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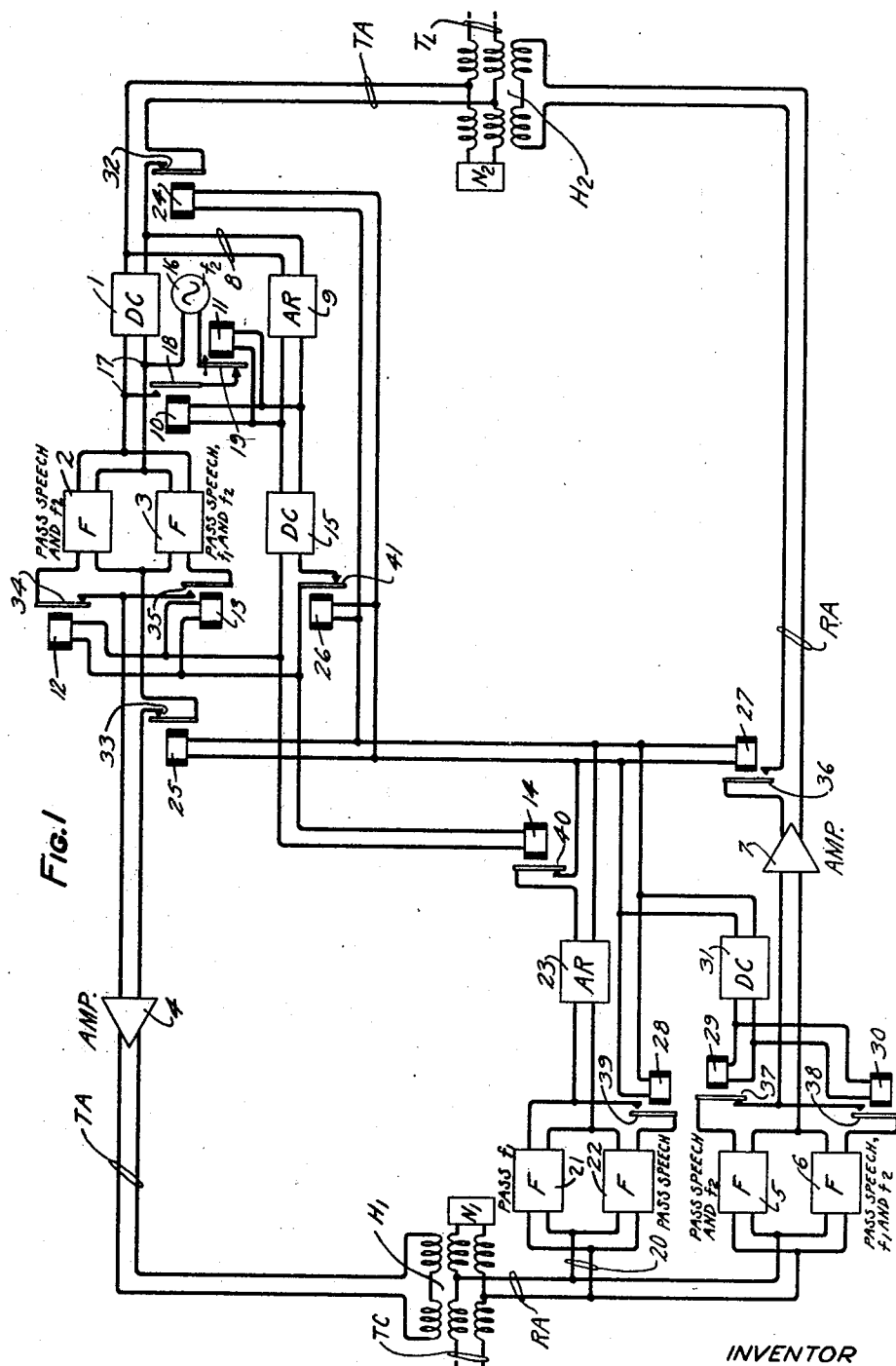
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1,830,219

TRANSMISSION CONTROL

Filed Feb. 1, 1930

2 Sheets-Sheet 1



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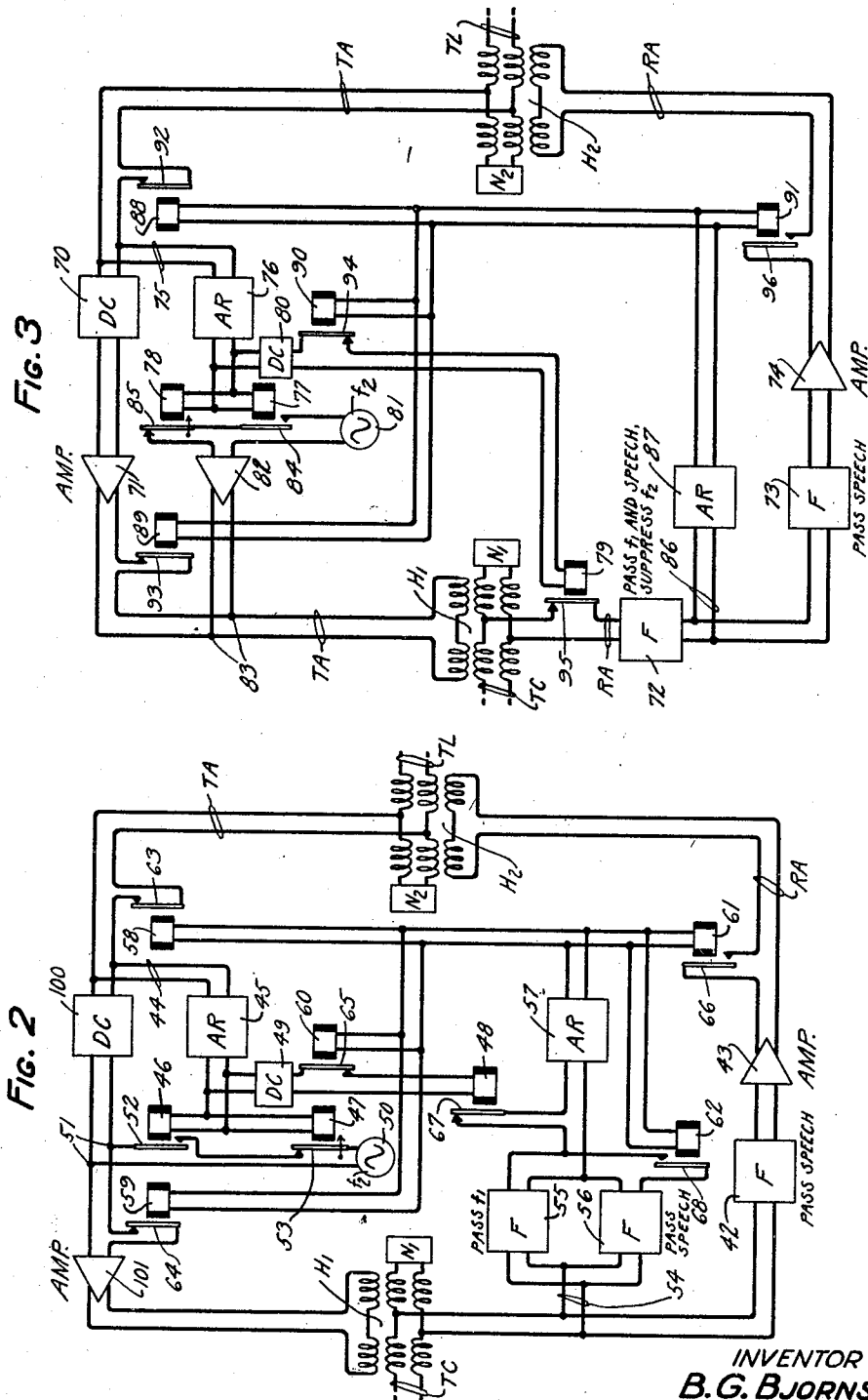
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2 Sheets-Sheet 2



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TRANSMISSION CONTROL

Application filed February 1, 1930. Serial No. 425,092.

