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TRANSMISSION CONTROL IN TWO-WAY SIGNAL TRANSMISSION SYSTEMS

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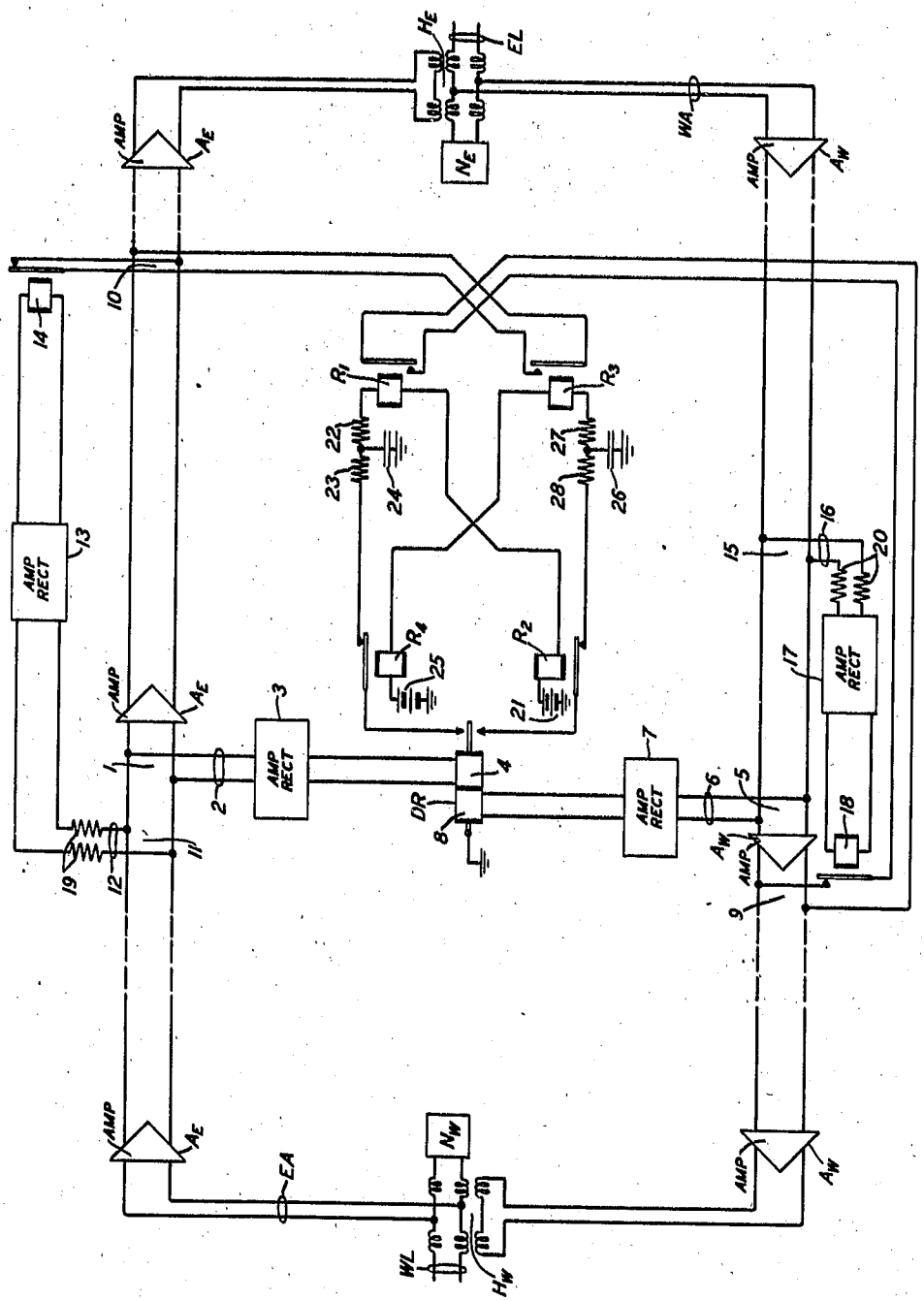

