May 22, 1934. B. G. BJÖRNSON 1,959,405

TRANSMISSION CONTROL

Filed Jan. 9, 1930 2 Sheets-Sheet 1

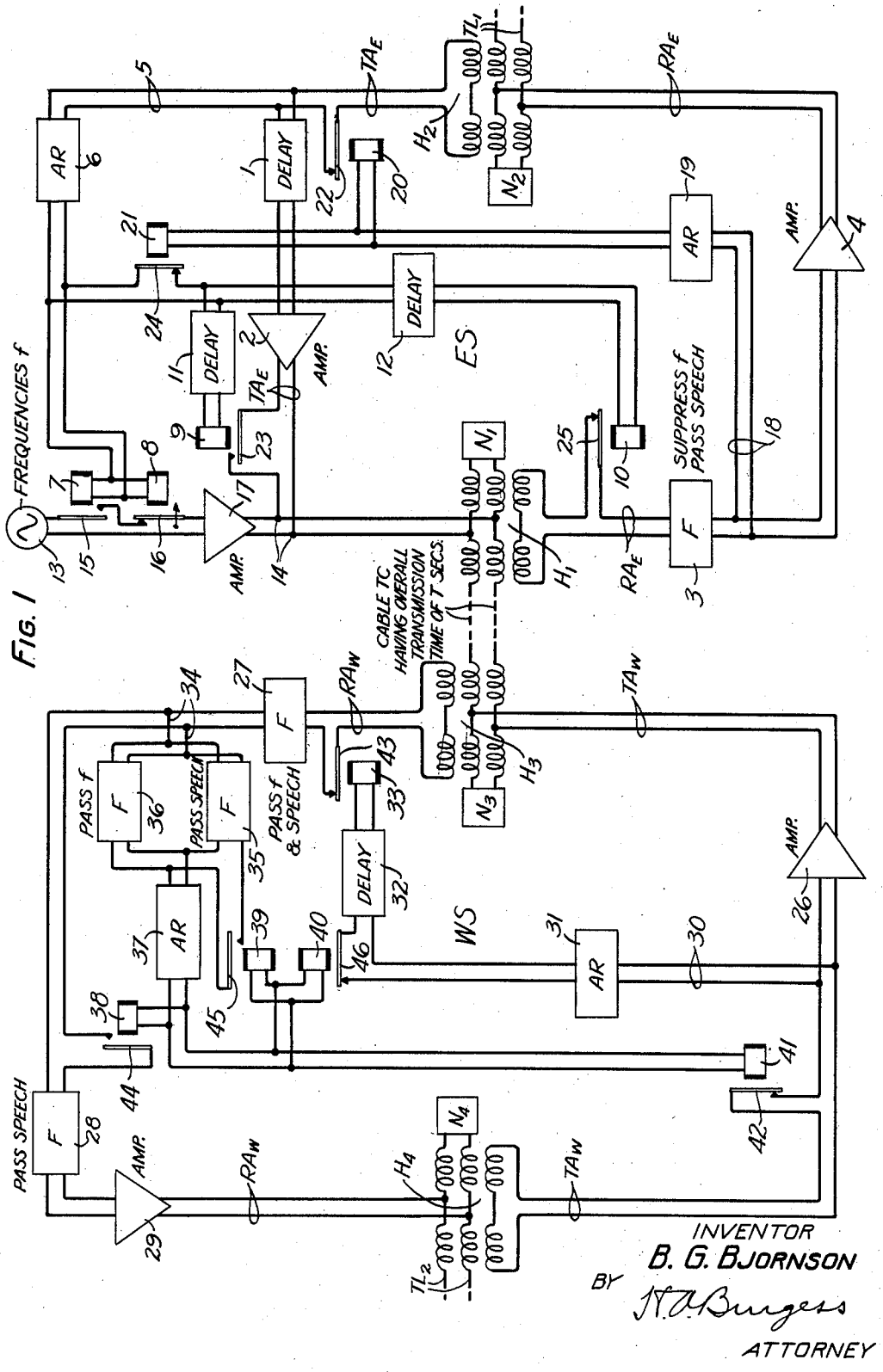

FIG. 1

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TRANSMISSION CONTROL

Filed Jan. 9, 1930 2 Sheets-Sheet 2

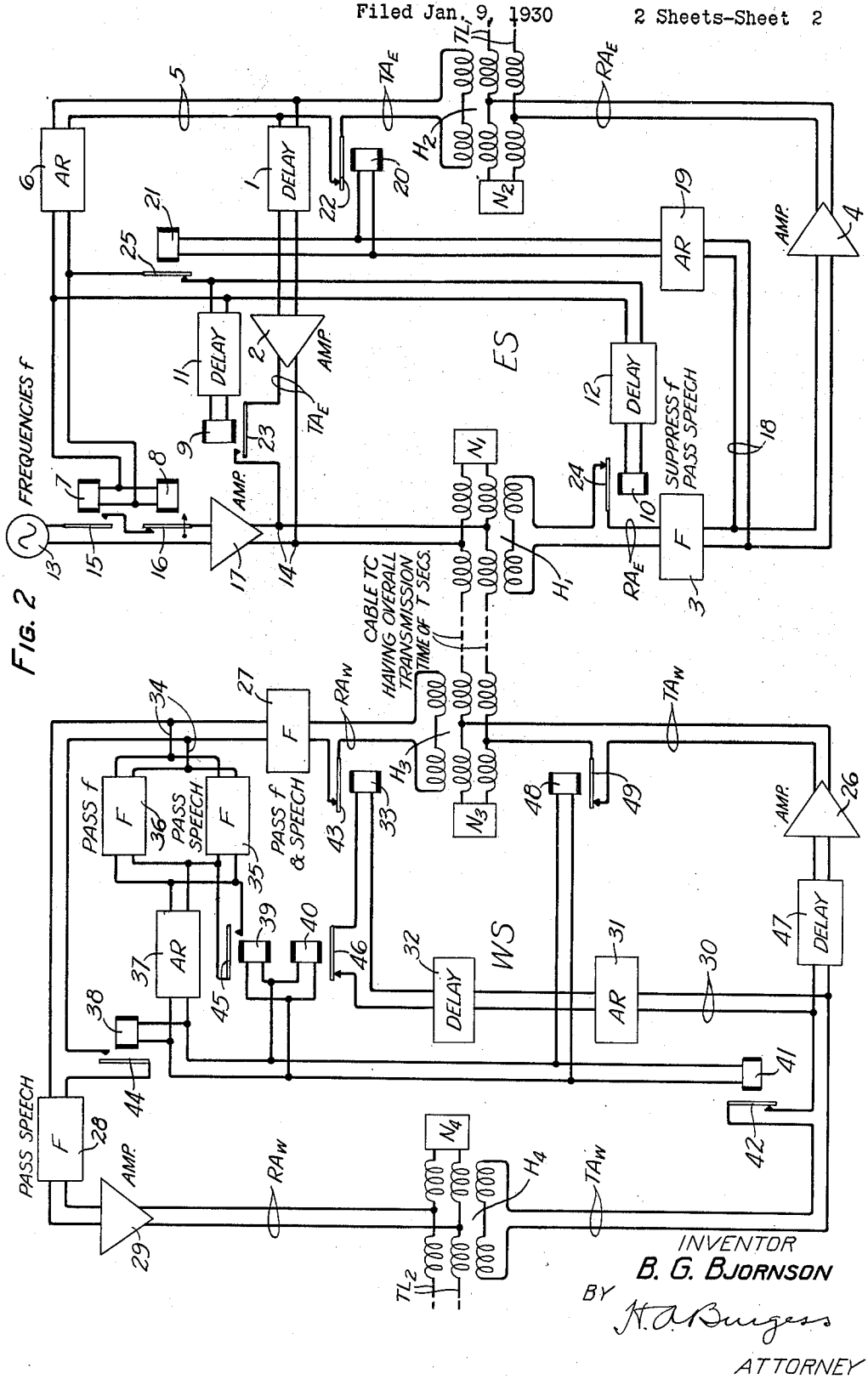

FIG. 2

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1,959,405

TRANSMISSION CONTROL

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Application January 9, 1930, Serial No. 419,668

11 Claims. (Cl. 179—170)

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

The invention broadly relates to a signaling system of the type employing auxiliary control waves for controlling signal transmission therein.

An object of the invention is to improve the operation of a signal transmission system including therein circuit control means adapted to be 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 within the same frequency range, 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, variously designated in the prior art as singing suppressors, reaction suppressors or anti-singing devices, are usually associated with the transmitting and receiving circuits 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 suppress singing, echoes, or both. 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.

The invention is specifically directed to the preventing of transmission lockouts in such a system, that is, loss of part of the transmitted signals due to improper operation of the switching circuits. Such transmission lockouts may occur in such a system as described above because of the relatively long time (as compared to radio circuits, for example) required to transmit signals over a cable of the type described. This long transmission time increases the chance that two