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

The invention broadly relates to methods of and means for controlling transmission in a signal transmission system utilizing control energy under control of signals transmitted over the system in advance of the signals to control the operation of 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 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. Signal-controlled switching devices, which in the prior patent 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 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 effectively to prevent singing and to suppress echoes. This is usually accomplished by making the switching apparatus at each terminal responsive to transmission in one direction to render the circuits thereat operative to transmit in that direction, and effectively to 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 switching 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 sys-

tem may both start talking within the time interval equal to the transmission time of the cable, resulting in each subscriber, by means of the switching 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 the system have made necessary the use of new methods of operation and special switching circuits.

In general the above-mentioned difficulties may be overcome by circuits designed to give complete control of the switching circuits at both terminals of the cable to that subscriber who first starts talking.

The copending applications of R. C. Mathes, Serial Nos. 370,034 and 370,035, both filed June 11, 1929, disclose certain circuits of that type, which employ a method of transmission control called the "courier" method. In accordance with that method, the speech energy generated at each cable terminal or incoming, thereat over an associated line 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 are different for each terminal. This courier is utilized to initially seize control of the circuit-control switching 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 switching points. The terminal which first starts its courier on the way obtains exclusive control of the talking circuits of the system.

The circuits of the present invention are in the nature of improvements over the circuits disclosed in the two Mathes applications referred to above, the improvements consisting mainly in means for increasing the efficiency of the circuits, and in simplification of the circuits enabling a reduction in the amount of transmission apparatus used therein.

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A feature of the invention is a control circuit of the courier type for a two-way signal transmission system in which the frequency ranges utilized by the couriers are made available for speech transmission as soon as complete control of the system has been initially obtained for either terminal of the system.

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 in which Figs. 1, 2 and 3 show circuit diagrams of cable terminal stations embodying different modifications of the invention.

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

Figs. 1, 2 and 3 show alternative types of terminal circuits for a two-way cable system in which the courier method of transmission control is used to prevent transmission lockouts when two subscribers at opposite ends of the system both start talking within the time interval equal to the overall transmission time of the cable between terminals.

Since in each modification of the invention to be described, the terminal stations at both ends of the cable may be substantially identical in construction except for changes in the design of the courier generators and the filters necessitated by the fact that the values of the frequencies of the couriers transmitted from the two terminals are different, it has been deemed sufficient in each case to illustrate only one terminal of the cable system.

In a cable signaling system having terminal circuits of the type shown in Fig. 1, transmission lockouts are prevented and in addition the limited frequency range of the cable is utilized to maximum efficiency for transmitting signals.

The terminal station of Fig. 1 comprises, connected between a source of speech waves TL, such as a toll telephone line, and a two-way cable TC of high attenuation and high transmission-time constant, such as a deep sea submarine telephone cable, a one-way transmitting amplifying path TA and a one-way receiving amplifying path RA. The output of the transmitting path TA and the input of the receiving path RA are connected to the east end of the two-way cable TC by means of a three winding transformer or hybrid coil H_1 , which cooperates with the cable TC and the balancing network N_1 to insure substantial conjugacy between the paths TA and RA. For a similar purpose the input of

the transmitting path TA and the output of the receiving path RA are connected to the circuit TL through the hybrid coil H_2 , having an associated balancing network N_2 .

It will be assumed that the cable TC has an overall transmission time between its terminal stations of T seconds.

The transmitting path TA comprises, connected between the hybrid coil H_2 and the hybrid coil H_1 , a delay circuit 1, filters 2 and 3 connected in parallel branches of the transmitting path, and the one-way transmitting amplifier 4. The receiving amplifying path RA comprises connected between the hybrid coil H_1 , and the hybrid coil H_2 , the filters 5 and 6 connected in parallel branches of the receiving path, and the one-way amplifier 7.

Connected across the transmitting path TA between the hybrid coil H_2 and the delay circuit 1 is a control circuit 8 comprising the current-controlled relay-controlling device 9 and the windings of relays 10 to 14 connected in parallel across the output of the control device 9. A delay circuit 15 is connected between the windings of relays 12 to 14 and the output of the device 9 to delay the energization of those relays in response to the operation of device 9 with respect to the energization of relays 10 and 11. Relay 10 is designed to operate in response to the operation of the device 9 slightly in advance of the operation of relay 11.

A source 16 of alternating current waves of frequencies f_2 , which are outside the initial speech frequency transmission range of the system (temporarily a part of the useful transmission frequency range of the system is utilized for the courier frequencies), is adapted to be momentarily connected across the transmitting path TA at the points 17 in the output of delay circuit 1 by means of switches 18 and 19 controlled by the operation of relays 10 and 11, respectively.

Connected across the receiving path RA between hybrid coil H_1 and the filters 5 and 6 is a control circuit 20 comprising the filters 21 and 22 connected in parallel branches thereof, a current controlled relay controlling device 23 connected to the outputs of the filters 21 and 22, and the windings of relays 24 to 30 connected in parallel across the output of the device 23. A delay circuit 31 is connected between the windings of relays 29 and 30 and the output of the device 23 to delay the energization of these relays in response to the operation of device 23 with respect to the energization of relays 24 to 28.

A normally closed switch 32 adapted to be opened by operation of relay 24 is connected in the transmitting path TA between the point of connection of the control circuit 8 thereto and the hybrid coil H_2 . A normally closed switch 33 adapted to be opened by operation of relay 25 is connected in the

transmitting path TA between the outputs of filters 2 and 3 and the input of amplifier 4. A normally closed switch 34 adapted to be opened by operation of relay 12 is connected in the transmitting path TA between the output of the filter 2 in the upper branch thereof and the switch 33. A normally open switch 35 adapted to be closed by operation of relay 13 is connected in the transmitting path TA between the output of filter 3 in the lower branch thereof and the switch 32.

A normally open switch 36 adapted to be closed by operation of relay 27 is connected in the receiving path RA between the output of the receiving amplifier 7 therein and the hybrid coil H₂. A normally closed switch 37 adapted to be opened by operation of relay 28 is connected in the receiving path RA between the output of filter 5 in the upper branch thereof and the input of amplifier 7. A normally open switch 38 adapted to be closed by operation of relay 30 is connected in the receiving path RA between the output of filter 6 in the lower branch thereof and the input of amplifier 7.