INVENTOR
K. H. DAVIS
BY
Earl C. Laughlin
ATTORNEY

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TRANSMISSION CONTROL IN TWO-WAY SIGNAL TRANSMISSION SYSTEMS

Kingsbury H. Davis, Bernardsville, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

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6 Claims. (Cl. 178—44)

The invention relates to two-way signal transmission systems, and particularly to the signal-controlled switching circuits used with such systems to directionally control signal transmission therein while suppressing echoes and preventing singing.

Such signal-controlled switching circuits, commonly called echo suppressors, usually employ two switching branches respectively connected to a different one of the two oppositely-directed one-way signal transmission paths at a terminal or intermediate point in a two-way telephone system, each including a rectifier for rectifying the portion of the signals diverted into the switching branch, and electromagnetic relays or other switching devices operated by the rectified signals to suitably control the transmission efficiencies of the signal transmission paths and to effectively disable the other switching branch, so as to provide the desired directional control of signal transmission while suppressing echoes and preventing singing.

The copending patent application of K. H. Davis and A. C. Norwine, Serial No. 421,704, filed December 5, 1941, which issued as Patent No. 2,306,689 on December 29, 1942, discloses such an echo suppressor applied to a four-wire telephone circuit with an associated break-in control circuit of the amplitude type, which enables one subscriber by talking loudly to break in on another who is talking and has obtained directional control of the system, while the latter continues to talk and regardless of how loudly he is talking. This is accomplished by the use of relatively insensitive auxiliary break-in controls properly located with respect to the echo suppressor controls, operating on an amplitude basis to disable the echo suppressor controls of the talking party when the breaking party talks with the required loudness. Such break-in controls necessarily have to be relatively low in sensitivity to avoid false operation by echoes of loud speech, which requires that the breaking party talk substantially louder than the talker who has control in order to break in.

In tests of echo suppressors on actual toll circuits, it has appeared that it would be advantageous to permit break-in by a talker who was relatively weak but louder than the other talker on the circuit. One known arrangement for accomplishing this is the so-called differential echo suppressor in which two voice-operated echo suppressor branches respectively controlled from a different one of the oppositely directed one-way paths of a four-wire telephone circuit, operate in opposition on a differential circuit, which may be a differential relay, the differential circuit being unbalanced in one direction or the other depending on which echo suppressor branch is supplied with the stronger signal energy, to so control the relative transmission efficiencies of the oppositely directed signal transmission paths as to give directional control of the system with suppression of the echoes of his speech signals to the louder of the two talkers. Ordinarily, the latter sort of break-in, which may be called differential break-in, is relatively slower than "amplitude break-in" because the breaking party cannot get control of the system until after the expiration of the hang-over in the echo suppressor branch controlled by the first talker; that is, a talker to take control must maintain his speech energy higher in amplitude than that of the party he is interrupting for a period at least as long as the hang-over in operation of the echo suppressor branch controlled by the latter, provided to prevent signal clipping.

An object of the invention is to improve the operation of break-in echo suppressors of the above-described types.

This is accomplished by combining differential and amplitude break-in controls in the same echo suppressor in such manner as to obtain the advantages of both. This is, the two types of break-in are combined so that the stronger of two "weak" talkers can obtain control, which could not be done with only amplitude break-in, and also so that a talker who is "loud," can interrupt another talker no matter how loudly the latter is speaking, which could not be done with only differential break-in.

The various objects and features of the invention will be better understood from the following detailed description when read in conjunction with the accompanying drawing in which the single figure shows schematically an echo suppressor embodying the invention applied to a four-wire telephone circuit.

