March 22, 1932. R. C. MATHES 1,850,593

TRANSMISSION CONTROL

Filed March 8, 1930 2 Sheets-Sheet 1

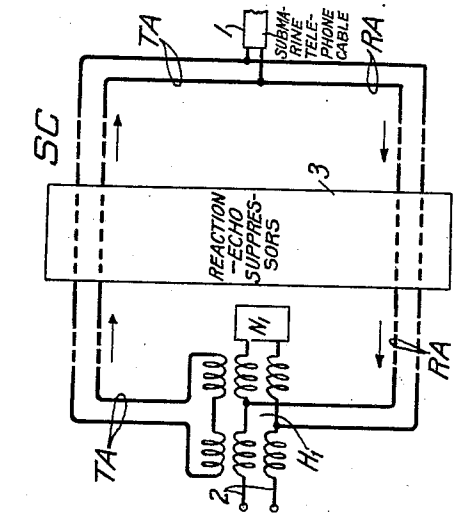
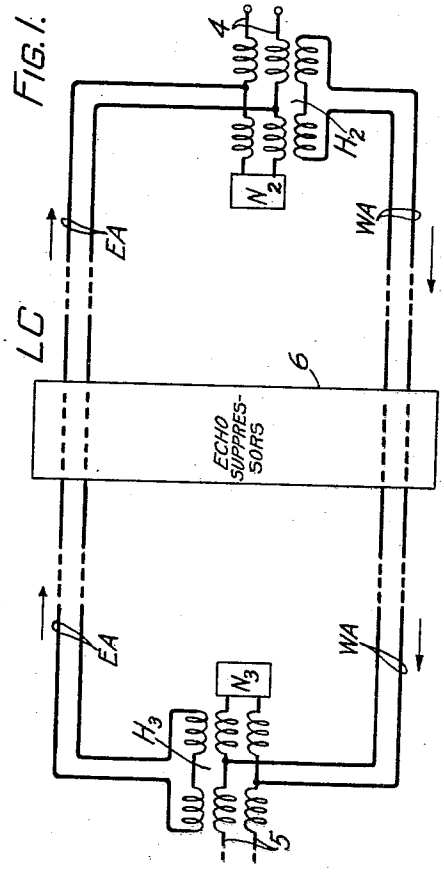


FIG. 1.



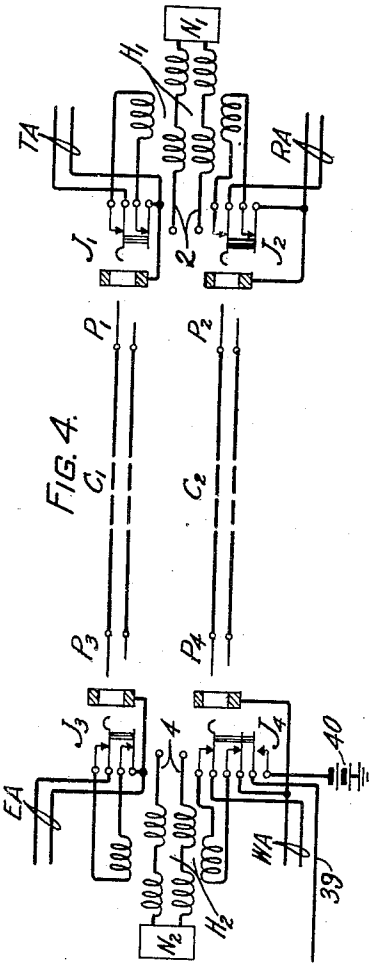


FIG. 4.

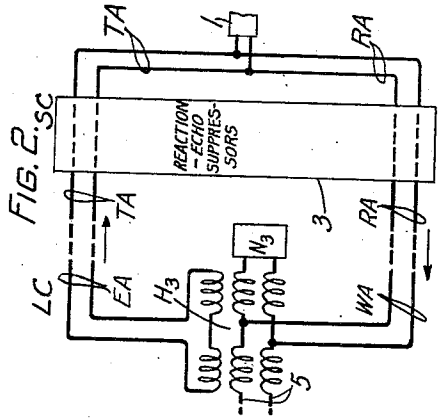


FIG. 2.