A normally open switch 39 adapted to be closed by operation of relay 28 is connected in the control circuit 20 between the output of the filter 22 in the lower branch thereof and the input of control device 23. A normally closed switch 40 adapted to be opened by operation of relay 14 is connected in control circuit 20 between the output of control device 23 and the windings of relays 24 to 30. A normally closed switch 41 adapted to be opened by operation of relay 26 is connected in control circuit 8 between the output of device 15 and the winding of relays 12 to 14.

It is apparent that the cable terminal circuit which has been described is of the form which is known in the art as semi-biased, that the circuit is normally operative to transmit in one direction (in this case from east to west) and transmission in the opposite direction is dependent upon switching operations.

The relay controlling devices 9 and 23 may be vacuum tube, amplifier-rectifier devices of any type well known in the art, or any other devices which will respond to alternating current waves impressed upon their inputs to control the operation of switching devices, such as mechanical relays, in their outputs. The delay circuit 1 may be a network of any type suitable for producing a delay in transmission therethrough of alternating currents impressed upon its input; for example, it may be a low pass electrical filter such as disclosed in the U. S. patents to Campbell Nos. 1,227,113 and 1,227,114, issued May 22, 1917, an acoustic filter, or a work for a similar purpose such as disclosed in Arnold Patent No. 1,565,302, issued September 15, 1925. The delay circuits 1 and

31 and the corresponding delay circuits at the west terminal stations are designed to produce a very small delay of t seconds in the transmission of currents therethrough.

The delay circuits 15 and 31 may be low pass filters or networks of any other type suitable for producing a delay in rectified, alternating currents transmitted therethrough. As the delay circuits 15 and 31 are merely utilized to produce a lag in the operation of the relays connected to their outputs, they may be dispensed with if other means, such as suitable mechanical design of the relays, are used to produce the required lag. The delay circuit 15 and the corresponding delay circuit at the west terminal station are each designed to produce a time delay in the currents transmitted therethrough which is substantially equal to the overall transmission time of the cable TC between stations which has been assumed to be T seconds. If the delay circuits 15 and 31 are not used the relays 12 to 14 and the relays 29 and 30 must be delayed in operation in response to the operation of device 9 or device 23 for the required length of time by other means.

The filters 2, 3, 5, 6, 21 and 22 may be of the band pass type disclosed in the U. S. patents to Campbell mentioned above. The filters 2 and 5 are designed to transmit frequencies within the speech frequency range and the frequencies corresponding to the courier frequencies f_2 generated by the generator 16 at the east terminal station shown, and to suppress frequencies corresponding to the courier frequencies f_1 generated at the west terminal station (not shown) by a generator corresponding to the generator 16 at the east terminal station. The courier frequencies f_1 and f_2 may be any frequencies outside the initial signal frequency range, which in the case being described is the initial speech frequency range, and differing from each other.

The one-way amplifiers 4 and 7 and the relays 10 to 14, and 24 to 30 at the east terminal station and the corresponding apparatus at the west terminal station may be of any of the types well known in the art.

The operation of the system as a whole will now be described referring to Fig. 1 only. It will be assumed that speech waves to be transmitted over the cable TC in the direction from east to west are being received at the east terminal station over the circuit TL, and at that time no speech waves to be transmitted over the cable TC from west to east have as yet been received at the west terminal station.

The east to west speech waves received over the circuit TL are impressed on the transmitting path TA at the east terminal station by the hybrid coil H₂, and will be divided between the input of delay circuit 1 and the

control circuit 8. The portion diverted into control circuit 8 will operate control device 9 therein which in turn will cause the windings of relays 10 to 14 to be energized.

Relay 10 will operate quickly to close switch 18 to connect the generator 16 across the transmitting path TA at the points 17. The comparatively slow operating relay 11 will operate a given instant later to open the switch 19 so as to disconnect the generator 16 from the path TA. The effect of this momentary connection of generator 16 to the transmitting path TA will be to cause a short train of waves of frequencies f_2 to be transmitted out over the path TA. This short train of waves, which in the following description will be referred to as the courier f_2 , may be made as short as is desired or is necessary by the design of relays 10 and 11. The relays 10 and 11 are also so designed that they will remain operated as long as speech waves from the source TL are being substantially continuously supplied to the input of control device 9. They are designed so that they will release only after a complete pause in the speech transmission such as would occur at the end of a sentence, and not for the ordinary pauses between words or syllables.

Due to the retarding action of the delay circuit 15 in their inputs, relays 12 to 14 will not be energized so as to operate until substantially T seconds after the courier f_2 has been sent out to the cable TC in response to the previous operation of relays 10 and 11. Relay 12 will then operate to open the normally closed switch 34 in the output of filter 2, which filter is designed to transmit waves of frequencies within the ordinary speech frequency range and waves within the frequency range of the courier f_2 , thus effectively disabling the transmitting circuit TA for transmitting waves between the output of the delay circuit 1 and the input of the transmitting amplifier 4 through the filter 2. Relay 13 will simultaneously operate to close the normally open switch 35 in the output of filter 3, which filter is designed to transmit waves within the ordinary speech frequency range and waves of frequencies within the frequency range of both couriers f_2 and courier f_1 , thus effectively closing a transmission path for the waves in the transmitting circuit TA for the waves in the transmitting circuit TA through the output of delay circuit 1 through the filter 3 to the input of amplifier 4. The effect of disconnecting the filter 2 from the transmission path TA and connecting in its place the filter 3 in the manner described above is to increase effectively the transmission frequency range of the transmission path TA T seconds after the courier f_2 has been transmitted for the transmission frequency range of the transmitting path TA includes the initial speech frequencies and the frequencies f_1 and f_2 , while previously it

comprised only those frequencies within the speech frequency range and frequency f_2 .

Relay 14 will operate substantially at the same time as relays 12 and 13 to open the normally closed switch 40 in the output of the control circuit 20 connected to the receiving amplifying path RA, so as to prevent false operation of the relays 24 to 30 by a courier f_1 or west to east speech waves which might happen to be transmitted to the cable TC at the west terminal station in the short interval of time between the time the courier f_2 is sent out from the east terminal and the time the courier f_2 is effective to seize control of the switching circuits at the west terminal.

In the manner which has just been described, the east to west speech waves have obtained complete control of the transmitting and receiving circuits of the east terminal station, and this control will be maintained as long as the east to west speech are being substantially continuously impressed on the input of control device 9.

The main portion of the east to west speech waves have been delayed in transmission to the input of filters 2 and 3 in the transmitting path TA by a small time interval of t seconds. This interval need only be long enough to insure initial operation of the switching circuits at the west terminal by the courier f_2 before the speech waves arrive there. The delayed speech waves before the operation of relays 12 and 13 will be transmitted through the branch of the transmitting path TA comprising the filter 2. After the operation of relays 12 and 13, the delayed speech waves will be transmitted through the branch of the transmitting path comprising the filter 3. The east to west speech waves passed by the filter 2 or 3 are impressed upon the input of the transmitting amplifier 4. The amplified speech waves in the output of amplifier 4 will be transmitted to the hybrid coil H₁. These waves will be impressed by the hybrid coil H₁ upon the cable TC and transmitted thereover to the west terminal station, the first speech waves arriving at that station substantially t seconds after the arrival thereat of 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 to west speech waves will now be described by reference to the circuit of Fig. 1. 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 which designate the corresponding apparatus at the east terminal but followed by a prime (') mark.

