecting terminal stations, a repeater station for repeating the transmitted signals, connected intermediate said terminal stations, circuit-control means at said stations, means at the intermediate re-

peater station under control of the signals received from one of said terminal stations for sending over said path, and in advance of the signals, a control wave to operate the circuit-control means at the other of said terminal stations, and means for utilizing the repeated signals when they arrive at said other station to maintain the circuit-control means thereat in its operated condition.

7. A two-way signaling system comprising a two-way signal transmission path connecting terminal stations, circuit-control means at said terminal stations a repeater station connected in said path intermediate said terminal stations, for repeating the transmitted signals in opposite directions, means at said repeater station and responsive to signals received over said path from one terminal station for causing a control wave to be transmitted over said path, and in advance of the signals, to actuate the circuit-control means at the other terminal station, and means at said repeater station also responsive to the signals received from one station for preventing later received signals from said other terminal station from being repeated by said repeater station and from disturbing the operation of said control wave-transmitting means.

8. A system for the two-way transmission of signals comprising a two-way line connecting two terminal stations each comprising a normally operative transmitting path and a normally disabled receiving path through an intermediate repeater comprising normally disabled one-way amplifying paths for the currents transmitted in opposite directions, circuit-control means at each terminal station responsive to transmission received from the intermediate repeater station for disabling the transmitting path at said terminal station and for rendering the receiving path thereat operative, and means for giving exclusive control of the circuit-control means at said terminal stations and said intermediate repeater to the one of said terminal stations whose signals are first transmitted to said repeater station.

9. The system of claim 8 and in which the last mentioned means comprise individual means at said repeater respectively under the control of the signals received from the respective terminal stations for sending an impulse of current over said line to the other terminal station to initially operate the circuit-control means thereat, and for rendering the amplifying path of said repeater for the direction of the controlling signals operative to transmit the signals to said other terminal station, means at said intermediate repeater for delaying transmission of the signals to prevent their arrival at said other terminal station until after the circuit-control means thereat has been operated by the preceding impulse of current, means for utilizing the delayed signals when they arrive at said other station to maintain the circuit-control means thereat in the initially operated condition, and means to prevent operation of the means for sending an impulse of current over said line, and of the means for controlling operation of said amplifying paths in response to the signals from one terminal station if they begin to arrive at the intermediate repeater later than the signals from the other station at least until the last mentioned signals in substantially continuous form cease to arrive at said intermediate repeater.

10. The system of claim 8 and in which the last mentioned means is controlled by the signals which first begin to arrive at the intermediate repeater.

11. A repeater station for repeating in opposite directions signals between two sections of signal transmission line comprising two normally disabled, oppositely directed one-way amplifying paths, two sources of control waves, control means responsive to the signals received at said repeater station from one of said two-way line sections for rendering operative the proper one-way amplifying path to transmit the controlling signals to the other one-way line section, and for causing the control waves from one of said sources also to be transmitted to said other two-way line section in advance of the signals, control means responsive to the signals received at said repeater from the other two-way line section for rendering operative the proper one-way amplifying path to transmit the controlling signals to said one two-way line section, and for causing the control waves from the other of said sources to be transmitted to said one two-way line section in advance of the signals, and means responsive to the signals first arriving at the repeater over one two-way line section for preventing subsequent operation by the later arriving signals from the other two-way line section of the control means normally controlled thereby.

12. The repeater station of claim 11 and in which said oppositely directed, one-way amplifying paths comprise a portion in common connected so as normally to receive transmission from either two-way line section while preventing transmission between the two-way line sections, and in which said one-way amplifying paths are normally disabled in their output.

In witness whereof, I hereunto subscribe my name this 22d day of January, 1930.

ROBERT C. MATHES.