subscribers at the ends of the system may both start talking within an interval equal to the overall transmission time of the cable resulting in each subscriber seizing control of the switching apparatus at his own terminal for transmitting, and locking out the transmission from the other subscriber.

Circuits have heretofore been designed to avoid the above mentioned difficulty by giving complete control of the switching circuits at both ends of the system to that subscriber who first starts talking. The copending applications of R. C. Mathes, Serial Nos. 370,034 and 370,035, both filed on June 11, 1929, now respectively Patents Nos. 1,829,805 and 1,829,806, issued November 3, 1931, disclose various circuits of that kind which employ the so-called "courier" method of transmission control. In accordance with the courier method, the speech energy generated at each cable terminal, or incoming from a land line connected thereto, is made to control the sending out over the transmission circuits, and in advance of the speech waves, of a courier comprising a short train of control waves of frequencies which are different for each terminal to initially seize control of the circuit-control switching apparatus at both terminals and at intermediate repeater points, which control is 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 courier circuits disclosed in the above mentioned applications. The improvements mainly consist in the modification of the circuits of the system to provide satisfactory operation of the system by transmitting a courier in one direction only. The circuits are normally in condition to transmit in one direction over the system and are controlled for transmission in the opposite diection by a single courier sent out ahead of the speech waves from one terminal station.