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TRANSMISSION CONTROL

Filed March 8, 1930 2 Sheets-Sheet 2

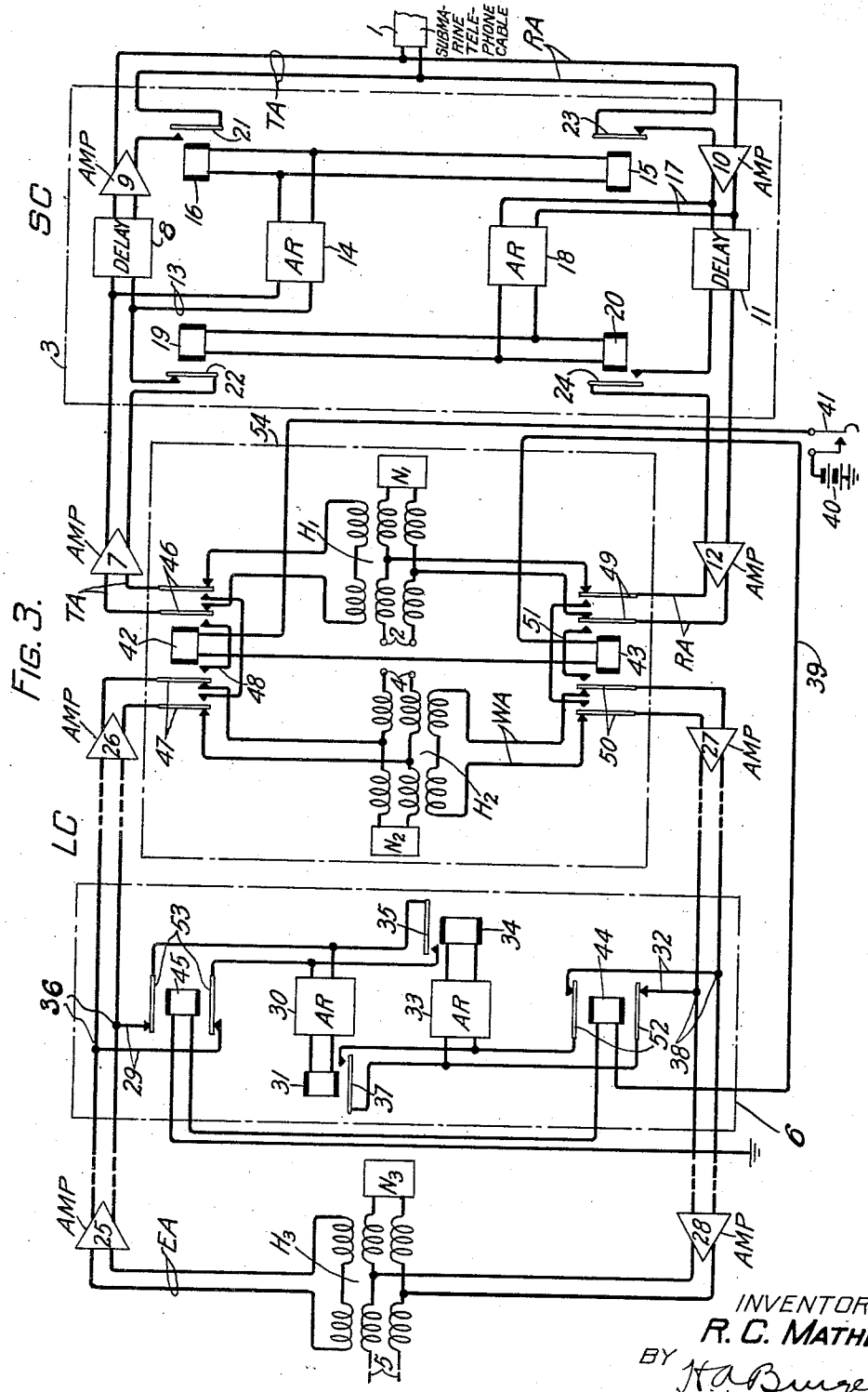

FIG. 3.

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UNITED STATES PATENT OFFICE

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TRANSMISSION CONTROL

Application filed March 8, 1930. Serial No. 434,223.

This invention relates to two-way signal transmission systems and particularly to such systems made up of a plurality of two-way signal transmission circuits connected in tandem.

An object of the invention is to improve the operation characteristics of two-way communication systems made up of two or more long two-way signaling systems connected in tandem.

The invention has particular application to a two-way built-up signal transmission system comprising one or more four-wire telephone toll circuits and a two-way submarine telephone cable system or a two-way radio telephone system connected in tandem.

To obtain satisfactory operation from a transmission standpoint, it has been found desirable in the past to utilize signal-controlled, circuit-control apparatus in connection with the oppositely directed transmission paths of a long four-wire toll telephone system to suppress undesired echoes, singing, or both. This signal-controlled, circuit-control apparatus, commonly known as echo suppressors, is usually located near the middle of the system, and operates in response to signal transmision in either direction over the system to disable effectively the oppositely directed one-way transmission path.

It has also been desirable in the past to employ echo suppressors at each terminal of a two-way submarine telephone cable system, or a two-way radio telephone system, and in combination therewith or in addition thereto other signal-controlled, circuit-control apparatus to insure that the system is operative to transmit in only one direction at a time, so as to prevent singing and interference between the operation of the transmitting and receiving circuits. The latter circuit-control apparatus, which has been referred to in the prior art under various names, such as reaction suppressors, singing suppressors or anti-singing devices, is usually arranged so as to be responsive to signals to be transmitted to the submarine cable or radio link, to make the normally disabled transmitting circuit operative, and to simultaneously disable the normally operative receiving circuit.

