

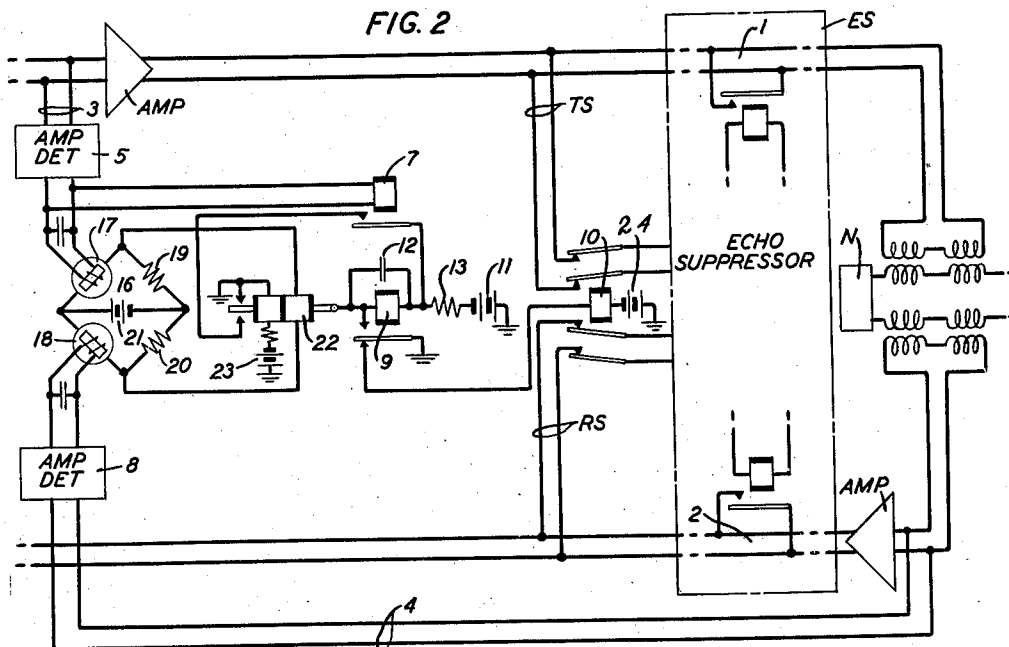
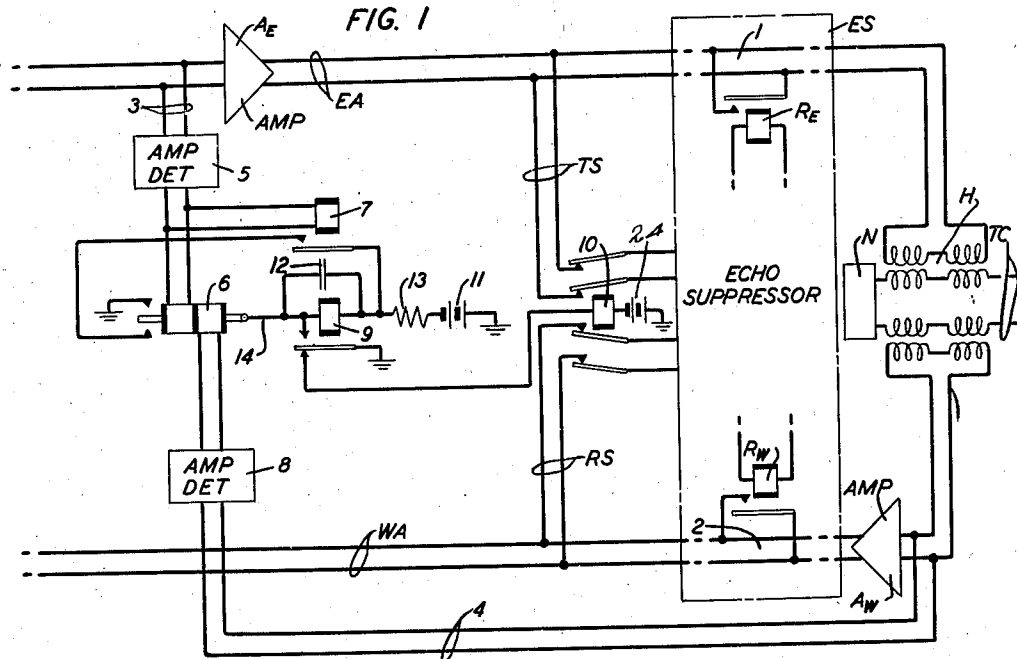
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TRANSMISSION CONTROL IN TWO-WAY SIGNALING SYSTEMS