In Fig. 1, the four-wire telephone circuit includes a one-way, two-wire transmission path EA including the one-way amplifiers A_E, normally conditioned to transmit in the direction from west to east between the west two-way line WL and the east two-way line EL, and a one-way, two-wire transmission path WA including the one-way amplifiers Aw, normally conditioned to transmit in the direction from east to west between the same two-way lines. The input of the transmission path EA and the

output of the transmission path WA are coupled at the west terminal of the four-wire telephone circuit in conjugate relation with each other and in energy transmitting relation with the two-way line WL by the hybrid coil Hw and associated line balancing network Nw, and the output of the transmission path EA and the input of the transmission path WA are coupled at the east terminal of the four-wire telephone circuit in conjugate relation with each other and in energy transmitting relation with the two-way line EL by the hybrid coil H_E and associated line balancing network N_E.

Connected across the transmission path EA at an intermediate point 1 is the input of the "west" switching branch 2 of a differential echo suppressor, including the amplifier-rectifier 3 and one winding 4 of the differential relay DR, poled so that when it is energized by the rectified signals in the output of amplifier-rectifier 3 it tends to operate the relay DR to its upper contact. Similarly, connected across the transmission path WA at an intermediate point 5 is the input of the "east" switching branch 6 of the differential echo suppressor, including the amplifier-rectifier 7 and a second winding 8 of the differential relay DR, wound in opposition to the winding 4, which when energized by rectified signals in the output of the amplifier-rectifier 7 tends to operate the relay DR to its lower contact. As will be described in detail later in connection with the complete description of operation of the circuit of the drawing, the operation of the differential relay DR to its upper contact will cause the operation of switching relays to respectively connect a short-circuiting connection across the path WA at a point 9 beyond the point 5 to which the input of the west echo suppressor branch 6 is connected, and to disable the switching relays controlled by operation of the differential relay DR to its lower contact; and the operation of the differential relay to its lower contact will cause the operation of switching relays to respectively close a short-circuiting connection across the path EA at a point 10 beyond the point 1 to which the west echo suppressor branch 2 is connected, and to disable the switching relays controlled by the operation of the differential relay DR to its upper contact.

Connected across the transmission path EA at a point 11 in front of the disabling point 10 is the input of a third switching control circuit 12 including the amplifier-rectifier 13 and the electromagnetic relay 14 which when completely energized by operation of the amplifier-detector 13 operates to put a break in the short-circuiting connection across the path EA at the point 10. Similarly, connected across the path WA at a point 15 in front of the disabling point 9 is the input of a fourth switching circuit 16 including the amplifier rectifier 17 and the relay 18 which when completely energized by operation of the amplifier-rectifier 17 operates to put a break in the short-circuiting connection across the path WA at the point 9. As indicated by the series resistances 19 in the input of the amplifier-rectifier 13, the switching circuit 12 is relatively insensitive compared to the echo suppressor switching branch 2, and, as indicated by the series resistances 20 in the input of the amplifier-rectifier 17, the switching circuit 16 is relatively insensitive compared with the east echo suppressor branch 6.

In the subsequent description, it will be convenient to speak of a "loud talker" meaning one who can operate a break-in control, and a "weak" talker, meaning one who cannot. Since we are to deal with circuits from the terminals of which portions of signals are returned as echoes, it is assumed that a loud talker, in order to break in, must operate a control at least insensitive enough so that it will not operate on the echo of the other talker's speech energy. The resistances 19 in the input of the amplifier-rectifier 13 in control circuit 12, and the resistances 20 in the input of the amplifier-rectifier 17 in control circuit 16, respectively, are therefore each selected to provide sufficient desensitization of the control circuits 12 and 16 to prevent their operation on the maximum amount of signal echo which may be applied thereto from the associated signal transmission path in response to direct signal transmission in the oppositely directed transmission path.