The exact nature of the invention and its advantages will be clear from the following detailed description thereof when read in connection with the accompanying drawings in which;

Figs. 1 and 2 show circuit diagrams of submarine telephone cable systems embodying different modifications of the invention.

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.

Fig. 1 shows an east terminal station ES connected to a west terminal station WS by a two-way cable TC of high attenuation and high transmission-time constant, such as a long submarine telephone cable. The overall transmission time of the cable TC will be assumed to be equal to T seconds.

The east terminal station ES of Fig. 1 com-

prises, connected between a two-way, speech wave transmission circuit TL_1, such as a toll telephone line, and the two-way cable TC, a one-way transmitting amplifying path TA_E and a one-way receiving amplifying path RA_E. The output of the transmitting path TA_E and the input of the receiving path RA_E 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 cable TC and the balancing network N_1 to insure substantial conjugacy between the paths TA_E and RA_E. For a similar purpose the input of the transmitting path TA_E and the output of the receiving path RA_E are connected to the circuit TL_1 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 path TA_E is a delay circuit 1 and a one-way transmitting amplifier 2, and connected between the hybrid coils H_1 and H_2 in the receiving path RA_E is a filter 3 and a one-way receiving amplifier 4. Connected across the path TA_E between the hybrid coil H_2 and the input of the delay circuit 1 is a control circuit 5 comprising a current-controlled, relay-controlling device 6, and the windings of relays 7 to 10 connected in parallel across the output of the control device 6. The delay circuits 11 and 12 are connected between the output of device 6 in control circuit 5 and the windings of relays 9 and 10, respectively. The relay 7 is a fast-operating relay while the relay 8 is a comparatively slow-operating relay. A source 13 of alternating current of frequencies f which are outside the frequency range of the signals, in this case that of the speech signals, is adapted to be momentarily connected across the transmitting path TA_E at the points 14 in the output of the amplifier 2 therein by means of switches 15 and 16 controlled by the operation of relays 7 and 8, respectively. A one-way amplifier 17 is connected between the source 13 and the points 14 in the transmitting path TA_E.

Connected to the receiving amplifying path RA_E between the output of filter 3 and the input of transmission amplifier 4 therein is a control circuit 18 comprising the current-controlled relay-controlling device 19 and the windings of relays 20 and 21 conected in parallel to the output of the device 19.

Connected in the input of the transmitting path TA_E between the point of connection of control circuit 5 thereto and the hybrid coil H_2 is a normally closed switch 22 adapted to be opened by operation of relay 20. Connected in the transmitting path TA_E between the points 14 therein and the output of the transmitting amplifier 2 is a normally open switch 23 adapted to be closed by operation of relay 9. Connected between the output of control device 6 in control circuit 5 and the inputs of delay circuits 11 and 12 is a normally closed switch 24 adapted to be opened by operation of relay 21. Connected in the input of receiving path RA_E between the filter 3 therein and the hybrid coil H_1 is a normally closed switch 25 adapted to be opened by operation of relay 10.

The west terminal station comprises, connected between the two-way, speech wave transmission circuit TL_2, such as a toll telephone line, and the cable TC, a one-way transmitting amplifying path TA_W and a one-way receiving amplifying path RA_W. The output of the transmitting path TA_W and the input of the receiving path RA_W are connected to the west end of the cable TC by means of a three-winding transformer or hybrid coil H_3, which cooperates with the cable TC and the balancing network N_3 to insure substantial conjugacy between the paths TA_W and RA_W. For a similar purpose the input of the transmitting path TA_W and the output of the receiving path RA_W are connected to the circuit TL_2 through the hybrid coil H_4 having an associated balancing network N_4.

Connected between the hybrid coils H_4 and H_3 in the one-way path TA_W is a transmitting amplifier 26, and connected between the hybrid coils H_3 and H_4 in the receiving path RA_W are a band pass filter 27, a band pass filter 28 and a one-way receiving amplifier 29.

Connected to the input of the transmitting path TA_W between the hybrid coil H_4 and the input of the amplifier 26 is a control circuit 30 comprising a current-controlled, relay controlling device 31, a delay circuit 32 and the windings of a relay 33 connected to the output of delay circuit 32. Connected to the receiving path RA_W between the filter 27 and the filter 28 therein is a control circuit 34 comprising a filter 35 and a filter 36 connected in parallel branches thereof, a current controlled relay controlling device 37, and the windings of relays 38 to 41 connected in parallel to the output of the device 37.

In the input of transmitting path TA_W between the point of connection of control circuit 30 thereto and hybrid coil H_4 is a normally closed switch 42 adapted to be opened by operation of relay 41. In the input of the receiving path RA_W between the input of filter 27 and the hybrid coil H_3 is a normally closed switch 43 adapted to be opened by operation of relay 33. Also, in the receiving path RA_W between the point of connection of control circuit 34 thereto and the input of filter 28 is a normally open switch 44 adapted to be closed by operation of relay 38. In the output of the branch of control circuit 34 containing filter 35 between the output of that filter and the input of control device 37 is a normally open switch 45 adapted to be closed by operation of relay 39. In control circuit 30 between the output of control device 31 and the input of delay circuit 32 is a normally closed switch 46 adapted to be opened by operation of relay 40.