The courier f_2 transmitted over the cable TC in advance of the east to west speech waves by a time interval of t seconds on ar-

rival at the west terminal station will be impressed on the receiving amplifying path RA' thereat by the hybrid coil H'. The impressed courier f_2 will be divided in the receiving path RA' between the input of filter 6' therein (the filter 5' is designed to suppress the courier f_2) and the input of control circuit 20'. The portion transmitted through the filter 6' will be dissipated therein as the output of that filter is open-circuited by the normally open switch 38'. The portion of the courier f_2 diverted into the control circuit 20' will be transmitted through the filter 21', which is designed to transmit frequencies within the range of f_2 , and will cause the initial operation of control device 23' in the output thereof to energize the windings of relays 24' to 30'. Relays 24' to 28' will operate immediately, and relays 29' and 30' will operate a short time, t' seconds (where t' is slightly more than the relay time t produced by the delay circuit 1) after the operation of the former relays because of the action of the delay circuit 31' in delaying for a time interval of t' seconds the supply of current from the output of device 23 to the winding of relays 29' and 30'.

Relay 24' operates to open the normally closed switch 32' in the input of the transmitting path TA', and relay 25' operates to open the normally closed switch 33', located in the same path in the output of the filters 2' and 3'. The transmitting amplifying path TA' at the west terminal station is thus initially made inoperative to transmit waves from the circuit TL' to the cable TC', or to the input of control device 9'.

Relay 26' operates substantially at the same time as relays 24' and 25' to open the normally closed switch 41' in the control circuit 8', thus effectively preventing false operation of relay 14' by any energy which may be stored in delay circuit 15' in control circuit 8' at the time switch 32' in the transmitting path TA' is opened by operation of relay 24'.

Relay 27' operates substantially at the same time as relays 24' to 26' to close the normally open switch 36' in the output of the receiving amplifying path RA' at the west terminal station, thus at that time making that path operative to transmit waves from the output of the receiving amplifier 7' to the circuit TL'.

Relay 28' operates substantially at the same time as relays 24' to 27' to close the normally open switch 39' in the output of filter 22' in control circuit 20', thus making that circuit operative to transmit speech waves to the input of the control device 23' through the filter 22', which filter is designed to transmit frequencies within the speech frequency range.

Relays 29' and 30' will operate substantially t' seconds after the operation of the relays 24' to 27'. Relay 29' operates to open the

normally closed switch 37' in the output of the branch of the receiving path RA' comprising the filter 5', thus making the receiving path RA' inoperative to transmit waves from the cable TC through the filter 5' to the input of amplifier 7'. Relay 30' simultaneously operates to close the normally open switch 38' in the output of the branch of the receiving path RA' comprising the filter 6', thus making the receiving path RA' operative to transmit waves from the cable TC through the filter 6' to the input of amplifier 7'.

As the transmission frequency range of the filter 6' comprises the initial speech frequency range plus the frequencies f_1 plus the frequencies f_2 , while the transmission frequency range of the filter 5' only includes the initial speech frequency range and the frequencies f_1 , it is apparent that by effectively disconnecting the filter 5' from the receiving path RA' and connecting in its place the filter 6', the transmission frequency range of the receiving path RA' has been effectively increased at a time after the courier f_2 has arrived at the west terminal station about equal to the delay of the speech waves behind the courier. This increase in the transmission frequency range of the receiving path RA' at the west terminal station takes place substantially just after exclusive control of the transmitting and receiving circuits at the east terminal station has been obtained by the east to west speech waves and at about the same time the transmission frequency range of the transmitting path TA at the east terminal station has been effectively increased by adding the frequencies f_1 to its transmission frequency range. It is apparent, therefore, that as soon as the east to west speech waves have obtained initial control of the transmitting and receiving circuits at both terminals, the part of the useful transmission frequency range of the system temporarily required for the courier frequency band f_2 has been made immediately available for speech transmission in the direction from east to west. All the speech frequency components included in the initial speech frequency range and in addition the frequency bands f_1 and f_2 may now be transmitted over the system in that direction.

The speech waves which are transmitted from the east terminal station over the cable TC to the west terminal station T seconds behind the preceding courier f_2 , on the arrival at the latter station will also be impressed by the hybrid coil H_1 upon the receiving amplifying path RA'. The impressed speech waves will be divided between the main receiving path RA' and the control circuit 20' connected thereto. The portion diverted into the control circuit 20' will be transmitted through the filter 22' therein and impressed on the control device 23' maintain-

ing that device in the operated condition initiated by the preceding courier f_2 . The relays 24' to 30' in the output of the device 23' will therefore be maintained energized, as long as the east to west speech waves are being impressed substantially continuously upon the input of the device 23'. The transmitting path TA' will, therefore, be maintained disabled and the receiving path RA' maintained operative for the same period of time.

The main portion of the received east to west speech waves will be passed by the filter 6' in the receiving path RA' therein and amplified by the receiving amplifier 7' therein. The amplified waves in the output of amplifier 7' will then be impressed by the hybrid coil H_2' upon the circuit TL' over which they will be transmitted to the listening subscriber.

Fig. 2 discloses an improved cable terminal circuit of the general type disclosed in Fig. 2 of the copending patent application of R. C. Mathes, Serial No. 370,034 mentioned above, which terminal circuit is applicable to cable systems in which the two-way cable between terminals is comparatively short or of such low attenuation that it is feasible to select the courier control currents in the presence of simultaneously outgoing speech energy.

The terminal station of Fig. 2 comprises connected between a two-way speech transmission circuit TL, which may be a telephone line, and a two-way cable TC of high attenuation and high transmission-time constant, such as a deep sea submarine telephone cable, a one-way transmitting amplifying path TA and a one-way receiving amplifying path RA. The output of the transmitting path TA and the input of the receiving path RA are connected to the east end of the cable TC by means of a three-winding transformer or hybrid coil H_1 which cooperates with the balancing network N_1 to insure substantially conjugacy between the paths TA and RA. For a similar purpose the input of the transmitting path TA and the output of the receiving path RA are connected to the circuit TL through the hybrid coil H_2 having an associated balancing network N_2 .

Connected between the hybrid coils H_2 and H_1 in the one-way transmitting path TA is a delay circuit 100 and a one-way transmitting amplifier 101, and connected between the hybrid coils H_1 and H_2 in the receiving path RA is a band-path filter 42 and a one-way receiving amplifier 43. Connected across the path TA between the hybrid coil H_2 and the input of delay circuit 100 is a control circuit 44 comprising a current-controlled, relay controlling device 45, and the windings of relays 46 to 48 connected in parallel to the output of the device 45. The relay 47 is slow operating as com-

pared to the relay 46. The operation of relay 48 is delayed with respect to the operation of relays 46 and 47 by means of the delay circuit 49 connected between the winding of relay 48 and the output of the device 45.

A source 50 of alternating current of frequencies f_2 outside the signal frequency range, which in the case being described is the speech frequency range, is adapted to be momentarily connected across the transmitting path TA at the points 51 between the output of relay circuit 100 and the input of the transmitting amplifier 101, by means of switches 52 and 53 respectively controlled by operation of relays 46 and 47.