Let it be assumed that a west telephone subscriber associated with the line WL starts to speak, and at that time the east subscriber associated with the line EL is silent. The speech waves of the west subscriber received over the line WL will be impressed by the hybrid coil Hw on the path EA and will pass over that path with an amplification depending on the gain setting of the amplifiers A_E to the hybrid coil H_E. The main portion of these speech waves will pass through the hybrid coil H_E to the line EL over which it will be transmitted to the east subscriber, and another portion, due to imperfect balance of the line EL by the balancing network N_E, will be reflected into the input of the path WA and will pass as echoes over that path in the direction from east to west.

A portion of West's speech waves will be diverted at the point 11 in the path EA into the input of the control circuit 12, but, if the west subscriber is talking with normal loudness, will be of insufficient amplitude level to overcome the desensitization of that control circuit produced by the resistances 19, and, therefore, will not operate the switching relay 4 in the output of the amplifier-rectifier 13.

Another portion of West's speech waves will be diverted at the point 1 in path EA into the west echo suppressor switching branch 2 and will be amplified and rectified by the amplifier-rectifier 3. The rectified waves in the output of the amplifier-rectifier 3 will be supplied as energizing current to winding 4 of the differential relay DR and, the opposing winding 8 of that relay being unenergized in the absence of a rectified signal output from the amplifier-rectifier 7 with the east subscriber silent, will cause the operation of that relay to its upper contact. This will cause switching relays R_1 and R_2 to be energized by current from the battery 21 over a circuit extending from the positive terminal of that battery through the windings of relays R_2 and R_1, resistances 22, 23, the normally closed contacts of switching relay R_4, the closed upper contact and armature of relay DR and ground back to the negative terminal of battery 21, causing the operation of relays R_1 and R_2. Also, when relay DR operates to its upper contact, the condenser 24 normally charged by battery 21 through the windings of relays R_2 and R_1 and resistance 22, will be discharged to ground. The operation of the relay R_1 will close a short-circuiting connection across the path WA at the point 9 effectively disabling that path so as to suppress the echoes of West's signals when they arrive at that point in the path. The operation of relay R_2 will put

a break in the connection between the lower contact of the differential relay DR and the resistance 28 in the energizing circuit for the relays R_3 and R_4 from battery 25, preventing subsequent operation of the latter relays when the relay DR is operated to its lower contact in response to loud speech from the east subscriber, and during the hang-over operating period of relays R_1 and R_2 when the energizing circuit for the latter relays is broken by the break of the upper contacts of relay DR. The west subscriber by operating the relays R_1 and R_2 has thus obtained directional control of the system with suppression of the echoes of his signals.

Now, let it be assumed that while the west subscriber is still talking, the east subscriber associated with the line EL starts to talk. The latter's speech waves will pass from the line EL through the hybrid coil H_E into the transmission path WA and will pass over that path in the direction from east to west towards the west subscriber. A portion of West's speech waves will be diverted at the point 15 into the control circuit 16 and another portion will be diverted at the point 5 into the east echo suppressor branch 6. If East is a weak talker (as previously defined), his speech currents will not cause operation of the relatively insensitive control circuit 16, but the portion of his speech currents diverted into the east echo suppressor branch 6 will cause operation of the amplifier-detector 7 in that branch to apply energizing currents to the winding 8 of the differential relay DR. If East's speech waves applied to the input of the east echo suppressor branch 6 are weaker than West's speech waves applied to the input of the west echo suppressor branch 2, the energizing current supplied to the winding 8 of the differential relay DR will not be strong enough to shift the armature of the relay DR from the upper to the lower contact. The stronger energizing currents applied to the winding 4 will maintain the armature of the relay DR on its upper contact so that the relays R_1 and R_2 will be maintained operated to hold the transmission path WA blocked at the point 9 and the energizing circuit for the relays R_3 and R_4 disabled. Thus West will maintain directional control of the system for such talking conditions.