It can be readily seen from the above description that the cable system which has just been described is of the form which is known in the art as semi-biased, that is, the circuits thereof are normally operative to transmit in one direction (in this case from west to east), and transmission in the opposite direction (in this case from east to west) is dependent upon switching operations.

The current controlled, relay controlling devices 6, 19, 31 and 37 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 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 of the required amount in the transmission therethrough of alternating currents impressed upon its input; for example, it may be a low pass electrical filter such as disclosed in the United States patents to Campbell Nos. 1,227,113 and 1,227,114, issued May 22, 1917, an acoustic filter or a network for a similar purpose, such as disclosed in Arnold Patent 1,565,302, issued December 15, 1925. In the system being described the delay circuit 1 is designed so that it will produce a delay in the speech currents

transmitted therethrough substantially equal to the overall transmission time of the cable TC, which in the present case was assumed to be T seconds.

The delay circuits 11 and 12 at the east terminal station and 32 at the west terminal station may be networks of any type suitable for introducing a delay of the required amount in the transmission of rectified alternating currents impressed upon their inputs from the outputs of the preceding current-controlled, relay controlling devices; for example, low pass electrical filters such as disclosed in the United States patents to Campbell, mentioned above. Each of the delay circuits 11, 12 and 32 is also designed to introduce a delay of substantially T seconds in the transmission of currents therethrough.

Filter 3 at the east terminal station and filters 27, 28 35 and 36 at the west terminal station may be of the band pass type disclosed in the United States patents to Campbell, mentioned above. The filter 3 at the east terminal station is designed to pass frequencies within the speech frequency range, and to suppress frequencies *f* corresponding to the courier frequencies generated by the generator 13. The filter 27 at the west terminal station is designed to pass frequencies within the speech frequency range and the courier frequencies *f* received from the east terminal station. The filters 28 and 35 at the west terminal station are designed to transmit frequencies within the speech frequency range and to suppress the frequencies *f*. The filter 36 is designed to transmit the courier frequencies *f*, and to suppress frequencies within the speech frequency range. The courier frequencies *f*, generated by the generator 12 at the east terminal station, may be any frequencies outside the speech frequency range.

The one-way amplifiers 2, 4 and 17 at the east terminal station and 26 and 29 at the west terminal station, the relays 7 to 10, 20 and 21 at the east terminal station and 33, 38 to 41 at the west terminal station, and the generator 13 at the east terminal station may be of any of the types well known in the art.

The operation of the system of Fig. 1 will now be described. To aid in the explanation, it will be assumed that speech waves to be transmitted over the cable TC from west to east are being received at the west cable terminal station over the circuit TL_2 and at that time no speech waves for transmission from east to west are being received at the east terminal station over the circuit TL_1.

The speech waves from circuit TL_2 are impressed by the hybrid coil H_4 upon the transmitting circuit TAw of the west terminal station, and will be divided between the input of the transmitting amplifier 26 therein and the control circuit 30. The portion diverted into the control circuit 30 will operate control device 31. After a delay of T seconds, produced by the delay circuit 32 in the output of device 31, the winding of relay 33 will be energized by operation of device 31. Relay 33 will operate to open the normally closed switch 43 in the input of the receiving amplifying path RAw making that path inoperative to receive east to west waves from the cable TC substantially T seconds after the main west to east speech waves are transmitted out over the cable TC.

The main portion of the west to east speech waves are amplified by the amplifier 26 in the transmitting path TA. The amplified waves are impressed by the hybrid coil H_3 upon the cable TC and transmitted thereover to the east terminal station. At the east terminal station the received speech waves are impressed by the hybrid coil H_1 upon the receiving path RA_E and passed by the band pass filter 3 therein. In the output of filter 3 the speech waves will be divided between the input of amplifier 4 and the control circuit 18.

The main portion of the speech waves passed by the filter 3 will be transmitted over the receiving path RA_E to the input of the receiving amplifier 4, and amplified thereby. The amplified waves will be impressed by hybrid coil H_2 on the circuit TL_1 and transmitted thereover to the listening subscriber.

A small portion of the west to east speech waves passed by the filter 3 will be diverted into the control circuit 18 and will operate control device 19 therein, causing relays 20 and 21 in the output thereof to be energized. Relay 20 will operate to open the normally closed switch 22 in the input of transmitting path TA_E making that path inoperative to transmit any later received, east to west speech waves from the circuit TL_1 to the input of delay circuit 1, or to the input of control device 6 in control circuit 5. Thus any east to west speech waves received over the circuit TL_1 after the operation of relay 20 by the west to east speech waves cannot be transmitted to the cable TC or cause a courier *f* to be transmitted thereover.

Relay 21 will operate substantially simultaneously with relay 20 to open the normally closed switch 24 in the path 5 between the output of control device 6 and the input of delay circuits 10 and 11, thus preventing false operation of the relays 9 and 10 by any energy which may be stored in the control path 5 at the time switch 22 is opened by the relay 20.

The switching circuits at both the east and west terminal stations are now under the exclusive control of the west to east speech waves, and, the switch 43 at the west terminal station and switches 22 and 24 at the east terminal station being open, will remain in that condition as long as the west to east speech waves are being substantially continuously impressed on the input of the control device 31 at the west terminal station, and on the input of the control device 19 at the east terminal station.