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TRANSMISSION CONTROL IN TWO-WAY
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The invention relates to two-way signal transmission systems and particularly to circuits for controlling transmission in such systems.

Proper operation of long two-way telephone systems has required the use of voice-operated switching devices, commonly known as echo suppressors, to directionally control signal transmission in the oppositely directed repeating paths of the system while suppressing echoes and preventing singing. Such echo suppressors may comprise, for example, an amplifier-rectifier-relay circuit connected to each repeating path, operating in response to signal transmission in that path to disable the oppositely directed repeating path to suppress the signal echoes.

Such echo suppressors often introduce detrimental effects on transmission, such as an increase in the time required for a listening subscriber to break in on a talking subscriber, and partial or complete signal transmission lock-out when both subscribers at the two ends of the system start talking at about the same time. There are many calls in present-day systems which do not require the operation of echo suppressors to suppress echoes but which cause the echo suppressors, which are present because they will be needed on other calls involving the same circuit, to function, and there is at present no means available for distinguishing adequately which calls do need echo suppressors.

It is an object of the invention to reduce the effects of echoes in a two-way telephone system while preventing or reducing the above-mentioned detrimental effects.

This object is attained in accordance with the invention by circuits operating automatically to remove an echo suppressor from a system or to effectively disable it when it is not needed to suppress echoes. In one embodiment, these circuits compare the voice currents received from a two-way line on one side of a four-wire telephone circuit with the echoes sent back in the other direction from the two-way line on the other side of the four-wire circuit, and if and when the echoes returned are weaker than the direct speech currents by an amount predetermined as satisfactory from an echo standpoint, remove or disable the echo suppressor and restore it when the echoes become relatively stronger than the limiting amount.

The invention will be better understood from the following detailed description when read in conjunction with the accompanying drawing, Figs. 1 and 2 of which show schematically a por-

tion of a two-way telephone system embodying different modifications of the invention.

Fig. 1 shows a four-wire terminating circuit at the east terminal of a two-way telephone system. It comprises a west-to-east incoming two-wire path EA including the one-way amplifying device AE, and an outgoing east-to-west two-wire circuit WA including the one-way amplifying device AW, coupled by the usual three-winding or two-coil hybrid transformer H in conjugate relation with each other and in energy-transmitting relation with the two-way telephone circuit TC which may lead to an east subscriber's telephone set (not shown). The circuits EA and WA may extend to the west to a similar four-wire terminating circuit at the west terminal of the system directly or through an intermediate radio or two-way wire link (not shown).

An echo suppressor represented by the box ES, which may be of any of the well-known types, is associated with the paths EA and WA at the east terminal, as indicated. In the particular type of echo suppressor diagrammatically illustrated, the incoming path EA is normally enabled due to the normal break in the short-circuiting connection across that path at the point 1, provided by the normal open condition of the contacts of the unenergized switching relay RE, and the outgoing path WA is normally enabled due to the normal break in the short-circuiting connection across the latter path at the point 2, provided by the normal open condition of the contacts of the unenergized switching relay RW. In the ordinary operation of the echo suppressor ES, a portion of the incoming telephone signals received over the path EA from a west subscriber, diverted into the transmitting switching control TS, which may include an amplifier-rectifier, not shown, will cause the operation of the relay RW to close its switching contacts to short-circuit the path WA at the point 2, thereby effectively disabling the latter path at that point. Thus, any echoes of the incoming west-to-east signals appearing in the input of the path WA, due to improper unbalance of the hybrid coil H and associated balancing network N, or any subsequently received east-to-west signals received over the circuit TC, will be prevented from passing out over the path WA to the west station or from entering the receiving switching control RS to cause false operation of echo suppressor ES. Also, in the ordinary operation of echo suppressor ES, when the transmitting control TS is not operated by incoming west-to-east signals, and east-to-west signals received over