However, if the east subscriber begins to talk more loudly than west so that the energizing currents supplied by him to the winding 8 of the differential relay DR are of greater amplitude than the energizing currents applied to the winding 4 of that relay in response to West's weaker speech waves, the differential relay DR will be operated to its lower contact. As soon as the armature of the relay DR leaves the upper contact, the energizing circuit for the winding of the relays R_1 and R_2 through the upper contact and armature of relay DR from the battery 21 is broken, but the latter relays will be maintained in the operated condition for a hang-over interval determined by the time required for the condenser 24 to be charged up to the potential of battery 21 through the windings of these relays and resistance 22, and the path WA will be maintained blocked at the point 9 and the switching relays R_3 and R_4 will be maintained disabled for this hang-over interval. Thus, if East desires to reverse control of the differential echo suppressor circuit he must maintain his speech energy higher in amplitude than that of West for a period at least as long as the suppressor hang-over.

However, East may immediately break West's directional control of the system, if he (East) talks with sufficient loudness to overcome the desensitization of the amplitude break-in control circuit 16 provided by resistance 20, regardless of how loudly West is talking. If East does so, his speech signals will cause the operation of the amplifier-rectifier 17 of the break-in control 16 and thus the operation of the relay 18 in its output to put a break in the short-circuiting connection across the path WA at the point 9 which has been previously closed by operation of the switching relay R_1 in response to West's previous signals. The consequent enabling of the path WA at the point 9 will allow East's speech signals to be transmitted out over the output of that path through the hybrid coil Hw and over the line WL to the west subscriber and to be heard by the latter. As described above, the portion of East's stronger speech signals diverted from the path WA at the point 5 into the switching branch 6 and causing the operation of the amplifier-detector 7 to supply stronger energizing current to the winding 8 of the differential relay DR, will be effective to cause the disabling of the path EA to give directional control of the echo suppressor to East with suppression of his echoes, only if the latter talks louder than West for a time interval at least as long as the west suppressor hang-over.

However, if at the time East talks loud enough to operate his break-in control circuit 16, West is talking still louder, the energizing current supplied to the winding 4 of the relay DR will be greater than that supplied to the winding 8 of that relay, and the armature of the relay DR will be maintained on its upper contact to continue the operation of the relays R_1 and R_2. The continued operation of the relay R_1, however, will not continue the disabling of the path WA at the point 9 because of the operation of the relay 18 in the east break-in control circuit 16 in response to East's loud speech to put a break in the short-circuiting connection across the path WA at the point 9. The continued operation of the relay R_2 will maintain the energizing circuits for the switching relays R_3 and R_4 disabled. Then, as both of the paths EA and WA are unblocked, each subscriber will hear the other and echoes of his own speech signals.

West's loud speech signals will also cause the operation of his break-in control circuit 12, to put a break in the short-circuiting connection across EA at the point 10, but this will have no effect on the operation because that connection is already in the disabled condition because of the unoperated condition of relay R_3 with relay DR operated to its upper contact.

In a similar manner, when the east subscriber talks first so that his speech currents cause the operation of the relay DR to its lower contact, the switching relays R_3 and R_4 will be operated to respectively connect a disabling short-circuit across the path EA at the point 10 and to disable the switching relays R_1 and R_2, so as to give directional control of the circuit to East. Then, if West desires to break in, he needs only to talk loud enough to overcome the desensitization of his break-in control circuit 12 to operate the amplifier-rectifier 13 and thus the relay 14 to put a break in the short-circuiting connection across the path EA at the point 10, to enable that path and allow his signals (West's) to be transmitted out over that path through the hybrid coil H_E to the line EL leading to the east subscriber.

If West's interrupting speech waves are louder than East's the operation of the differential relay DR will be reversed. If West then maintains the amplitude of his speech waves greater than that of East's speech waves for a time at least as long as the hang-over time of the switching relays R_3 and R_4, West will be able to operate his relays R_1 and R_2 to respectively connect a short-circuit across the path WA at the point 9, and to disable the energizing circuit for the relays R_3 and R_4, so as to seize directional control of the circuit away from East.