At the complete cessation of the west to east speech transmission or after a pause therein corresponding to the pause which would ordinarily occur at the end of a sentence, control device 19 will return to its unoperated condition and relays 20 and 21 will release. Switches 22 and 24 will therefore return to their normally closed condition, thus making the transmission circuit TA_E again operative to transmit waves from circuit TL_1 to the input of delay circuit 1 and to the input of control device 6, and the path 5 operative to transmit energizing current to the windings of relays 9 and 10 in response to operation of the device 6.

Now, let it be assumed that speech waves to be transmitted over cable TC are received at the east terminal station over circuit TL_1, and at that time no speech waves for transmission in the direction from west to east are being received at the west terminal station over circuit TL_2.

The received waves are impressed by hybrid coil H_2 upon the transmitting path TA_E. A portion of these waves will be diverted into the control circuit 5 and will operate control device

6 therein, causing the windings of relays 7 and 8 in the output thereof to be energized. Fast-operating relay 7 will operate immediately to close the switch 15, so as to connect the source 13 of courier *f* through amplifier 17 across the output of the transmitting path TA_E at the points 14. Slow-operating relay 8 will operate a given instant later to open the normally closed switch 16 so as to disconnect the generator 13 from the transmitting circuit TA. This will result in a short train of waves, or impulse of current, of the frequencies *f*, which we will refer to hereafter as the courier *f*, after amplification by the amplifier 17 being transmitted over the transmitting path TA_E to the hybrid coil H_1. The transmitted impulse may be made as short as is desired or as is necessary by the design of, or the adjustment of the operating characteristics of relays 7 and 8. The relays 7 and 8 are so designed that they will remain operated as long as speech waves from the source TL_1 are being supplied to the input of control device 6. They are also designed so that they will release only after a complete pause in the conversation, such as at the end of a sentence and not for the usual pause between words or syllables. The courier *f* will be impressed upon the cable TC by the hybrid coil H_1 and transmitted thereover to the west terminal station.

Meanwhile, the main portion of the east to west speech waves received from the circuit TL_1 will be transmitted over the main transmission path TA_E in which they will be delayed substantially T seconds due to the action of delay circuit 1 in their path, T, as indicated above, being the overall transmission time of the cable TC.

Substantially T seconds after relays 7 and 8 have operated to transmit the courier *f* to the cable TC, relays 9 and 10 will operate to respectively close the normally open switch 23 in the output of amplifier 2 in transmitting path TA_E and to open the normally closed switch 25 in the input of the receiving path RA_E. The delayed action of relays 9 and 10 with respect to the action of relays 7 and 8 is due to the delay introduced in the transmission of current from the output of control device 6 to the windings of relays 9 and 10 caused by the delay circuits 11 and 12 in their paths. Although separate delay circuits 11 and 12 have been shown for introducing a delay of T seconds in the energization of relays 9 and 10, respectively, it is apparent that this delay may be introduced by a single delay circuit instead of the two delay circuits, or that it may be obtained without the use of electrical delay circuits by a suitable design of relays 9 and 10 to make them slow acting. It may be desirable to have the delay introduced by delay circuit 12 slightly less than that introduced by delay circuit 11, or to design relay 10 so that it will operate slightly before relay 9, thus disabling the receiving path RA_E slightly before the transmitting path TA_E is made operative.

The delayed speech waves in the output of delay circuit 1 in the main transmission path TA_E are amplified by amplifier 2 therein, and, the switch 23 now being in the closed condition, will be transmitted directly to the hybrid coil H_1 and impressed thereby on the cable TC. The impressed speech waves will be transmitted over the cable TC with a lag of substantially T seconds behind the preceding courier *f*.

As the delay in the operation of relays 9 and 10 is substantially equal to the overall transmission time of the cable TC between the east and west terminal stations, it is apparent that the receiving amplifying path RA of the east terminal station is disabled and the transmitting amplifying path TA_E thereat made operative about the same time that the carrier *f* arrives at the west terminal station over the cable TC.

The courier *f* on arrival at the west terminal station will be impressed by the hybrid coil H_3 upon the receiving amplifying path RA_W thereat and will be transmitted by the filter 27 therein. The courier *f* in the output of filter 27 will be diverted into the control circuit 34 and passed by the filter 36 therein. The passed courier will initially operate control device 37 causing the windings of relays 38 to 41 in the output thereof to be energized.

Relay 38 will operate to close the normally opened switch 44 in receiving path RA_W, making that path operative to transmit the following east to west speech waves to the circuit TL_2. Relay 39 will operate substantially simultaneously with relay 38 to close the normally opened switch 45 in the output of the filter 35, thus providing a path from the output of filter 35 to control device 37 for the east to west speech waves.

Relay 41 will operate to open the normally closed switch 42 in the input of the transmitting path TA_W, thus making that path inoperative to transmit waves from the circuit TL_2 to the input of the transmitting amplifier 26 or to the input of control device 31. Relay 40 will operate to open the normally closed switch 46 in control circuit 30, thus preventing false operation of relay 33 by any energy which may be stored in control circuit 30 or in the transmitting path TA_W at the time relay 41 operates.