In the following description and in the appended claims, the combined signal-controlled, circuit-control apparatus at each terminal of a radio signaling or submarine cable telephone system will be called reaction-echo suppressors.

When two or more of the different types of systems described above are connected together in tandem to form a built-up system to enable direct communication between two subscribers at the two ends of the system, satisfactory operation of the associated sets of signal-controlled, circuit-control apparatus is difficult because of the relatively long time involved in transmitting the signal waves from one subscriber at one end of the system to the other subscriber at the other end of the system. A serious result of the long time of transmission over such a built-up system is the increased chance that the two subscribers at the ends of the system will both start talking within the time interval equal to the total time of transmission over the system, resulting in each subscriber obtaining control of the signal-controlled apparatus at his end of the system for transmitting and blocking out the transmission received from the other subscriber. This means that at times neither subscriber will be able to hear the other.

In accordance with the present invention satisfactory operation in such a built-up system under substantially all conditions is obtained by arranging the circuits so that the echo suppressors normally associated with the four-wire toll system are disconnected therefrom when they are coupled to a submarine telephone cable system or a radio telephone system, and so that the four-wire systems without their echo suppressors are connected directly to the transmitting and receiving terminals of the submarine cable or radio system over four-wire circuits without any intervening two-way two-wire circuits. Then the reaction-echo suppressors at the terminals of the submarine cable or radio system besides performing their normal functions will act also as the echo suppressors for the

whole built-up system. Because of the relatively short time for transmission over the submarine cable or radio link of the built-up system as compared to the time of transmission over the whole system including the four-wire toll systems, the chances of lock-outs of transmission due to the two subscribers starting to talk about the same time is greatly reduced in the system of the invention.

The exact nature and advantages of the invention will be clear from the following detailed description thereof in which:

Fig. 1 shows schematically a two-way toll telephone cable system and a portion of a two-way submarine telephone cable system adapted to be connected in tandem by two-way, two-wire circuits to form a built-up system in the manner in which short four-wire telephone systems are usually combined for through transmission in present practice;

Fig. 2 illustrates schematically a four-wire toll telephone system and a submarine telephone cable system combined in the manner of the invention; and

Figs. 3 and 4 show circuit diagrams illustrating in more detail means for combining a four-wire toll telephone system and a two-way submarine telephone system in accordance with the invention.

Fig. 1 shows schematically a four-wire land toll telephone system LC and the west terminal of a two-way submarine telephone cable system SC.

The west terminal of the submarine cable system SC comprises a transmitting circuit TA and a receiving circuit RA. The output of the transmitting circuit TA and the input of the receiving circuit RA are connected directly to the west end of the submarine telephone cable 1. The input of the transmitting circuit TA and the output of the receiving circuit RA are connected to a two-wire terminating circuit 2 and in conjugate relation with each other in well-known manner by a three-winding transformer or hybrid coil H_1 and an associated balancing network N_1. Signal-controlled, circuit-control apparatus of the reaction-echo suppressor type, represented by the box 3, are associated with the transmitting circuit and the receiving circuit of the west terminal of the submarine cable system in suitable manner to insure that the receiving path is effectively disabled when the transmitting path is transmitting signals to the cable 1, and that the transmitting circuit is effectively disabled when the receiving circuit is receiving signals from the cable 1, so as to prevent singing and interference between the operation of these circuits.

The four-wire toll telephone system LC comprises an east transmission path EA and a west transmission path WA, both of which may be assumed to be operative in the absence of signal transmission over either path. The output of the east path EA and the input of the west path WA are shown connected to a two-wire terminating circuit 4 and in conjugate relation to each other in the usual way by means of a hybrid coil transformer H_2 and associated balancing network N_2. For a similar reason, the input of the east path EA and the output of the west path WA are connected to the two-wire circuit 5 by a hybrid coil transformer H_3 and associated balancing network N_3. A pair of signal-controlled echo suppressors, represented by the box 6, is associated with the transmission paths EA and WA near the middle thereof to insure that when one path is utilized for transmitting signals between the circuits 4 and 5 the other path is effectively disabled, so as to suppress echoes, singing or both.

It will be assumed that the east terminal station (not shown) of the submarine cable system SC comprises apparatus similar to that at the west cable terminal described above, and that another four-wire toll telephone system similar to the system LC described above is located at that end of the cable.

It will be assumed that it is desired to associate the several systems together so that a subscriber A at the extreme west end of the system having his transmitting and receiving apparatus associated with the two-wire circuit 5 in well-known manner may communicate with subscriber B at the extreme east end of the system having his transmitting and receiving apparatus associated with the two-wire circuit of the east toll telephone system corresponding to the two-wire circuit 5 connected to the west toll telephone system LC illustrated.

Now let it be assumed, that, to put the subscribers A and B in communication with each other, the toll telephone systems at each end of the system are connected to the respective cable terminal stations through two-wire circuits, as is usual when short four-wire land toll telephone systems are connected together. This type of connection would be made in the system of Fig. 1 by the direct connection of the two-wire terminating circuits 2 and 4 respectively associated with the system LC and the west cable terminal of the system SC by the hybrid coils H_1 and H_2.