Connected across the receiving path RA between the input of the filter 42 therein and the hybrid coil H_1 is another control circuit 54 comprising filters 55 and 56 in parallel branches thereof, a current-controlled, relay controlling device 57 in the output of the filters 55 and 56 and the windings of relays 58 to 62 connected in parallel to the output of the device 57.

Connected in the transmitting path TA between the point of connection of the control circuit 44 thereto and the hybrid coil H_2 is a normally closed switch 63 adapted to be opened by operation of relay 58. Connected in the transmitting path TA between the points 51 therein and the input of the transmitting amplifier 41 is a normally closed switch 64 adapted to be opened by operation of relay 59. Connected between the windings of relay 48 and the output of the delay circuit 49 in control circuit 44 is a normally closed switch 65 adapted to be opened by operation of relay 60.

Connected in receiving path RA between the output of the receiving amplifier 43 therein and the hybrid coil H_2 is a normally open switch 66 adapted to be closed by operation of relay 61. Connected in control circuit 54 between the output of filters 55 and 56 and the input of control device 57 is a normally closed switch 67 adapted to be opened by operation of relay 48. Connected between the output of filter 56 in the control circuit 54 and the switch 67 in that circuit is a normally open switch 68 adapted to be closed by operation of relay 62.

It is apparent that the cable terminal circuit of Fig. 2 is of the form known in the art as semi-biased.

The relay controlling devices 45 and 57 are similar to the current-controlled, relay controlling devices 9 and 23 of the system of Fig. 1.

The delay circuit 40 is similar to the delay circuit 1 in the system of Fig. 1, but differs therefrom in that it is designed to introduce only a very small delay in the transmission of currents therethrough.

The filters 42, 55 and 56 are band pass filters similar to the filters 2 and 3 of the system of Fig. 1. The filters 42 and 56 are designed to transmit frequencies within the speech frequency range, and to suppress the courier frequencies f_2 and f_1 respectively generated by the generator 50 at the east terminal station and the corresponding generator at the west terminal station (not shown). The filters at the west terminal station corresponding to the filters 42 and 56 at the east terminal stations have the same transmission range as the latter filters. The courier frequencies f_1 and f_2 may be any frequencies outside the speech frequency range and differing from each other. The filter 55 is a band pass filter designed to transmit the courier frequencies f_1 generated at the west terminal station and to suppress the courier frequencies f_2 generated at the east terminal station. The filter at the west terminal station corresponding to the filter 55 at the east station is designed to pass the courier frequencies f_2 , and to suppress the courier frequencies f_1 .

The operation of the system as a whole will now be described referring to Fig. 2 only. It will be assumed that speech waves for transmission from east to west are received first at the east terminal station over the circuit TL, and at that time no speech waves have been received at the west terminal station for transmission over the cable TC in the direction from west to east.

The east to west speech waves from source TL are impressed upon the transmitting circuit TA by the hybrid coil H_2 . The impressed currents in the transmitting path TA are divided between the input of delay circuit 100 and the input of the control circuit 44. The portion diverted into control circuit 44 will operate the control device 45 therein causing the windings of relays 46 to 48 to be energized.

The relay 46 will operate quickly to close the switch 52 so as to connect the source 50 of waves of frequencies f_2 across the transmitting circuit TA at the points 51. The comparatively slow operating relay 47 will operate a given instant later to open the switch 53 so as to disconnect the generator 50 from the transmitting circuit TA. The momentary connection of the generator 49 to the transmitting path TA will cause a short train of waves of frequencies f_2 , which we refer to hereinafter as the courier f_2 , to be transmitted over the transmitting circuit TA. The courier f_2 may be made as short as is desired or is necessary by the design of relays 46 and 47. Relays 46 and 47 are so designed that they will remain operated as long as speech waves from the circuit TL are being supplied to the input of control device 45 and so that they will release only after a complete pause in a conversation and not for the usual pauses between words or syllables.

The courier f_2 will be amplified by the transmitting amplifier 101 and the amplified courier impressed upon the cable TC by the hybrid coil H_1 over which they are transmitted to the west terminal station to establish initial control of the switching circuits thereat in a manner which will be described later.

The relay 48 will operate substantially T seconds after relays 46 and 47 have operated to open the normally closed switch 67 in the control circuit 54 connected to the receiving path RA, thus making that circuit inoperative at that time to transmit waves incoming over the cable TC to the control device 57.

The main portion of the east to west speech waves received from the circuit TL and impressed on the transmission path TA through hybrid coil H_2 will pass through the delay circuit 100 therein which will delay the speech waves in transmission for a short time t . The delay circuit 100 is so designed that the delay time t of the speech waves behind the courier f_2 is only long enough to insure completion of the initial operation of switching apparatus at the west terminal station by the preceding courier f_2 before the speech waves arrive at the switching points. The delay time t would be in the order of a few hundredths of a second.

The delayed speech waves in the output of delay circuit 100 are amplified by the amplifier 101 and transmitted to the hybrid coil H_1 . The amplified waves will be impressed by the hybrid coil H_1 on the cable TC and transmitted thereover to the west terminal station lagging behind the courier f_2 by a time interval of t seconds.

In the manner which has just been described complete control of the transmitting and receiving circuits at the east terminal station has been obtained for the east to west speech waves.

The manner in which complete control of the transmitting and receiving circuits at the west terminal is also obtained for the east to west speech waves will now be described by reference to the Fig. 2. 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 which designate the corresponding apparatus at the east terminal station but followed by a prime (') mark.

Courier f_2 on arrival at the west terminal station is impressed upon the receiving path RA' by the hybrid coil H_1' . As stated above the filter 42' in the receiving path RA and the filter 56' in the control circuit 54' are designed to suppress the courier f_2 . The courier f_2 will therefore be diverted into the control circuit 54' and passed by the filter 55' in the upper branch thereof, and then will be impressed upon the input of the control device 57'. The control device 57' will

then operate to energize the windings of relays 58' to 62'.

Relay 58' will operate to open the normally closed switch 63' in the input of the transmitting path TA', and relay 59' will operate to open the normally closed switch 64' in the same path in the input of the transmitting amplifier 101'. The transmitting path TA' at the west terminal will therefore be disabled so as to prevent the transmission of any later received west to east speech waves over the circuit TL' from being transmitted to the cable TC or to the input of the control device 45' to cause false operation of relays 46' to 48'.

Relay 60' operates to open the normally closed switch 65' in control circuit 44', thus preventing false operation of relay 48' by any speech energy which may be stored in the delay circuit 49' or in the control circuit 44' at the time the switch 63' in the input of the transmitting path TA' is opened by operation of relay 58'. Relay 61' will operate to close the normally open switch 66' in the output of the receiving path RA', thus making that path operative to transmit incoming east to west speech waves from the cable TC to the circuit TL'. Relay 62' will simultaneously operate to close the normally open switch 68' in the output of filter 56' in the lower branch of control circuit 54' thus making that branch operative to transmit incoming east to west speech waves through filter 56' to the input of control device 57'.

The transmitting and receiving circuits of both the west terminal station and the east terminal station are now under complete control of the east to west speech waves. The control of the west terminal transmitting and receiving circuits initiated by the courier f_2 will be maintained by the following speech waves in the following manner.