The switching circuits at both the east terminal station ES and the west terminal station WS are now under complete control of the east to west speech waves due to the action of the courier *f* which has just been described. This control will be maintained by the east to west speech waves following the courier *f* in transmission over the cable TC by T seconds in the following manner.

The east to west speech waves on their arrival at the west terminal station over cable TC will be impressed by the hybrid coil H_3 upon the receiving path RA_W. The main portion of the impressed waves will be transmitted through the filters 27 and 28, and after amplification by the amplifier 29 will be impressed on the circuit TL_2 over which they will be transmitted to the west subscriber. A portion of the speech waves in the output of filter 27 will be diverted into control circuit 34 and will be passed by the filter 35 in the lower branch thereof. The switch 45 in the output of the filter 35 having been previously closed by the action of the preceding courier *f*, these speech waves will be impressed on the input of control device 37. The impressed speech waves will maintain the control device 37 in the operated condition as long as speech waves are being substantially continuously received at the west terminal station over the cable TC. Relays 38 to 41, therefore, controlled by device 37 will maintain the transmitting and receiving circuits of the west terminal station under the exclusive control of the east to west speech waves for the same period. At the complete cessation of the transmission of speech waves from east to west or at a complete pause in the conversation corresponding to the pause which occurs at the end of the sentence, the control device 37 will return to its unoperated condition, causing the relays 38 to 41 to release. The circuits will then return to their normal condition, that is, they will again be

biased for speech transmission from west to east.

It will be apparent that the delay in the transmission of speech waves produced by the delay circuit 1 at the east terminal station and the equivalent delay in the operation of the switching apparatus at the east and west terminal stations produced by the delay circuits 11 and 12 at the east terminal and 32 at the west terminal insures that the control of the talking circuits at both terminal stations will always be given to the terminal station at which the speech waves are first received for transmission over the cable. The speech that arrives first over the land line at either terminal will control the system.

It will be noted that in the system of Fig. 1 which has just been described, that the time of transmission from east to west is T seconds longer than from west to east. Also it may be noted that the courier *f* must be received at the west terminal station through any west to east speech energy which may be outgoing over the cable TC at that time. This requires that the receiving apparatus at the west terminal station be properly designed to select the courier in the presence of simultaneously outgoing speech waves. If the cable TC is not too long or does not have too high attenuation, this design should not be difficult.

In Fig. 2 is shown a modification of the system of Fig. 1 which is applicable to systems employing between terminal stations a very long cable or one of very high attenuation. In the system of Fig. 2 the necessity of selecting the courier in the presence of simultaneously outgoing speech is avoided by a circuit arrangement which will insure that when the subscriber associated with the east terminal station starts talking before the subscriber associated with the west terminal station, the latter's speech waves are not transmitted to the cable.

Except for the following changes the system of Fig. 2 is identical with that of Fig. 1. In the system of Fig. 2, the delay circuits 1, 11 and 12 at the east terminal station ES are designed to introduce a delay in the waves transmitted therethrough for a time interval substantially equal to twice the overall transmission time of the cable TC between stations, that is, 2T seconds, while in the system of Fig. 1 the corresponding delay circuits introduced a delay of only T seconds in the waves transmitted therethrough. In the system of Fig. 2, an additional delay circuit 47 is inserted in the transmitting amplifying path TA_W at the west terminal station and an additional relay 48 controlled by operation of control device 37 is utilized to open a normally closed switch 49 in the transmitting path TA_W between the output of the amplifier 26 therein and the hybrid coil H_3.

Due to the action of delay circuit 1, the courier *f* is transmitted out over the cable TC substantially 2T seconds ahead of the east to west speech waves. Due to the action of delay circuit 11 the transmitting amplifying path is not made operative by the east to west speech wave until substantially 2T seconds after the courier *f* has been transmitted to the cable TC. Similarly, due to the action of delay circuit 12, the receiving amplifying path RA_E is not disabled by the east to west speech waves until substantially 2T seconds after the courier *f* has been transmitted to the cable TC. Due to the action of delay circuit 47 at the west terminal station, the west to each speech waves are delayed in transmission to the cable TC for a time interval of substantially T seconds after they are received at the west terminal station over the circuit TL_2. The transmitting path TA_W at the west terminal station is disabled by the opening of switch 49, which is caused by the operation of the control device 37 to energize the relay 48 under the control of the incoming courier *f*. The transmitting path TA_W is therefore substantially simultaneously disabled in its input and output by courier *f*, and is maintained so disabled by the east to west speech waves when they arrive at the west terminal station. Therefore no speech wave in the direction from west to east can be impressed on the cable TC until the cable is clear of the courier *f* and the east to west speech waves.