the circuit TC are impressed on the outgoing path WA through hybrid coil H, a portion of these signals diverted into the receiving switching control RS, which also may include an amplifier-recifier (not shown), will cause its operation to operate switching relay R_E to short-circuit the incoming path EA at the point 1, to suppress any subsequently received west-to-east signals or echoes. In a modified echo suppressor, the relay R_w under control of transmitting switching control TS would operate to close the contacts at point 2 to insert loss in the path WA, as shown, but R_E under control of receiving switching control RS would operate to disable the transmitting switching control TS of the echo suppressor to avoid false operation, etc. In such a case, a similar echo suppressor device at the west terminal of the system (not shown) would be arranged to operate in similar manner to block the outgoing path EA in response to incoming signals in the incoming path WA. In the suppressor as shown on Fig. 1, no echo suppressor need be used at the distant end of the circuit.

The control circuits for accomplishing the objects of the invention, illustrated in Fig. 1, include one control branch 3 having its input bridged across the incoming path EA at a point in front of amplifier A_E, and a control branch 4 having its input bridged across the input of the outgoing path WA at a point in front of amplifier A_w. The control branch 3 includes the amplifier-detector 5 and connected in parallel across its output the left-hand operating winding of differential relay 6 and the operating winding of relay 7. The control branch 4 includes the amplifier-detector 8 and connected across its output the right-hand winding of the differential relay 6, poled to oppose the left-hand winding of that relay. The differential relay 6 and relay 7 control the operation of the relays 9 and 10 and the associated circuits in the manner to be described in the following complete description of the operation of the circuits of Fig. 1.

With no speech current being received over the incoming path EA and no speech currents being transmitted over the outgoing path WA, the circuits described above are in the condition shown in the drawing, with the differential relay 6 de-energized so that its armature is in the neutral position, the relays 7 and 9 deenergized and the relay 10 energized by current from battery 24 flowing through the winding of that relay and the back contact of relay 9, the operated contacts of relay 10 maintaining the control circuits TS and RS effective for echo-suppressor operation.

Now, let it be assumed that speech currents from a west subscriber are being received over the incoming transmission path EA at the east terminal of the system, and at that time no speech currents from an east subscriber associated with the circuit TC are present in the outgoing path WA at the east terminal. The incoming speech waves in path EA are amplified in the amplifier A_E and, the echo suppressor relay R_E being in its normally unenergized condition so that the path EA is unblocked at the point 1, the amplified voice waves will pass over the output portion of the path EA and through the hybrid coil H to the two-way circuit TC over which they will be transmitted to the east subscriber. A portion of west's speech waves will be diverted into the transmitting control TS of echo suppressor ES and will operate relay R_w to block WA at the point 2.

Another portion of west's speech waves passing over the path EA will be diverted into the control branch 3 of the differential control circuit, will be amplified and detected by the amplifier-detector 5 therein, and will be supplied as energizing current to the operating winding of relay 7 to operate that relay, and to the left-hand operating winding of the differential relay 6 tending to operate that relay upwards. The echoes of west's signals produced in the outgoing path WA due to improper balance of the circuit TC by the balancing network N will be transmitted over that path through amplifier A_w towards the west terminal.