The speech waves transmitted from the east terminal station over the cable TC behind the courier f_2 on their arrival at the west terminal station will be impressed upon the receiving path RA' by the hybrid coil H_1 and will be divided between the input of filter 42' in the main speech transmission path and the input of the control circuit 54'.

The portion of the impressed speech waves diverted into the control circuit 54' will be passed by the filter 56' therein and impressed upon the input of control device 57' and serve to maintain that device operated as long as the east to west waves are being substantially continuously received from the cable TC. The relays 58' to 62' will therefore be maintained in the operated condition for an equivalent interval of time.

The main portion of the received east to west speech waves will be transmitted by the band pass filter 42' in the main receiving path RA' and amplified by the receiving amplifier 43' in the output thereof. The ampli-

fied east to west speech waves in the output of amplifier 43' will be impressed by the hybrid coil H_2 upon the receiving circuit TL' and transmitted thereover to the listening subscriber.

If the speech waves for transmission over the cable from west to east are received over the circuit TL' at the west terminal before speech waves for transmission from east to west are received over the circuit TL at the east terminal station, in a manner similar to that which has been described, the courier wave of frequencies f_1 which are outside the speech frequency range and different from the courier frequencies f_2 generated at the east terminal, will obtain exclusive control of the transmitting and receiving circuits at both the west and east terminals, which control will be maintained by the west to east speech waves when they arrive at the control points.

It is apparent from the above description of the operation of Fig. 2 that the relation of the delay times produced in the transmission of the speech waves and in the operation of the switching circuits by the delay circuits 100 and 49 respectively at the east terminal, and by the corresponding delay circuits at the west terminal station, to the overall transmission time of the cable TC between terminal stations is such that the terminal station which first sends out its courier obtains exclusive control of the transmitting and receiving circuits at both stations, and this control cannot be interrupted until a complete or partial cessation of speech wave transmission.

If the oppositely directed speech waves from the two talkers at the two ends of the system reach the two terminals almost simultaneously, but the east talker starts ahead of the west talker, the cable TC will be charged with outgoing transmission from the west talker at the time control device 57' at the west station operates. Speech incoming at the west station over the cable TC, therefore, will be masked by the reflections from outgoing speech during the time it takes the cable to dissipate the portion of the outgoing speech energy. This means that a small amount of the speech may be lost or distorted if the system of the invention illustrated in Fig. 2 is used. This loss or distortion will not be sufficiently great to be troublesome in practice unless a very high grade of quality is desired, especially as such losses will occur relatively infrequently.

In the system of Fig. 2 it may be necessary to receive the incoming couriers f_1 and f_2 at the terminals of the cable in the presence of simultaneous outgoing speech energy. The filters and other apparatus in the system should, therefore, be so designed that the courier may be separated from the speech energy, and so that the outgoing courier or

speech does not falsely operate the receiving control apparatus. This should not be difficult if the cable TC is not too long or of too high attenuation, or if the modulation products of the speech frequencies fall at the frequencies f_1 and f_2 .

If the two-way cable between terminals is so long or of such high attenuation that the couriers cannot be properly selected in the presence of simultaneous outgoing speech energy by selection apparatus or ordinary design, it may be desirable to utilize a system employing terminal circuits of the kind illustrated in Fig. 3, in which means are provided for avoiding the necessity of separating the couriers from the speech. As indicated in Fig. 3, the terminal circuits are such that the speech energy for either direction is not transmitted to the cable until initial control of the switching circuits at both terminals has been obtained by a preceding courier for one terminal or the other.

The cable terminal circuit of Fig. 3 is an improvement over the similar circuit disclosed in Fig. 2 in the copending Mathes application, Serial No. 370,035 referred to above.

As in the case of Figs. 1 and 2, the terminal circuit of Fig. 3 comprises a transmitting amplifying path TA and a receiving amplifying path RA connected between the two-way circuit TL and the two-way cable TC by hybrid coil transformers H_1 and H_2 equipped with associated balancing networks N_1 and N_2 .

The transmitting circuit TA comprises, connected between the hybrid coils H_2 and H_1 , a delay circuit 70 and a one-way transmitting amplifier 71, and the receiving circuit RA comprises, connected between the hybrid coils H_1 and H_2 , a band pass filter 72, a band pass filter 73, and a one-way receiving amplifier 74. Connected to the transmitting path TA between the input of the filter 70 and the hybrid coil H_2 is a control circuit 75 comprising a current-controlled, relay controlling device 76 and the windings of relays 77, 78 and 79 connected in parallel to the output of the device 76. The relay 78 is slow operating with respect to the relay 77. A delay circuit 80 is connected between the output of the device 76 and the windings of relay 79.

A generator 81 of alternating current waves of frequencies f_2 is adapted to be momentarily connected through a one-way amplifier 82 to the transmitting path TA at points 83 between the output of the transmitting amplifier 71 and the hybrid coil H_1 by the switches 84 and 85 respectively controlled by operation of the relays 77 and 78.

Connected to the receiving path RA between the filters 72 and 73 is a control circuit 86 comprising a current-controlled, relay controlling device 87 and the windings of relays 88 to 91.

Connected in the transmitting path TA

between the connection thereto of control circuit 75 and the hybrid coil H_2 is a normally closed switch 92 adapted to be opened by operation of relay 88. Connected in the transmitting path TA between the output of amplifier 71 and the points 83 is a normally closed switch 93 adapted to be opened by operation of relay 89. Connected in control circuit 75 between the output of delay circuit 80 and the windings of relay 79 is a normally closed switch 94 adapted to be opened by operation of relay 90. Connected in the input of the receiving path RA between the filter 72 and the hybrid coil H_1 is a normally closed switch 95 adapted to be opened by operation of relay 79. Connected in receiving path RA between the output of amplifier 74 and hybrid coil H_2 is a normally open switch 96 adapted to be closed by operation of relay 91.

The west terminal station (not shown) is identical with the east terminal station described above with the exception of the design of the generator corresponding to the generator 81 and the design of the filter corresponding to filter 72.

The relay controlling devices, the band filters and the other apparatus used at the two terminal stations are similar to the apparatus used for a similar purpose in the circuits of Figs. 1 and 2. The courier frequencies f_2 generated by the generator 81 at the east terminal station may be any frequencies outside the speech frequency range. The courier frequencies f_1 generated by the generator at the west terminal station corresponding to the generator 81 at the east terminal station may be any frequencies outside the speech frequency range and differing from the frequencies f_2 .

The filter 73 at the east terminal station and the corresponding filter at the west terminal station is designed to transmit frequencies within the speech frequency range and to suppress the courier frequencies f_1 and f_2 . The band filter 72 at the east terminal station is designed to pass frequencies within the speech frequency range and the courier frequencies f_1 received from the west terminal station, and to suppress the courier frequencies f_2 . The filter at the west terminal station corresponding to the filter 72 at the east terminal station is designed to pass frequencies within the speech frequency range and the courier frequency f_2 received from the east terminal station, and to suppress the courier frequencies f_1 generated at the west terminal station.

As the system operates in a similar manner when the speech transmission is set up first in the direction from east to west as when the speech transmission is set up first in the opposite direction, the operation of the system in the former case need only be described. It will be assumed that speech currents for transmission from east to west are first re-

ceived at the east terminal station over the circuit TL, and that not more than T seconds later, where T is the overall transmission time of the cable TC between the stations, speech currents are received at the west terminal station for transmission from west to east.