If the east to west speech waves are received over the circuit TL_1 at the east terminal station before west to east speech waves are received over the circuit TL_2 at the west terminal station, the courier *f* will arrive at the west terminal station and seize control of the transmitting and receiving circuits thereat before the later west to east speech waves can be sent out over the cable. If, however, west to east speech waves are received over the circuit TL_2 at the west terminal station before east to west speech waves are received over the circuit TL_1 at the east terminal station, the west to east speech waves will arrive at the east terminal station and seize control of the transmitting and receiving circuits thereat before the later east to west speech waves have been transmitted through the delay circuit 1, or have been effective to seize control of the transmitting and receiving circuits at the east terminal station. As in the system of Fig. 1, the time of transmission over the system of Fig. 2 from east to west will be T seconds longer than the time of transmission over the system from west to east, but the total transmission of time of the speech waves from the circuit TL_1 to the circuit TL_2 or from TL_2 to TL_1, will in each case be T seconds longer in the system of Fig. 2 than in the system of Fig. 1.

Although in the particular embodiments of the invention illustrated and described, current-controlled mechanical relays are employed for producing open circuits in transmission paths to disable them, or for closing normally open circuits therein to make the paths operative, it is to be understood that the invention is not limited to conditioning means of this type. For example, within the scope of the invention the transmission paths may be conditioned by utilizing current-controlled relays to disable the transmission paths by producing short circuits across the paths or by inserting losses in the path, and to make the paths operative by removing short circuits or loss network therein, or by any other suitable means. Instead of utilizing mechanical switching relays and movable contacts for performing the switching operations, stationary means may be used, such as vacuum tube relays, as disclosed, for example in an article by C. A. Beers and G. T. Evans in the Journal of the Institute of Electrical Engineers (London), vol. 20, pages 65–72, inclusive, published in April, 1927, or in the United States patent to Crisson No. 1,647,212, issued November 1, 1927, or the U. S. patent to Beatty No. 1,470,954, issued October 16, 1923.

Other modifications which may be made in the circuit illustrated and described without departing from the spirit and scope of the invention will be apparent to those skilled in the art.

What is claimed is:

1. A two-way signaling system comprising a two-way signal transmission medium connecting two stations, transmitting and receiving circuits at each station, wave-controlled means at said stations for controlling the transmission efficiency of the transmitting and receiving circuits, said means being normally operated to so control the transmitting and receiving circuits at said stations as to enable signal wave transmission therebetween in the direction from one of said stations to the other station, while preventing signal wave transmission between said stations in the opposite direction, means responsive to the initiation of signal waves in the transmitting circuit at said other station in the absence of prior received signal waves in the receiving circuit thereat for so controlling the wave-controlled means at said other station as to disable the receiving circuit thereat while allowing transmission of said signal waves to said medium over the transmitting circuit thereat, means also responsive to said signal waves for causing a control wave of short duration to be transmitted over said medium to said one station in advance of said signal waves, means for utilizing the received control wave to control initially the wave-controlled means at said one station so as to disable the transmitting circuit thereat and to allow transmission of the following signal waves over the receiving circuit thereat, and means for utilizing the received signal waves for maintaining the wave-controlled means at said one station in the operated condition initiated by said control wave.

2. In a two-way telephone transmission system, a two-way wave transmission medium connecting terminal stations, speech wave transmitting and receiving circuits at said terminal stations, wave-controlled, circuit-control apparatus at said terminal stations for controlling the transmission efficiency of said transmitting and receiving circuits, said circuit-control apparatus being normally operated to so control the transmission efficiency of the transmitting and receiving circuits at said terminal stations as to enable speech wave transmission therebetween in one direction only, and means for conditioning said system for speech wave transmission between said terminal stations in the opposite direction only, said means comprising means responsive to the initiation of speech waves in the transmitting circuit of the station which is normally the receiving station for sending a control wave out over said medium in advance of said speech waves to the other station, means for causing said control wave to initiate operation of the circuit-control apparatus at said other station to so control the transmission efficiency of the transmitting and receiving circuits thereat as to allow speech wave transmission in the direction from said other station to said medium only, and means independent of said control wave for maintaining, while said speech waves are being transmitted over said system, the circuit-control apparatus at said other station in the operated condition initiated by said control wave.

3. The system of claim 2 and in which the last mentioned means comprises means for causing said speech waves when they arrive at said other station to control the circuit-control apparatus thereat.

4. In a two-way telephone system a two-way wave transmission medium connecting terminal stations, wave-controlled, circuit-control apparatus at each station which in one condition of operation conditions the station only for speech wave transmission to said medium and in another condition only for receiving waves from said medium, said circuit-control apparatus being normally operated so that one station is in condition only to transmit to said medium and the other station in condition only to receive from said medium, means responsive to the initiation of speech waves at said other station for transmission to said one station, for causing a control wave to be transmitted over said medium to said one station, means for applying said control wave at said one station to the circuit-control apparatus thereat in such manner as to initiate its conversion to said other condition, means responsive to said speech waves for converting the circuit-control apparatus at said other station to said one condition a given time after said control waves have been sent out therefrom, and means for utilizing said speech waves when they arrive at said one station for maintaining the circuit-control apparatus in the operated condition initiated by said control wave.

5. The system of claim 4 and in which the circuit-control apparatus at said other station is converted to said one condition in response to said speech waves substantially at the same time as said control wave initially converts the circuit-control apparatus at said one station to said other condition.