Then, if subscriber A starts to talk, his speech currents will be transmitted over the circuit 5 and will be impressed by hybrid coil H_3 upon the east transmission path EA of the system LC. The main portion of the impressed speech currents will be transmitted over the path EA to hybrid coil H_2. A small portion of the speech currents will be diverted near the middle of the path EA to cause the operation of the signal-controlled echo suppression apparatus 6 associated therewith

to disable the oppositely directed transmission path WA near its middle so as to suppress return echo currents. The speech currents transmitted over the path EA to the hybrid coil H_2 will be impressed thereby upon the two-wire terminating circuit 4 and transmitted over the connecting two-wire circuit to the two-wire terminating circuit 2 of the west terminal of the cable system SC. The transmitted speech currents will be impressed by the hybrid coil H_1 upon the transmitting circuit TA of the west cable terminal. If the reaction-echo suppression apparatus 3 associated with the circuit TA has not already been operated by previously received westerly directed speech currents from the cable 1 to disable the input of the circuit TA, the east speech currents (A's) will cause the operation of the apparatus 3 to disable the receiving circuit RA, and to make the output of the transmitting circuit TA operative to transmit A's speech currents to the submarine cable 1.

The operation of the echo suppressors 6 and the reaction-echo suppressor 3 by A's speech currents will give the subscriber A complete control of the circuits at the west end of the cable for transmitting, and will effectively cut off from A the transmission received from the subscriber B at the other end of the system.

Now suppose that after the subscriber A at the west end of the system has started talking, but within a time interval thereafter less than the overall transmission of the built-up system between the point of location of A at the west end of the system and the point of location of the echo suppressors to the east of cable 1, corresponding to the echo suppressors 6 to the west of the cable 1, the subscriber B also starts to talk. B's speech currents will arrive at the echo suppressor associated with the east toll telephone system, of course, before the speech currents from A have arrived thereat, and by operating that suppressor will obtain control of the circuits of the east toll telephone system for transmitting, and will shut off from B any later received transmission from the subscriber A in a manner similar to that described above in connection with A. It is apparent, therefore, that under such conditions neither subscriber A nor subscriber B may be able to hear the other.

In Fig. 2 is shown schematically how the four-wire toll telephone systems and the submarine telephone cable system of Fig. 1 may be combined in the manner of the invention to form a built-up system in which the chance of transmission lockouts is very much less than in the built-up system of Fig. 1.

Referring to Fig. 2 it will be noted that the east transmission path EA and the west transmission path WA of the four-wire toll telephone system LC are connected directly to the transmitting circuit TA and the receiving circuit RA, respectively, of the west terminal of the submarine telephone cable system SC. The echo suppressors 6 and the junction apparatus, comprising the hybrid coil H_2, the balancing network N_2 and the two-wire circuit 4, normally associated with the four-wire toll telephone system LC, and the junction apparatus comprising the hybrid coil H_1, the balancing network N_1 and the two-wire circuit 2, normally associated with the transmitting and receiving circuits of the west terminal of the cable system SC, have been eliminated in the system of Fig. 2. In the manner which will be explained in connection with the more detailed circuits of Fig. 3 the reaction-echo suppressors 3 besides performing their normal functions act also as echo suppressors for the whole built-up system.

In the built-up system of Fig. 2, the chance of transmission lockouts due to the simultaneous locking up of the signal-controlled, suppression apparatus to the west and east of the cable 1 by the easterly and westerly directed speech currents, respectively, is greatly reduced, for these lockouts can only occur if one subscriber at one end of the system starts talking after the other subscriber at the other end of the system within a time interval equal to the overall transmission time of the built-up system between the point of location of said other subscriber and the point of location of the reaction-echo suppressor at the opposite terminal of the cable 1. This time interval is less than the time interval in which transmission lockouts may occur in the system of Fig. 1 by an amount equal to the overall transmission time of the built-up system between the point of location of the reaction-echo suppressors at said opposite cable terminal and the point where the echo suppressors for the associated toll telephone system at the same side of the cable were normally located. If the associated four-wire toll telephone systems are of considerable length, it is apparent that the arrangement of the invention as shown in Fig. 2 is of considerable value from the standpoint of increased operation efficiency.

The circuit diagram of Fig. 3 shows in detail one way in which four-wire toll telephone systems and a two-way submarine telephone system may be associated in accordance with the invention to produce a circuit equivalent to that shown schematically in Fig. 2.

In order that the principle of operation of the system of the invention may be better understood, in the system of Fig. 3 well-known types of echo suppression and reaction suppression circuits are shown within the boxes 6 and 3, respectively.