The east to west speech waves from the line TA are impressed on the transmitting circuit TL of the east terminal station by the hybrid coil H_2 and divided between the input of delay circuit 70 therein and the control circuit 75. The portion diverted into control circuit 75 will operate the control device 76 causing the windings of relays 77 and 78 to be energized first and substantially T seconds later (the delay circuit 80 being designed to introduce a delay of T seconds in the transmission of currents from the output of the device 76 to the windings of relay 79), the windings of relay 79 will be energized.

Relay 77 will quickly operate to close the switch 84 so as to connect the source 81 of frequencies f_2 across the transmitting circuit TA, and an instant later slow operating relay 78 will operate to open the normally closed switch 85 so as to disconnect the generator 81 from the transmitting path TA. The momentary connection of generator 81 through the amplifier 82 to the transmitting path TA will cause an amplified short train of control waves of the frequencies f_2 , which will be referred to hereafter as the courier f_2 , to be transmitted out over the transmitting path TA towards the cable TC. The courier f_2 may be made as short as is desired or is necessary by the design of relays 77 and 78. The relays 77 and 78 are so designed that they will remain operated as long as speech waves from the circuit TL are being supplied to the input of the control device 76, and so that they will release only after a complete pause in a conversation, and not for the usual pauses 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 relay 79 will operate substantially T seconds after the courier f_2 has been transmitted to the cable TC to open the normally closed switch 95 in the input of the receiving path RA, thereby making that path inoperative at that time to transmit waves from the cable TC to the circuit TL, or to the input of the control device 87 so as to cause false operation of the relays 88 to 91. Thus, at the time the courier f_2 arrives at the west terminal station, the east to west speech waves have obtained complete control of the transmitting and receiving circuits at the east terminal station.

Meanwhile the east to west speech waves in the main transmission path TA are de-

layed therein by the delay circuit 70 for a time interval of T seconds equal to the overall transmission time of the cable TC. The delayed speech waves are amplified by the transmitting amplifier 71 and impressed by the hybrid coil H_1 on the cable TC over which they are transmitted to the west terminal station following the preceding courier f_2 by a time interval of T seconds.

The manner in which complete control of the transmitting and receiving circuits at the west terminal is obtained by the east to west speech waves 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 used for designating the corresponding apparatus at the east terminal station, but followed by a prime (') mark.

The courier f_2 on its arrival at the west terminal station is impressed by the hybrid coil H_1' on the input of the receiving path RA' thereat. The impressed courier f_2 is selected by the filter 72'. As the filter 73' in the main receiving path RA' is designed to suppress the frequency f_2 , the courier f_2 passed by filter 72' will be diverted into the control path 86' in which it initially operates control device 87' causing the windings of relays 88' to 91' to be energized.

Relay 88' operates to open the normally closed switch 92' in the input of the transmitting path TA', thus making that path inoperative to transmit waves from the circuit TL' to the cable TC or to the input of the control device 76' in control circuit 75'. Relay 89' simultaneously operates to open the normally closed switch 93' in the output of the transmitting path TA', thus making that path inoperative to transmit any wave energy which may be stored therein at the time switch 93' opens from the output of amplifier 71' to the cable TC. Relay 90' operates to open the normally closed switch 94' in the control circuit 75', thus preventing false operation of the relay 79' by energy which may be stored in the delay circuit 80' in control circuit 75' at the time switch 92' in the input of the transmitting path TA' is opened. Relay 91' operates substantially at the same time as relays 88' to 90' to close the normally open switch 96' in the output of the receiving path RA', thus making that path operative to transmit waves from the cable TC to the circuit TL'.

The transmitting and receiving circuits at both the east and west terminal stations are now under the exclusive control of the east to west speech waves. The control of the west terminal transmitting and receiving circuits initiated by the courier f_2 will be maintained by the east and west speech waves when they

arrive at the west terminal station in the following manner.

The east to west speech waves which are transmitted over the cable TC lagging behind the courier f_2 by an interval of T seconds, on arrival at the west terminal station will be impressed by the hybrid coil H_1' on the receiving path RA' thereat. The impressed speech waves will be passed by the filter 72' therein and will be divided in the output thereof between the control circuit 86' and the input of the band pass filter 73'. The portion diverted into control circuit 86' will be impressed upon the input of control device 87' maintaining that device in the operated condition initiated by the preceding courier f_2 as long as speech waves are being substantially continuously received over the cable TC. The relays 88' to 91' therefore will be maintained in the energized condition, and therefore the transmitting path TA' will be maintained disabled and the receiving path TA' maintained operative for the same interval of time.

The main portion of the speech waves in the output of filter 72' will be passed by the band pass filter 73' in the receiving path RA'. The passed waves will be amplified by amplifier 74' and transmitted from the output thereof to the hybrid coil H_2' and impressed thereby on the circuit TL' over which they will be transmitted to the listening subscriber.

It is readily seen that because of the particular relation of the delays produced in the transmitted waves by the delay circuits 70, 80, 70' and 80' at the east and west terminals respectively to the overall transmission time of the cable TC, that whichever terminal first sends out its courier over the cable will gain exclusive control of both sets of terminal apparatus. Because 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, therefore, there will be no loss of speech because of interference therewith.

It is to be understood that the invention is not limited to the particular circuits and the details of the particular terminal 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.

Although in the particular embodiments of the invention which have just been described, mechanical relays have been shown for conditioning the transmission paths for 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, 1927, or in an 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. In combination, a transmission path, means in said path normally preventing transmission thereover of waves of certain frequencies, while allowing transmission thereover of other frequencies, means for transmitting over said path waves of said other frequencies, and means for conditioning said path to transmit waves of said certain frequencies, a predetermined time after the waves of said other frequencies have been transmitted thereover.

2. In combination, a transmission path, circuit-control means therein responsive to waves transmitted over said path, means normally preventing transmission over said path of waves of certain frequencies while allowing transmission thereover of waves of other frequencies, means for transmitting over said path waves of said other frequencies to actuate said circuit-control means, and means for rendering said path operative to transmit waves of said other frequencies as soon as said circuit-control means have been actuated.

3. In combination, a transmission path supplied from a source of waves of a range of frequencies, circuit-control means in said path responsive to waves transmitted thereover, means in said path normally preventing transmission thereover of waves of certain frequencies in said range, while allowing transmission thereover of other frequencies within said range, means for transmitting over said path waves of said other frequencies to actuate said control means, and means for conditioning said path to transmit waves of both said certain frequencies and said other frequencies as soon as said circuit-control means have been actuated.

4. In combination, a transmission path supplied from a source of waves of a range of frequencies, a circuit-control means in said path responsive to waves transmitted thereover, means in said path normally preventing transmission thereover of waves of certain frequencies in said range while allowing transmission of other waves in said range, means responsive to waves received by said path from said source for transmitting over said path waves of said other frequencies to actuate said circuit-control means, means also responsive to the waves received from said

source for conditioning said path to transmit supplied waves of both said certain and said other frequencies as soon as said circuit-control means have been actuated by the transmitted waves of said other frequencies.