A portion of the echo currents in the input of amplifier A_w will be diverted into the control branch 4 of the differential control circuit, will be amplified and detected in amplifier-detector 8 and supplied as energizing current to the right-hand winding of differential relay 6 tending to operate that relay downward. The sensitivity of amplifier-detector 5 in control branch 3 and that of amplifier-detector 8 in control branch 4 are relatively adjusted so that the differential relay 6 operates downward to close its armature and lower contact when the echo in the path WA is greater than desired compared to the direct signal transmission in the path EA, and operates upwards to close its armature and upper contact when the echo in the path WA is weak enough compared to the direct transmission in the path EA to be negligible. When the differential relay 6 is operated downwards, the relay 9 remains released (as in its normal condition) and thus the relay 10 controlled thereby remains in the operated condition with its upper and lower contacts closed to maintain the transmitting switching control TS and the receiving control RS of echo suppressor ES operative so that the echo suppressor will continue to function to maintain the outgoing path WA disabled at the point 2 so as to suppress the echoes of west's signals at that point in the manner described above. However, when the differential relay 6 is operated upward indicating that the echo in the path WA is negligibly weak compared to the direct signal transmission in the path EA, relay 9 tends to operate from battery 11 through ground applied through the upper contacts of differential relay 6, but, due to the effect of condenser 12 in shunt with its winding and the resistance 13 in series therewith of properly selected values, relay 9 is slow to operate, requiring either a continuous closure of the upper contacts of differential relay 6 for a given time interval, or a considerable number of shorter closures of these upper contacts to charge up the condenser 12 before relay 9 operates. This is for the purpose of insuring that the return loss over the frequency band of interest is adequate, as a fast operating relay 9 might be improperly operated by a high return loss in one frequency range when a sound contained mostly those frequencies.

If at any time during this process, the differential relay 6 releases and stays neutral, nothing happens except that in time the charge on condenser 12 would drain away through relay 9. However, if the differential relay 6 operates downwards while relay 7 is operated, condenser 12 will be shorted by a circuit extending through the made contacts of relay 7 and the made lower contacts of differential relay 6, and the charging process must begin over again before relay 9 can be operated. When relay 9 does operate, removing ground from the normally en-

energized relay 10, the latter relay will release simultaneously disabling the control circuits TS and RS for echo suppressor ES and thus disabling the suppressor so that it is effectively removed from the system. Relay 9 will lock up through its operated front contact and ground. Relay 9 will then remain operated to hold relay 10 deenergized and thus the echo suppressor ES ineffective until such time as the differential relay 6 again becomes operated downward in response to a greater echo in the path WA than desired compared to the direct transmission, and relay 7 is operated simultaneously in response to the speech waves received from the path EA. When this happens, the winding of relay 9 will be short-circuited through the contacts of relay 7 and the lower contacts of relay 6 and relay 9 will therefore release to return relay 10 to the normal energized condition whereupon the echo suppressor ES again becomes operative.

The purpose of relay 7 is to prevent the near-end subscriber at the local toll terminal from restoring the echo suppressor to the circuit when he talks. For example, if the contacts of relay 7 were permanently closed when the subscriber at the near-end talks, differential relay 6 would be operated downward causing relay 9 to be released and relay 10 operated, thereby restoring the echo suppressor ES to the circuit while there is no need for it. With relay 7 released, however, as it would be with no speech coming in from the distant end of the four-wire circuit, the operation of the differential relay 6 downward will not cause the release of relay 9 with the result that the echo suppressor ES will remain inoperative.