The transmitting circuit TA of the west terminal of the submarine telephone cable

system SC in Fig. 3 comprises, connected between the hybrid coil H_1 and the submarine telephone cable 1, a one-way amplifier 7, a delay circuit 8 and the one-way amplifier 9. The receiving circuit RA comprises, connected between the submarine telephone cable 1 and the hybrid coil H_1, a one-way amplifier 10, a delay circuit 11 and a one-way amplifier 12. Connected across the transmitting circuit TA between the output of the amplifier 7 and the input of delay circuit 8 is a control circuit 13 comprising the current-controlled, relay-controlling device 14, and the windings of relays 15 and 16 connected in parallel across the output of the device 14. Connected across the receiving circuit RA between the output of the amplifier 10 and the input of delay circuit 11 is a control circuit 17 comprising the current-controlled, relay-controlling device 18, and the windings of relays 19 and 20 connected to the output of the device 18.

A normally open switch 21 adapted to be closed by operation of relay 16 is connected in the transmitting circuit TA between the output of the amplifier 9 and the submarine cable 1. A normally closed switch 22 adapted to be opened by operation of relay 19 is connected in the transmitting circuit TA between the point of connection thereto of control circuit 19 and the output of amplifier 7.

A normally closed switch 23 adapted to be opened by operation of relay 15 is connected in the input of the receiving circuit RA between the amplifier 10 therein and the submarine telephone cable 1. A normally open switch 24 adapted to be closed by operation of relay 20 is connected in the receiving circuit RA between the output of delay circuit 11 and the input of amplifier 12.

The east transmission path EA of the four-wire telephone system LC comprises, connected between the hybrid coil H_3 and the hybrid coil H_2, the one-way amplifier 25 and the one-way amplifier 26. The west transmission path WA of the system LC comprises connected between the hybrid coil H_2 and the hybrid coil H_3, the one-way amplifier 27 and the one-way amplifier 28.

Connected to the east transmission path EA intermediate the amplifiers 25 and 26 is a control circuit 29 comprising the current-controlled, relay-controlling device 30, and the windings of relay 31 connected to the output of the device 30. Connected to the west transmission path WA intermediate the amplifiers 27 and 28 is a control circuit 32 comprising the current-controlled, relay-controlling device 33, and the windings of relay 34 connected to the output of the device 33. A normally open switch 35 is adapted to be closed by operation of relay 34 to close a short circuit across the path EA near the middle thereof and intermediate the amplifiers 25 and 26, for example, at the points 36. A normally open switch 37 is adapted to be closed by the operation of relay 31 to close a short circuit across the west transmission path WA near the middle thereof and intermediate the amplifiers 27 and 28, for example, at the points 38.

An auxiliary control circuit 39 comprises the source of current 40, the key 41 and the windings of relays 42 to 45. The key 41 is preferably located so as to be operated by the cable operator at the west end of the submarine telephone system SC, but may be located so as to be operated by the operator for the toll telephone system LC or by another operator located at some other point under instructions from either of the first two operators.

In the transmitting circuit TA of the west cable terminal of the system SC between the input of the amplifier 7 and the hybrid coil H_1 are the normally closed switches 46, and in the east amplifying path EA of the system LC between the output of amplifier 26 and the hybrid coil H_2 are the normally closed switches 47. The switches 47 and 46 are adapted to be controlled by operation of the relay 42 respectively to disconnect the output of the amplifier 26 in the path EA from the bridge points of hybrid coil H_2, and the input of the amplifier 7 in the transmitting circuit TA from the series winding terminals of the hybrid coil H_1, and to connect the output of amplifier 26 directly to the input of amplifier 7 through a circuit 48.

In the receiving circuit RA of the system SC between the output of amplifier 12 and the hybrid coil H_1 are the normally closed switches 49, and in the west transmission path WA of the system LC between the input of the amplifier 27 and the hybrid coil H_2 are the normally closed switches 50. The switches 49 and 50 are adapted to be controlled by the operation of relay 43 respectively to disconnect the output of amplifier 12 from the bridge points of hybrid coil H_1 and the input of amplifier 27 from the series winding terminals of hybrid coil H_2, and to connect the output of amplifier 12 directly to the input of amplifier 27 through the circuit 51.

The normally closed switches 52 in the input of the control circuit 32 connected to the west transmission path WA, and the normally closed switches 53 in the input of the control circuit 29 connected to the east transmission path EA, are adapted to be opened by operation of relays 44 and 45, respectively, to disconnect the echo suppressors 6 from the four-wire toll telephone system LC.

As the circuits at the east end of the cable 1 may be assumed to be identical with those at the west end of the cable which have just been described and to operate in similar manner, the operation of the system as a whole will be clear from reference to the circuits at the west end of the cable only. To aid in this the apparatus in the circuits at the east end

of the cable are designated with the same characters as the similar apparatus at the west end of the cable but followed by a prime (') mark.

It will be assumed that the cable operator at the west terminal of the submarine cable 1 has been notified by the toll operator of the four-wire toll telephone system LC by any suitable means, for example, over an auxiliary circuit, that a subscriber A associated with the system LC wishes to communicate with a subscriber B associated with a toll telephone system located at the east end of the submarine cable 1. After having communicated with the cable operator at the east end of the cable 1 over that cable and having been informed that the connections to subscriber B may be made at that end, the west cable operator closes the key 41. It will be assumed that the key 41 is of such design that it will remain locked in the closed position until released by the west cable operator at the end of the conversation between A and B.