5 5. A terminal station for a two-way signal transmission circuit, comprising a one-way transmitting path supplied from a source of signals of a range of frequencies, and a one-way receiving path, means normally preventing
10 said transmitting path from transmitting to said two-way circuit waves of certain frequencies within said range while allowing transmission thereto of waves of other frequencies within said range, circuit-control
15 means connected to said receiving path and responsive to waves received over said two-way circuit, means responsive to signals supplied from said source to said transmitting
20 path for causing control waves of said other frequencies to be transmitted thereover to said two-way circuit, and means also responsive to the signals supplied from said source to said transmitting path for rendering that
25 path operative at a predetermined time after said control waves have been transmitted thereover to transmit signal waves of said certain and said other frequencies to said two-way circuit and for substantially simultaneously disabling said circuit-control means for
30 operation by the waves received over said two-way circuit.

6. A terminal station for a two-way transmission circuit comprising a transmitting
35 path and a receiving path connected to said two-way circuit, means in said receiving path normally preventing transmission thereover of waves of certain frequencies while allowing transmission of waves of other frequencies, and means responsive to waves received over said two-way circuit for rendering
40 said receiving path operative to transmit waves of said certain and said other frequencies.

45 7. In combination, a two-way signal transmission medium of limited useful transmission frequency range and terminal circuits therefor each comprising a transmitting circuit, a receiving circuit, a control path connected to said transmission medium and
50 responsive to waves received thereover to alter the transmission characteristics of said transmitting and said receiving circuit, means responsive to the initiation of signals in said transmitting circuit to be transmitted
55 over said medium to the other terminal thereof, for transmitting over said medium to said other terminal, a short train of control waves of frequencies differing for each terminal and
60 within said limited frequency range, means in said transmitting path normally preventing transmission to said medium of waves of frequencies within the frequency range of the control waves transmitted from the other
65 terminal, and means also responsive to the

signals to be transmitted over said medium for conditioning said transmitting path to transmit waves of substantially all frequencies within said limited frequency range, and for substantially simultaneously disabling said control path.

8. The combination of claim 7 and in which the last-mentioned means operates to condition said transmitting circuit to transmit substantially all frequencies within said limited range and to disable said control path at a time after the control waves have been transmitted to said medium substantially equal to the overall transmission time of the medium between terminals.

9. In combination, a two-way transmission medium of limited useful transmission frequency range and terminal circuits therefor each comprising a normally operative transmitting path, a normally disabled receiving path, a control circuit connected to said medium means responsive to the initiation of signals in said transmitting path to be transmitted over said medium to the other terminal thereof for transmitting over said medium and in advance of said signals a short train of control waves of frequencies within said frequency range and differing for each terminal, means also responsive to said signals to be transmitted, and independent of said control waves, for altering the transmission characteristics of said transmitting path and said control circuit, means in said receiving circuit normally preventing the transmission thereover of waves of frequencies corresponding to those of the control waves transmitted from the other terminal, and means in said control path and responsive to waves received over said medium for effectively disabling said transmitting path and the means responsive to signals in said transmitting path for transmitting control waves and for altering the transmission characteristics of said transmitting path and of said control circuit, and for thereafter rendering said receiving path operative to transmit substantially all waves of frequencies within the limited frequency range of said medium.

10. The system of claim 9 and in which said means responsive to signals in said transmitting path for altering the transmission characteristics of said transmitting path and said control circuit operates at a time after the transmission of said train of control waves to said medium substantially equal to the overall transmission of said medium between terminals.

11. The system of claim 9 and in which said means responsive to signals in said transmitting path for altering the transmission characteristics of said transmitting path and said control circuit operates at a time after the transmission of said train of control waves to said medium substantially equal to the overall transmission of said medium between

terminals and in which said means for rendering said receiving path operative to transmit substantially all waves of frequencies within the limited frequency range of said medium operate at a time after said waves are first received said medium slightly more than the interval of time by which the signals transmitted to said medium lag behind said control waves.

12. In combination, a two-way transmission medium of limited useful transmission frequency range, and a terminal circuit at each terminal of said medium, said terminal circuit comprising a transmitting circuit, a receiving circuit and a control circuit connected to said medium, means responsive to signals to be transmitted over said medium for sending out over said transmitting circuit to said medium and in advance of the signals, a control wave of frequencies different for each terminal circuit and within said limited frequency range, means in said receiving circuit normally preventing transmission thereover of waves of frequencies within the frequency range of the control waves transmitted from the other terminal, and means connected to said control circuit and responsive to waves received thereby from said medium for disabling said transmitting circuit for transmitting waves to said medium, and thereafter conditioning said receiving circuit to transmit waves of all frequencies within said limited frequency range of said medium.

13. In combination, a two-way transmission medium of limited frequency range having an overall transmission time of T seconds, and a terminal circuit at each end of said medium comprising a transmitting circuit a receiving circuit and a control path connected to said medium, means responsive to the initiation of signals in said transmitting circuit to be transmitted over said medium for sending over said transmitting circuit to said medium and in advance of said signals, a control wave of frequencies different for each terminal and within said limited frequency range, means in said transmitting circuit and in said receiving circuit normally preventing transmission thereover of waves of frequencies within the frequency range of the control waves transmitted from the other terminal, and means also responsive to the signals to be transmitted for conditioning said transmitting circuit substantially T seconds after the initiation of said signals therein to transmit to said medium waves of substantially all frequencies within the limited frequency range thereof, and for substantially simultaneously disabling said control path, and means in said control path responsive to waves received over said medium for effectively disabling said transmitting circuit and the control wave transmitting means and substantially at the

same time rendering said receiving circuit operative to transmit waves of substantially all frequencies in said range.

14. A terminal circuit for a two-way signal transmission line having an overall transmission time of T seconds, comprising a normally operative transmitting circuit, a normally disabled receiving circuit, a control path connected to said line, means responsive to the initiation of signals in said transmitting circuit for sending out thereover to said line and in advance of said signals by a time interval of t seconds, where t is small in comparison with T , a control wave of a frequency outside the frequency range of the signals to be transmitted over said line, means in said control path and responsive to waves received therein over said line for disabling said transmitting circuit and substantially simultaneously rendering said receiving circuit operative and means responsive to said signals in said transmitting circuit and independent of said control wave for disabling said control path substantially T seconds after said control wave has been sent out, and for maintaining said control path disabled during the duration of substantially continuous transmission of said signals in said transmitting circuit.

15. A terminal circuit for a two-way signal transmission line having an overall transmission time of T seconds, comprising a normally operative transmitting circuit, a normally disabled receiving circuit, a control path connected to said line, means responsive to initiation of signals in said transmitting circuit for sending out to said line a control wave of a frequency outside the frequency range of said signals, means for delaying transmission over said transmitting circuit to said line of said signals behind said control wave for substantially T seconds, means also responsive to the signals in said transmitting circuit and independent of said control wave for disabling substantially T seconds after said control wave has been transmitted to said line, said control path and said receiving circuit for receiving waves from said line, and means in said control path and responsive to waves received thereby from said line for disabling said control path, disabling means and said transmitting circuit, and for substantially simultaneously rendering operative said receiving circuit.

In witness whereof, I hereunto subscribe my name this 31 day of January, 1930.

BJORN G. BJORNSON.