This raises the question as to what happens when the west subscriber at the distant end of the four-wire circuit and the local subscriber associated with the circuit TC start talking at about the same time. In this case, the voice currents of the east subscriber would maintain control of the differential relay 6 with the result that the echo suppressor ES will be maintained operative to disable the incoming path EA until the east (near-end) subscriber paused. If tests on a given circuit indicated that this condition occurred often, it may be desirable to provide for the relay 9 one that is very slow to release, thus requiring considerable overlap in simultaneous speech before the echo suppressor restored. If this were not sufficient, it might be desirable to provide another relay operating from the output of the receiving amplifier-detector 8 with such low sensitivity that it never would be operated in response to echoes but would operate in response to loud near-end speech, and arranged for the release of the latter relay to close a break in wire 14 connecting the armature of relay 6 to the winding of relay 9. Then with loud speech from the near end, the echo suppressor ES would not be restored by double talking, since the open contact on the added relay would prevent relay 9 from being released.

In the above discussion, it will be understood that when the echo suppressor is stated to be operative and later inoperative, this might mean present on the circuit and later actually removed from the circuit and available for use on other circuits. Also, the two conditions might refer to different echo suppressor settings, say high and low zero level sensitivities, or two different values of suppression loss. A modification within the scope of the invention would be to provide two or more control circuits such as illustrated

in Fig. 1 associated with the incoming and outgoing paths EA and WA in similar manner as the control circuit illustrated, which operate to reduce the sensitivity of the echo suppressor ES in two or more steps, to obtain as little echo suppressor operation as possible.

Other modifications of the control circuit of Fig. 1 might be desirable in the interest of economy. For example, relay 7 might well be controlled from the amplifier-detector in the transmitting echo suppressor control TS instead of from the auxiliary amplifier-detector 5 as illustrated, and the two amplifier-detectors 5 and 8 might be partly or wholly made up of the amplifier-detectors normally provided in the transmitting and receiving switching controls TS and RS of the echo suppressor ES. In addition, the differential relay 6 might comprise a differential thermistor Wheatstone bridge 16 and an associated relay 22, such as illustrated in Fig. 2, or other differential means.

In the system of Fig. 2, the differential bridge 16 includes the thermistors 17 and 18 in two arms of the bridge and the equal resistors 19 and 20 in the other two arms of the bridge. A source of current 21, which may be a direct current battery, is connected across one diagonal of the bridge and the operating winding of the relay 22 is connected across the other bridge diagonal. The heater of the thermistor 17 in one arm of the bridge is connected to the output of the amplifier-detector 5 in the transmitting control branch 3 across a shunt condenser provided to suppress the alternating component of the detector output current from the heater element, and the heater element of the thermistor 18 in the opposing arm of the bridge is connected across another condenser provided for a similar purpose to the output of the amplifier-detector 8 in the receiving control branch 4. The relays 7, 9 and 10 and their associated resistance and condenser elements are arranged in the same manner as the similarly numbered elements in the system of Fig. 1 and provide the same functions.

When voice currents from the path EA are impressed on the amplifier-detector 5 of control circuit 3, and its output supplies heating current to the heater of thermistor 17, which is relatively greater than that applied to the heater of thermistor 18 by the amplifier-detector 8 in the receiving control branch 4 in response to the signal echoes in that branch, the resistance value of thermistor 17 becomes comparatively smaller than the resistance value of thermistor 18 with the result that the Wheatstone bridge 16 formed by the thermistor elements 17 and 18 and the equal resistors 19 and 20, is unbalanced, and the unbalance current of the bridge flows through the operating winding of relay 22. Relay 22 is normally biased by the current supplied to its biasing winding from battery 23 so that the unbalance current flowing in the operating winding of the relay tends to operate its armature upwards towards the grounded upper contact. When this unbalance current is greater than a predetermined amount indicating that the signal echoes in the path WA are negligibly small relative to the direct signal transmission in the path EA, the relay 22 will be operated to the grounded upper contact causing relay 9 to be operated and thus relay 10 to be released to disable the echo suppressor ES in the same manner as described for the system of Fig. 1.