The closing of the key 41 will cause the windings of relays 42 to 45 to be energized by current from battery 40. These relays will then operate. The operation of relays 42 and 43 will control switches 46, 47, 49 and 50 to disconnect the junction apparatus comprising hybrid coils H_1 and H_2, the balancing networks N_1 and N_2 and the two-wire terminating circuits 2 and 4 from the systems SC and LC, and to cause the outputs of amplifier 26 and amplifier 12 to be connected respectively to the inputs of amplifier 7 and amplifier 27.

The simultaneous operation of relays 44 and 45 will control switches 52 and 53 to disconnect the echo suppressors 6 from the toll telephone system LC.

At the west end of the cable 1, the circuit 5 associated with subscriber A is now connected directly to the west terminals of cable 1 over four-wire circuits without any intervening two-way two-wire circuits.

Meanwhile, a similar operation by the cable operator at the east end of the cable 1 will associate the subscriber B with the east terminals of cable 1 over four-wire circuits without any intervening two-way two-wire circuits.

Let it be supposed that A starts to talk first. A's speech currents will be impressed by the hybrid coil H_3 upon the east transmission path EA of the system LC and will be amplified by the amplifier 25 therein. The amplified speech waves in the output of amplifier 25 will then be transmitted to the input of the amplifier 26. The speech waves then will be amplified by the amplifier 26 and then transmitted over the circuit 48 to the transmitting circuit TA of the west terminal of the cable system SC, in which they will be amplified by the amplifier 7. The amplified currents in the output of amplifier 7 will be divided between the input of delay circuit 8 in the main path TA and the input of control circuit 13.

The portion diverted into the control path 13 will operate the control device 14 therein to energize the windings of relays 15 and 16. Relay 15 will operate to open the normally closed switch 23 in the input of the receiving circuit RA making that path inoperative to transmit waves incoming over the cable 1. Relay 16 simultaneously operates to close the normally open switch 21 in the output of the transmitting circuit TA making that path operative to transmit waves from the output of amplifier 9 to the submarine cable 1. A's speech waves in the main transmission circuit TA have meanwhile been delayed in the delay circuit 8 for a sufficient interval of time to enable the switch 21 to be closed before the speech waves arrive at the switching point. The speech waves transmitted through the delay circuit 8 are amplified by the amplifier 9, and the amplified waves are transmitted directly to the submarine cable 1 and transmitted thereover to the east cable terminal station.

At the east terminal cable station the waves are impressed on the receiving circuit RA' thereat and, if the switch 23' has not been previously opened by westerly directed speech waves from subscriber B, will be amplified by the receiving amplifier 10'. The amplified waves in the output of amplifier 10' are divided between the input of the delay circuit 11' in the main receiving circuit RA' and the control circuit 17'.

The portion diverted into control circuit 17' will operate control device 18' therein causing the windings of relays 19' and 20' to be energized. Relay 19' operates to open the normally closed switch 22' in the transmitting circuit TA' making that path inoperative to transmit westerly directed speech waves to the input of the control device 14'. Relay 20' simultaneously operates to close the normally opened switch 24' in the receiving path RA' making that path operative to transmit waves from the output of the delay circuit 11' to the input of amplifier 12'.

The main portion of the easterly directed speech waves meanwhile has been delayed in transmission through the delay circuit 11' for a time interval sufficient to enable the closing of switch 24' in the output thereof before the speech waves arrive at the switching point. The delayed waves are amplified by amplifier 12' in the receiving circuit RA' and the amplified waves transmitted over the bypass circuit 51' to the west transmission path WA' of the toll telephone system LC'. The received waves are amplified by the amplifiers 27' and 28' in the path WA', and the amplified waves are impressed by hybrid coil H_3' upon the two-wire circuit 5' over

which they are transmitted to the subscriber B.

It is apparent from the operation of the system described that the reaction-echo suppressors 3 and 3′ at the two terminals of the submarine cable 1 besides performing their normal function in preventing singing and interference between the transmitting and receiving circuits of the cable terminals, act as echo suppressors for the whole built-up system.

Now, transmission lockouts in the system of Fig. 3 will only occur when the two reaction-echo suppressors 3, 3′ at the two cable terminals are respectively operated and maintained operated simultaneously by the speech currents from subscribers A and B, respectively. The subscriber A or B who starts talking last can only obtain control of the reaction-echo suppressor at his end of the cable 1 if the other subscriber continues to talk, if the first-mentioned subscriber starts talking within a time interval after said other subscriber starts talking substantially equal to the over-all transmission time of that portion of the built-up system located between the other subscriber and the reaction-echo suppressor at the other end of the cable. If B starts talking at any time after A not within that time interval he can only obtain control of the reaction suppressor at his end of the system, when A ceases talking or pauses for a sufficient time to enable the reaction-echo suppressors 3, 3′ to release, for example, at the end of a sentence.