6. A system for the two-way transmission of signals comprising a two-way line having a transmission time of T seconds connecting two stations, one of said stations comprising a normally operative transmitting path, a normally disabled receiving path, and switching means responsive to waves received over said line from the other station for rendering operative said receiving path and disabling said transmitting path, said other station comprising a normally operative receiving path and a normally disabled transmitting path, means responsive to the initiation of signal waves in the transmitting path of said other station, for sending out a short train of control waves over said two-way line to said one station, means at said one station to apply the received control waves to the switching means thereat to cause initial operation thereof, means also responsive to the signal waves in the transmitting path of said other station and operative substantially T seconds after said control waves have been sent out for rendering the transmitting path at said other station operative to transmit and disabling the receiving path thereat, means for delaying transmission of said signals initiated at said other station in the transmitting path thereat until that path has been rendered operative, means at said one station for utilizing the delayed signals when they arrive thereat to maintain the switching means thereat in the condition initiated by the preceding control waves, and means at each station and responsive to the signals initiated thereat for transmission to the other station, for preventing operation of the switching means thereat by waves received over the line from the other station if the received waves were initiated at the other station after the oppositely directed signals were initiated at the first station.

7. A system for the two-way transmission of signal waves comprising a two-way line having a transmission time of T seconds connecting two stations, one of said stations comprising a normally operative transmitting path, a normally

disabled receiving path, and switching means responsive to waves received over said line from the other station for rendering operative said receiving path and disabling said transmitting path, said other station comprising a normally operative receiving path and a normally disabled transmitting path, means responsive to the initiation of signal waves in the transmitting path of said other station, for sending out a short train of control waves over said line to said one station, means at said one station for applying said control waves to the switching means thereat to cause initial operation thereof, means also responsive to the signal waves in the transmitting path at said other station and operative substantially 2T seconds after said control waves have been sent out for rendering the transmitting path at said other station operative to transmit waves to said line and the receiving path thereat inoperative to receive waves from said line, means for delaying transmission of the signal waves initiated at said other station in the transmitting path thereat until that path has been rendered operative, means at said one station for utilizing the delayed signal waves when they arrive thereat to maintain the switching means thereat in the condition initiated by the preceding control waves, and means at each station and responsive to the signals initiated thereat to be transmitted to said line, for preventing operation of the switching means at that station by waves received over said line from the other station if the received waves were initiated at said other station after the oppositely directed signals were initiated at the first station.

8. In a two-way telephone transmission system, a two-way signal transmission medium connecting terminal stations, wave-controlled, circuit-control apparatus at each station which in one condition of operation conditions the station only for speech wave transmission to said medium and in another condition of operation conditions the station only for receiving waves from said medium, said circuit-control apparatus being normally operated so that one station is in condition only to transmit to said medium and the other station in condition only to receive from said medium, means responsive to the initiation at said other station of speech waves for transmission to said one station, for causing a control wave to be transmitted out over said medium to said one station, means at said one station for utilizing the received control wave to initiate conversion of the circuit-control apparatus thereat to said other condition, means responsive to said speech waves for converting the circuit-control apparatus at said other station to said one condition at a time after the initial operation of the circuit-control apparatus at said one station substantially equal to the transmission time over said medium between said terminal stations, and means at said one station for delaying transmission of speech waves therefrom for a time substantially equal to said transmission time of said medium.

9. In a two-way telephone system, a two-way transmission medium, a terminal station therefor including a speech wave transmitting and a speech wave receiving circuit, said receiving circuit being normally in condition to receive speech waves from said medium, said transmitting circuit being normally inoperative to transmit speech waves to said medium, means responsive to the initiation of speech waves in said transmitting circuit for rendering said transmitting circuit operative to transmit said speech waves to said medium, and for sending out a control wave over said medium in advance of said speech waves, means responsive to speech waves received by said receiving circuit from said medium in the absence of prior initiated speech waves in said transmitting circuit, for preventing said transmitting circuit and said control-wave sending means from becoming operative, and means also responsive to the initiation of speech waves in said transmitting circuit in the absence of prior received speech waves in said receiving circuit for disabling said receiving circuit, the operation of said means for disabling said receiving circuit being independent of said control wave.

10. A two-way signaling system comprising a two-way transmission medium connecting stations each having a transmitting circuit and a receiving circuit, wave-controlled switching apparatus at each station which in one condition of operation disables the receiving circuit of the station and makes its transmitting circuit operative to transmit signals to the medium and in the other condition of operation disables the transmitting circuit and renders the receiving circuit operative, the switching apparatus at one station being normally in said one condition of operation and the switching apparatus at the other station being normally in the other condition of operation so that signal transmission can take place between the stations in the direction from said one station to said other station without further switching, a source of control waves at said other station only, means responsive to signals initiated at said other station in the absence of prior received signals in the receiving circuit thereat to convert the switching apparatus of that station to said one condition, and to cause a short train of control waves from said source to be transmitted over said medium to said one station in advance of said speech waves, means at said one station for applying the received control waves to the switching apparatus thereat to initiate its conversion to said other condition, and means independent of said control wave for maintaining the switching apparatus during transmission of said signals between said stations in the operated condition initiated by said control waves.

11. The system of claim 1 and in which the operation of said wave-controlled means at said other station is independent of said control wave.

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