On the other hand, when the current through the heater for thermistor 18 is relatively greater than that through the heater of thermistor 17 indicating that the amount of signal echo in the path WA is too great with respect to the direct signal transmission in the path EA, the Wheatstone bridge 16 will be unbalanced in the opposite direction and the unbalance current will flow in the opposite direction in the operating winding of relay 22, operating the armature of that relay to its lower contact. Then the winding of relay 9 will be shorted through the made lower contact of relay 21 and the made contact of relay 7 which has been operated by the output currents of amplifier-detector 5. Relay 9 will therefore release to reenergize the winding of relay 10 and the latter relay will reoperate to restore the echo suppressor ES to the circuit in the manner which has been previously described in connection with Fig. 1.

Other modifications of the circuits illustrated and described 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 signaling system, a four-wire circuit for transmitting signals in opposite directions, a two-way signal transmission medium coupled to one terminal of said four-wire circuit, an echo suppressor device responsive to signal transmission in the side of said four-wire circuit transmitting to said medium to insert an echo suppression loss in the other side of said four-wire circuit and means controlled by the transmission in both sides of said four-wire circuit for effectively disabling said echo suppressor device when the level of signal echoes in said other side of said four-wire circuit is less than a predetermined value and for rendering said echo suppressor device operative again when the level of the signal echoes in said other side of said four-wire circuit is above the predetermined value.

2. The combination of claim 1, in which the last-mentioned means comprising a differential circuit for continuously comparing the signals in said one side with the echoes of said signals in said other side of said four-wire circuit, means controlled by said differential circuit operating only when the ratio of the echo level in said other side to the signal level in said one side of said four-wire circuit is within predetermined limits considered tolerable, to disable said echo suppressor device.

3. The combination of claim 1, in which the last-mentioned means comprises differential means for continuously comparing the level of the signals in said one side of said four-wire circuit at a point in front of the input to said echo suppressor device with the level of the echoes due to said signals at a point in said other side of said four-wire circuit in front of

the suppression point, and means controlled by said differential means and operating only when the ratio of the echo level to the signal level is within predetermined tolerable limits, to disable said echo suppressor device.

4. In combination in a two-way signal transmission system, a two-way line, a four-wire terminating circuit operating to transmit signals to, and to receive signals from said line, one switching circuit connected to the transmitting side of said four-wire circuit, responsive to signal transmission therein to disable the receiving side of said circuit to suppress echoes therein, another switching circuit connected to said receiving side of said four-wire circuit at a point beyond the disabling point therein, operating when said receiving side is operative, in response to signal transmission therein to disable the transmitting side at a point beyond the point of connection of said one switching circuit thereto, a differential circuit continuously operating to compare the level of signals in said transmitting side at a point in front of the disabling point therein with the level of the signal echoes in said receiving side of said four-wire circuit at a point in front of the disabling point therein, relay means controlled by said differential circuit operating only when the echo level is relatively less with respect to the signal level than a predetermined value considered as tolerable, to disable both switching circuits, and means to prevent while signal transmission in said transmitting side continues, the two switching circuits from being restored to normal in response to signals subsequently received by said four-wire circuit from said two-way line.

5. The system of claim 4, in which said differential circuit comprises a differential relay having two opposing windings respectively energized by transmission in the two sides of said four-wire circuit, operating in one direction when the signal echo in said other side compared to the direct signal transmission in said one side of said four-wire circuit is greater than considered tolerable, and in the opposite direction when the echo is sufficiently weak compared to the direct signal transmission to be within the tolerable limits, and a relay circuit operating only when said differential relay operates in said opposite direction, to disable both said switching circuits.

6. The system of claim 4, in which said differential circuit comprises a Wheatstone bridge circuit including two opposing arms the resistances of which are respectively varied in accordance with the level of the transmission in the respective sides of said four-wire circuit, and said relay means is responsive only to an unbalance condition of said bridge corresponding to a ratio of the transmission levels in the two sides of said four-wire circuit obtained when the signal echo in said other side of said circuit is within the tolerable limits, to disable the two switching circuits.

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