For simplification, means for associating only one four-wire toll system with a submarine telephone cable system have been illustrated in the system of Fig. 3. It is apparent that in accordance with the invention the means shown may be easily extended to make possible the association of any one of a number of four-wire toll telephone systems with a particular submarine telephone cable or radio telephone system by providing additional relays, switches, and keys, similar to those shown, under the control of the connecting operator.

In Fig. 4 is shown a preferred circuit arrangement which may be utilized by the connecting operator for associating in the manner of the invention a given submarine telephone cable or radio telephone system with any one of a number of four-wire toll telephone systems. This circuit arrangement may be substituted in the system of Fig. 3 in place of the circuits and apparatus therein shown within the dot-dash box 54. The two-wire cord circuits C_1 and C_2 terminating in the plugs P_1, P_3, and P_2, P_4, respectively, are located at the station of the connecting operator. Spring jacks J_1, J_2 are permanently connected to the transmitting circuit TA and the receiving circuit RA between the hybrid coil H_1 and the amplifiers 7 and 12, respectively, at each terminal of the submarine telephone cable system SC. The jacks J_1, J_2 are arranged so that normally the transmitting circuit TA and the receiving circuit RA are connected through the hybrid coil H_1 to the line terminals 2 and balancing network N_1 in the usual manner.

Spring jacks J_3, J_4 are connected permanently to the west amplifying path WA and east amplifying path EA between the hybrid coil H_2 and the amplifiers 26 and 27, respectively, of the four-wire system LC. The jacks J_3, J_4 are arranged so that the east amplifying path EA and the west amplifying path WA are normally connected through hybrid coil H_2 to the line terminals 4 and the balancing network N_2 in the usual manner. Jacks similar to J_3 and J_4 are associated with each of the other four-wire toll telephone systems in similar manner.

When the connecting operator wishes to connect the submarine cable system SC with any given one of the four-wire toll telephone systems, for example, the LC, she inserts the plugs P_1, P_2 into jacks J_1, J_2 and the plugs P_3, P_4 into the corresponding jacks of the selected four-wire toll telephone system, in this case jacks J_3 and J_4 of the system LC. The insertion of plugs P_1, P_2 into jacks J_1, J_2 connects the transmitting circuit TA and the receiving circuit RA of the submarine cable terminal directly to the east terminals of the cord circuits C_1 and C_2 respectively, and simultaneously disconnects the circuits TA and RA from the hybrid coil H_1, the balancing network N_1 and the line terminals 2.

The insertion of plugs P_3, P_4 into jacks J_3, J_4 connects the east amplifying path EA and the west amplifying path WA of the system LC directly to the west terminals of the cord circuits C_1 and C_2, respectively, and simultaneously disconnects the paths EA and WA from the hybrid coil H_2, the balancing network N_2 and the line terminals 4. The east amplifying path EA and the west amplifying path WA of the system LC are now connected respectively to the transmitting circuit TA and the receiving circuit RA of the system SC through the cord circuits C_1 and C_2, respectively. The insertion of plug P_4 into jack J_4 also closes the direct current circuit 39 causing the relays 44 and 45 to be energized by current from battery 40. The resulting operation of these relays will open the switches 52 in control circuit 32 and the switches 53 in control circuit 29, respectively, to disconnect the echo suppressors 6 from the system LC.

The chance of transmission lockouts has been very much decreased in the systems of Figs. 2 and 3 over that of the system of Fig. 1, as in the former systems the time interval between which the two parties may both start talking without locking up the suppression apparatus is now reduced by the time differ-

ence between the over-all transmission time of the built-up system between the points in one toll system at which the echo suppressors 6 or 6′, are normally located and the point at which the reaction-echo suppressors at the same end of the cable are located.

It is apparent that the system of the invention does not interfere with normal operation of the toll telephone systems when used alone, for the echo suppressors normally associated therewith are only disconnected therefrom when the system is to be associated with a long two-way signaling system, such as a submarine telephone cable system, or a radio telephone system.

It is to be understood that the invention is not to be limited to the details of the system illustrated or described which are for purposes of example only, as various modifications therein within the spirit and scope of the invention will occur to persons skilled in the art. For example, although auxiliary direct current circuits controlled manually by the submarine cable or tool operators for disconnecting the echo suppressors from the toll circuits and connecting the oppositely directed transmission paths of the toll systems directly to the transmitting and receiving circuits of the cable or radio system have been illustrated in the drawings, it is apparent that these operations may be accomplished by other means, for example, by automatic equipment controlled by control energy or the speech waves themselves transmitted to the switching points.

What is claimed is:

1. In combination, two or more two-way signal transmission systems each comprising a four-wire portion consisting of oppositely directed one-way transmission paths, and terminating two-wire portions, and means for interconnecting said systems to form a built-up system for two-way signal transmission in opposite directions, said means comprising means for disconnecting a terminating two-wire portion from adjacent systems and means for connecting the corresponding one-way paths of the two systems directly together so that each pair of connected paths forms a single one-way transmission path.