However, if East is talking louder than West at the time that West has operated his break-in control circuit 12 to disable the short-circuiting connection across the path EA, the differential relay DR will be maintained operated to its lower contact with the result that relays R_3 and R_4 will be maintained operated and the relays R_1 and R_2 disabled. Thus, both paths EA and WA will be operative and both subscribers will hear each other and echoes.

While the arrangements of the invention have been shown as embodying certain specific forms which are deemed desirable, various modifications of these forms which are within the spirit and scope of the invention will be apparent to persons skilled in the art.

What is claimed is:

1. In combination in a two-way telephone system, oppositely directed one-way transmission paths for the voice signals transmitted in opposite directions, a voice-operated differential echo suppressor controlled from the two paths, operating to allow transmission over the path supplied with the stronger signals while effectively disabling the path supplied with the weaker signals, an auxiliary voice-operated control device connected to each path in front of the disabling point therein responsive to the supply of voice signals thereto a given amount stronger than normal signals to prevent that path from being disabled, or to effectively remove the disability from that path if already disabled.

2. The system of claim 1, in which said differential echo suppressor comprises differential means, a voice-operated control branch connected to each path operating to unbalance said differential means in one direction or the other depending on which control branch is supplied with the greater amount of voice signal energy, and switching means responsive to the unbalance of said differential means in one direction when the signals in one path are stronger than the signals in the other path, to insert a disabling loss in said other path, and responsive to unbalance of said differential means in the other direction when the signals in said other path are stronger than the signals in said one path, to insert a disabling loss in said one path, and said auxiliary voice-operated control device connected to each path is less sensitive than the echo suppressor control branch connected thereto by a given amount sufficient to prevent false operation of the device by the maximum amount of applied echoes of the signals which may be transmitted over the other path, and when operated effectively prevents a disabling loss from being inserted in the first path, or effectively removes the loss therefrom when already inserted.

3. In a two-way telephone system, two oppositely directed one-way transmission paths for respectively transmitting the oppositely directed voice signals of the subscribers at opposite terminals of the system, a voice-operated differential echo suppressor controlled from the two paths, operating to allow transmission over the path supplied with the stronger signals and to effectively disable the other path, so as to give directional control of the system to the subscriber talking loudest and to suppress echoes of his signals, and other switching means connected to each path in front of the disabling point therein, operating in response to voice signals in that path, only if at least a given amount stronger than normal signals, to prevent the disabling of that path or to reenable it if already disabled.

4. The system of claim 3, in which said differential echo suppressor has a given amount of hang-over in its operation to prevent signal clipping on cessation of the supply of controlling signal energy, so as to prevent an interrupting subscriber from reversing directional control of said system unless he talks louder than the subscriber who has obtained control for a time interval at least as long as the amount of echo suppressor hang-over.

5. The system of claim 3, in which said other switching means connected to each path is less sensitive than the differential echo suppressor by an amount at least sufficient to prevent false operation of the former by the echoes of the loudest voice signals transmitted over the other path.

6. In a two-way telephone system including oppositely directed one-way paths for respectively transmitting the signals of the subscribers at opposite terminals of the system, a voice-operated echo suppressor having a given amount of hang-over in its operation, operating to give directional control of the system to the one of two talking subscribers at opposite terminals of the system who talks loudest with suppression of the echoes of his signals, and to reverse directional control of the system obtained by one talker, in response to the voice signals of the other louder talker, only after expiration of the suppressor hang-over applied by the voice signals of said one talker, and an auxiliary voice-operated switching control connected to each transmission path, responsive to the voice signals of a subscriber supplied to that path, only if such signals are a given amount stronger than normal voice signals, to interrupt directional control of the system obtained by the other subscriber so as to enable voice signal transmission between the subscribers in both directions without suppression of signal echoes.

KINGSBURY H. DAVIS.