2. In combination, two or more two-way signal transmission systems each comprising a four-wire portion consisting of two oppositely directed one-way two-wire paths, and a two-wire terminating portion, certain of said systems being normally equipped with signal-controlled means for effectively disabling one of its one-way paths when its oppositely directed path is being utilized for transmitting signals, and means for combining said systems to form a built-up system for two-way signal transmission thereover, said means comprising means for effectively disabling the signal-controlled means of one of two adjacent systems, means for disconnecting two-wire terminating portions from said adjacent systems, and means for connecting the corresponding one-way paths of said adjacent systems together to form continuous one-way transmission paths.

3. In combination, a two-way signal transmission system comprising a two-way transmission medium having at each terminal thereof transmitting and receiving circuits and reaction-echo suppressors associated with said circuits, a four-wire signal transmission system equipped with echo suppressors, and means for interconnecting the systems to form a built-up system for through transmission, said means including means for rendering said echo suppressors inoperative while the systems are interconnected, and for connecting the oppositely directed two-wire portions of said four-wire system directly to the transmitting and receiving circuits respectively of one terminal of said medium so that the connected circuits of the two systems form homogeneous one-way transmission paths.

4. In combination, a four-wire toll telephone system including associated signal-controlled echo suppressors, a two-way submarine telephone cable system comprising a two-way submarine cable having terminals each comprising a transmitting circuit, a receiving circuit and means for effectively disabling one of said circuits when the other circuit is utilized for transmitting signals, and means for interconnecting said toll telephone system and said submarine cable system to form a built-up system for through signal transmission in opposite directions, said means comprising means for effectively disabling the echo suppressors of said toll telephone system and for connecting the two-wire, one-way portions of said toll circuit directly to the transmitting and receiving circuits, respectively, of one terminal of said submarine cable telephone system without intervening two-way two-wire circuits.

5. In a transmission system, a toll telephone circuit normally comprising two oppositely directed one-way transmission paths equipped with echo suppressing means and a two-way terminating circuit connected to a junction of the two one-way paths, a transmission link including at a terminal thereof a transmitting and a receiving circuit, a two-way terminating circuit connected to a junction of said transmitting and said receiving circuit and signal-controlled means for effectively disabling said transmitting circuit or said receiving circuit when the other circuit is transmitting signals, and means for connecting said telephone circuit with said transmission link to form a built-up through transmission circuit, the last mentioned means including means for disconnecting the echo suppressing means from said telephone circuit, for disconnecting the two-way terminating circuits from said telephone circuit

and said transmission link, and for connecting the one-way transmission paths of said toll telephone circuit directly to the transmitting and receiving circuits, respectively at said terminal of said transmission link.

6. The system of claim 5 and in which said transmission link includes a two-way transmission medium.

7. The system of claim 5 and in which said transmission link has a wave transmission time short in comparison with that of the complete built-up system.

8. The system of claim 5 and in which said transmission link comprises a two-way transmission line.

9. The system of claim 5 and in which said transmitting and said receiving circuit at each terminal of said transmission link includes wave transmitting and receiving apparatus, respectively.

10. The system of claim 5 and in which said transmission link comprises a two-way submarine telephone cable.

11. The system of claim 5 and in which the receiving circuit at each terminal of said transmission link is normally operative and the transmitting circuit is normally disabled.

12. In combination, a two-way signal transmission system comprising a two-way transmission medium having at each terminal thereof transmitting and receiving circuits and means for effectively disabling either one of said circuits when the other circuit is utilized for transmitting signals, a four-wire signal transmission system equipped with signal-controlled echo suppressors, and means for interconnecting said two-way signal transmission system and said four-wire signal transmission system to form a built-up system for through signal transmission in opposite directions, said means comprising means for effectively disabling one echo suppressor of said four-wire system, and for connecting the two-wire, one-way portions of said four-wire system directly to the transmitting and receiving circuits, respectively, of one terminal of said medium so that the connected circuits of the two systems form homogeneous one-way transmission paths.

13. In combination, a four-wire toll telephone system equipped with signal-controlled echo suppressors, a two-way submarine telephone cable system comprising a two-way submarine telephone cable having a transmitting and a receiving circuit at each terminal thereof and means responsive to transmission of telephone signals in said transmitting circuit or in said receiving circuit for effectively disabling the other circuit, and means for interconnecting said four-wire toll system and said submarine cable system to form a built-up system for through conversation in either direction, the last-mentioned means comprising means for connecting the individual one-way, two-wire portions of said four-wire system directly to the transmitting and receiving circuits, respectively, of one terminal of said cable system without intervening two-wire circuits, and means for effectively disabling one echo suppressor of said toll telephone system.

In witness whereof, I hereunto subscribe my name this 7th day of March, 1930.

ROBERT C. MATHES.